Storm water Management of Mumbai city by using Pervious Concrete on GIS based platform

Darshan Anil Sansare, Sumedh Yamaji Mhaske,

Abstract- ***Flooding is major cause in urban area particularly in Mumbai City which is due to haphazard alterations in land use–land cover (LULC), escalation in the amount of precipitation by virtue of climate change and related impacts due other hydrological changes augmented with deterioration of life and properties. Due to urbanization most of the city has gotten embedded in concrete and by the virtue of which the rainfall gets converted to runoff. The present SWD system in the city is more than 150 years old and 186 outfall also not in use in high tide associated with heavy rainfall situation. In relevance to the implications as stated above, Greater Mumbai is facing reckless Water Logging Problems in many low lying areas from the past 20 years. So, to eradicate and abolish this problem permeable concrete is a perfect solution which should be eco friendly, economical and universally accepted. In this study characteristic of permeable concrete with its type, mix design and application is suggested data base is created to get comparative idea for the same. By clicking on the respective flood spots one can avail the information pertinent to that flood spot location in terms of pervious type suitable to that location. Geographic Information System (GIS) proves to be a can prove to be a very effective tool for integrating & managing various types of information related to this Storm water Management.***

Keyword : Flood spots; QGIS; SWD; Permeable concrete;

I. INTRODUCTION

Mumbai also known as coastal city is enclosed by sea and creek from all sides which, makes its prone to flooding when heavy rainfall occurs together with high tide conditions. Storm water drainage system is central to addressing the long term sustainability of the city. The present SWD system in the city is more than 150 years old system. Mumbai is facing reckless Water Logging Problems in many low lying areas from the past 20 years. Out of the 186 SWD outfalls -46 are below the mean sea level and 140 above M.S.L of which 134 are below high tide level and only 6 outfalls are above high tide and also 2000km roadside open drain system also present, which means the condition is very pathetic. (FFC, 2006). In hydrological studies, LULC change and its hydrological impacts on design of drainage system are the major topics of research in the recent years (Amini et al. 2011; Chen et al. 2009; Fox et al. 2012; Sayal et al. 2014;). As per Sansare et al 2019, the study is to carry out hazard analysis and its thematic mapping for F-North ward, Mumbai using QGIS tools and techniques.

Due to Urbanization, Industrialization and the enormous growth of population, most of the parts of Mumbai had gotten embedded in concrete, and due to this impervious nature of concrete there is no scope for the infiltration of water, by the virtue of which the rainfall gets converted into run off. By the virtue of which, the city generally faces the problem of Water Logging. As per Sansare et al 2018, study is to carry out analyze the LULC change by comparing 1973 and 2018 LULC data for catchment area Mumbai, India along with the impact of LULC change spatially and temporally on the peak flood discharge and runoff generation for the catchment area , which is calculated by using Rational Method as :

$$Q=C*I*A/3.6 \quad (1)$$

Q=Discharge (m^3/sec), C= Runoff Coefficient, I= Intensity of Rainfall (mm/hr), A= catchment area (sq.km)

The analysis of the LULC data also suggests a similar point of view. There is an increase in peak discharge by 40 % for LULC change between the years 1973 and 2018. Significant change in LULC, increase in peak discharge and the drains are clogged due to wastes has resulted in there is a frequent occurrence of floods or water logging in Mumbai (Sansare D.A et al 2018).

Every dreadful year the precipitation in the form of heavy spells of rains substantially affects the Public Health, Safety and Property. So, to eradicate and abolish this problem a perfect solution need to be find out which should be eco-friendly, economical and universally accepted. To use concrete for flatwork applications where water from rainfall and other sources can easily permeate with the reduction of runoff from sides and improving water tables, a specially designed concrete with high porosity known as Permeable concrete is to be used. There is renewed interest in using permeable concrete as a pavement material because it recharges the ground water and reduce storm water runoff effectively.

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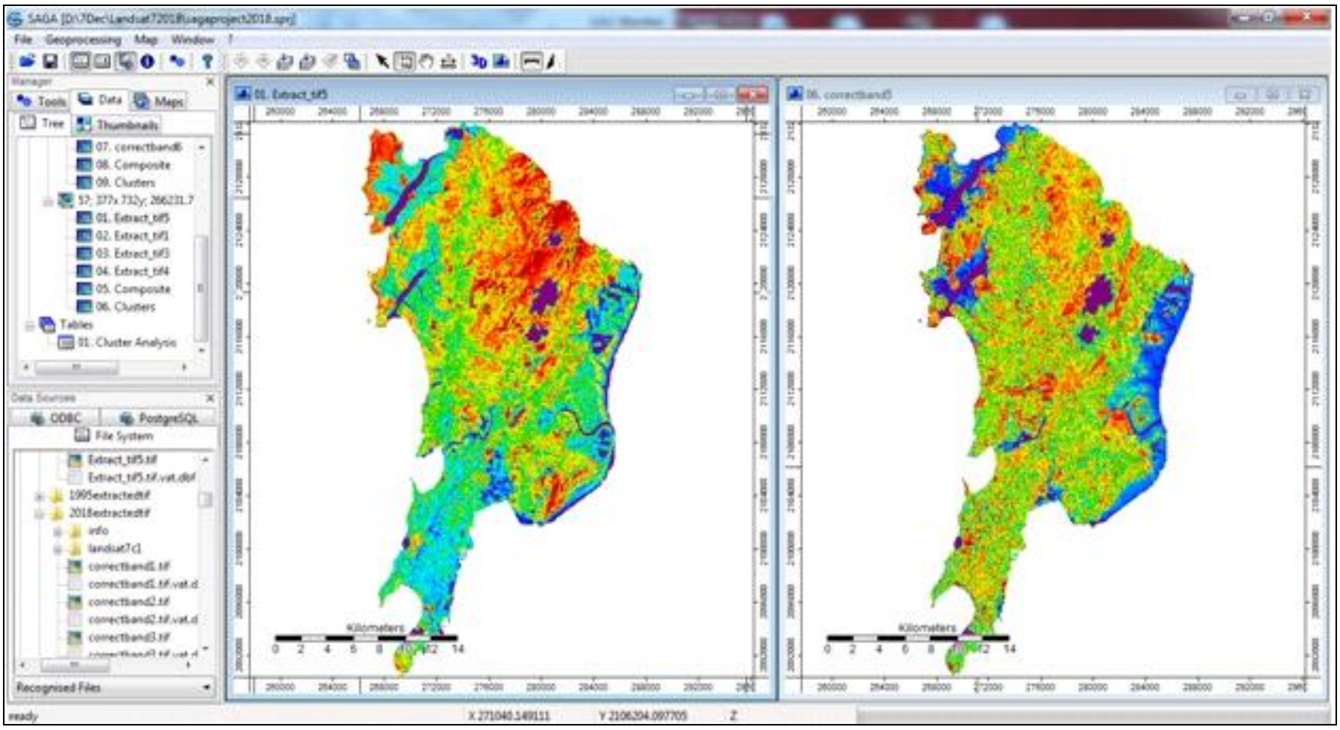

Figure 1- The Image showing result of change detection in LULC of Mumbai for Year-1973 and Year- 2018 by unsupervised classification by using SAGA GIS software. (Source: Sansare D.A et al 2018).

Table 1- Land use–land cover changes for the study area with changes from 1973 to 2018 (Source: Sansare D.A et al 2018).

Sr.No	Land Use Type	1973		2018		% Change in LULC
		Area(sq.km)	% Total	Area(sq.km)	% Total	
1	water	29.74	6.31	23.47	4.97	-22
2	Forest	131.93	28	100.21	21.25	-25
3	Built-up	166.95	35.44	285.89	60.63	+72
4	Open land	61.55	13.06	10.87	2.30	-83
5	Wetland	80.90	17.17	50.67	10.74	-48
	Total	471.07	100	471.5	100	

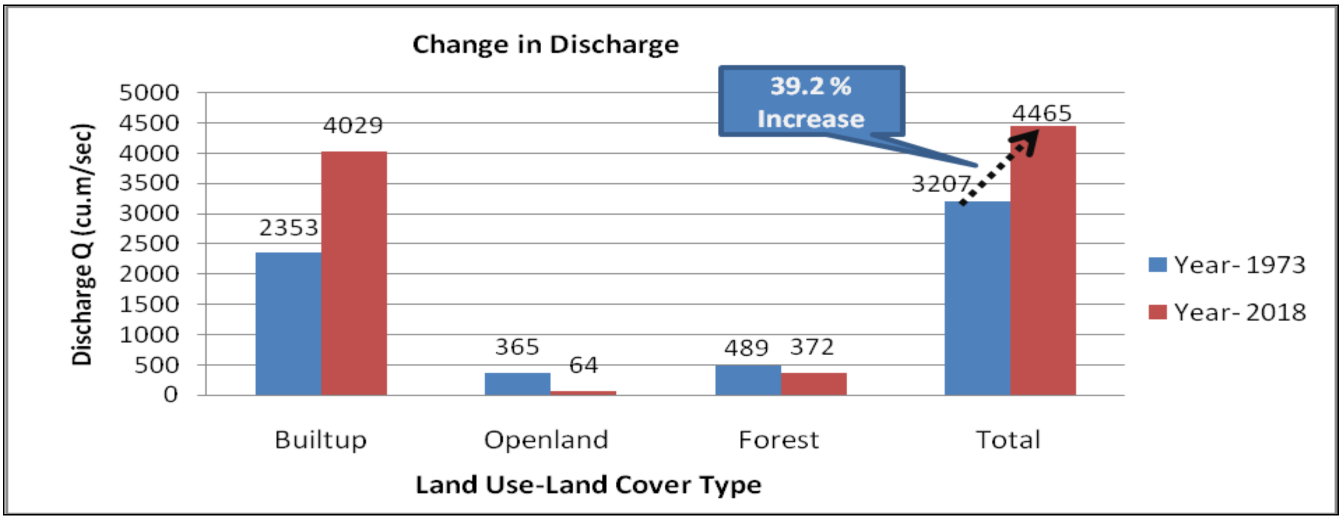

Figure 2-The above column chart indicates the changes in the discharge from run off for (Rainfall=53.4mm/hr) different geographical features over the period considered. (Source: Sansare D.A et al 2018).

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economical and universally accepted. To use concrete for flatwork applications where water from rainfall and other sources can easily permeate with the reduction of runoff from sides and improving water tables, a specially designed concrete with high porosity known as Permeable concrete is to be used. There is renewed interest in using permeable concrete as a pavement material because it recharges the ground water and reduce storm water runoff effectively. According to K.collins .et.al. (2007) discussed on selection & implementation of proper design of permeable pavement for improving water quality & reducing runoff. To evaluate various pervious pavement designs of a parking lot, it was found that all permeable pavement sections cause substantial reductions in surface runoff volume compare to asphalt runoff. As per Hein et al, 2013, the Various Configurations for the Permeable Pavements are as shown below in the figures and are described briefly and this is valid for any type of permeable Pavements. As per Chandrappa and Biligiri, (2016) established pavement surface temperature models based on meteorological factors using predictive models focusing on pavement temperature profiles. These models recommended the pavement surface type that is suitable for UHI mitigation Strategy. GIS provides an efficient way to identify, locate natural hazard prone areas and unsafe structures and resources. Enormous volumes of data are compiled on various parameters and are presented through maps. This study is aimed at generating water logging areas with flood spots, and flood hazard maps for Mumbai city using GIS software. GIS is considered as one of the useful tools for hazard, risk analysis and mapping.

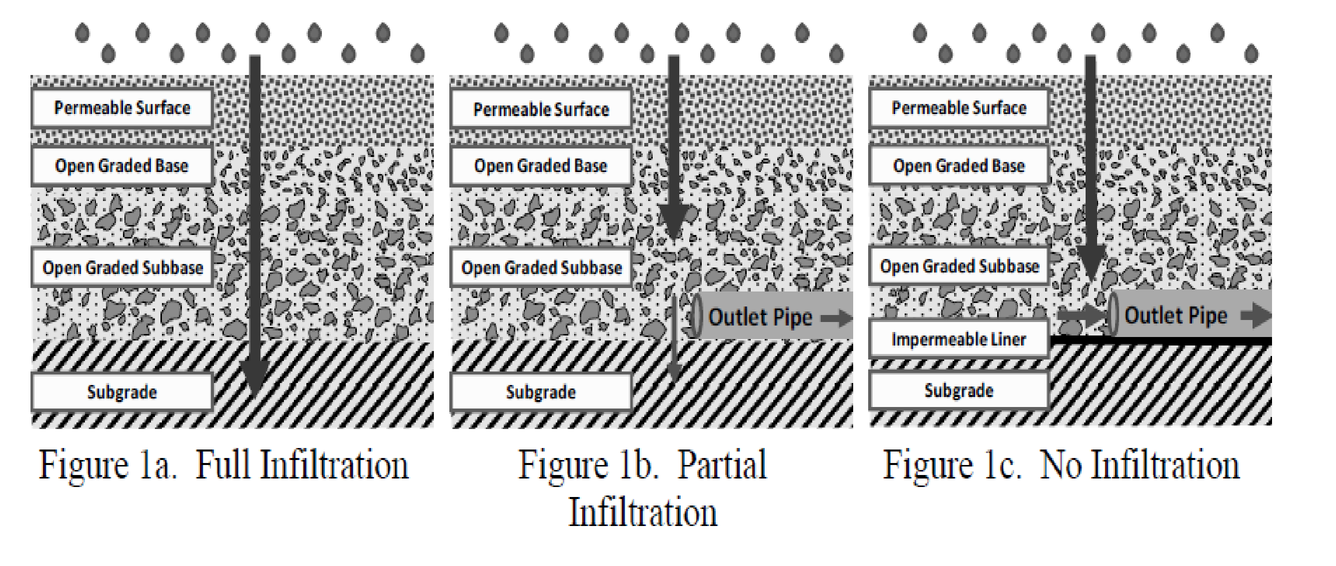

Figure 3- Structure of Permeable Pavements based on sub-grade Infiltration (Source: Hein et al, 2013).

II. STUDY AREA

Mumbai, once known as ‘Bombay’, is one of the largest metropolitan city and fastest growing economy in respect to financial and demographical terms, is considered as study area for the present analysis. It is located on the western part of India between 18°53’ N to 19°15’ N latitude and 72°48’ E to 73°00’ E longitude. Mumbai used to be encompassed with group of islands, and in due course of time demand for space were met by reclaiming the area between those islands. On July 26, 2005, the rainfall recorded touch the peak as compare to last 100 yrs in the suburban Mumbai and Thane, and these regions suffered acute problem of waterlogging in their history. According to Gupta (2007), the rainfall was the eighth heaviest ever recorded 24 hour rainfall (944 mm) in India and started in Mumbai at around 8:30 AM on the 26th July and continued intermittently over the next day. In the future, an increase in rainfall volume and/or intensity could increase the risk of severe flooding. The lat/long data of the outfall at its end were collected from the MCGM website.

Then open QGIS software in that one Mumbai boundary layer for marking Outfall create new point layer and mark all this 186 outfall and create attribute table and then Create Map. In above Thematic map Mumbai Boundary & also Seven Island(BOMBAY,COLABA,MAHIM,MATUNGA,MAZA GAON,OLD WOMENS ISLAND,WORLI) With water bodies are digitized in QGIS software by using polygon layer and attribute table is created for finding total area. Water bodies like lakes (eg. Powai, Tulsi , Vihar) , Rivers (eg. Mithi , Dahiar , Mahim) , Creeks (eg. Manori , Malad , Trombay) and Nala (eg. Irla , Vakola) are present in the study area . This Map (fig:4) Shows 186 outfalls of Mumbai and its suburban’s with their exact locations in terms of latitude and longitude and their elevations too. Most of the outfalls are present along Manori creek and Malad creek. Most of the outfalls are in the in sea coast and lie below the average elevation of Mumbai which is 14m. There are 135 outfall above M.S.L but which is below high tide level and 46 outfalls below M.S.L in the Mumbai city. Flash floods and high tides cause most of the outfalls to submerge under the sea water leaving it useless for disposal of city water. Only 6 outfalls are above high tide level out of 186.This map and its attribute table provides a base data for further modification in the outfalls.

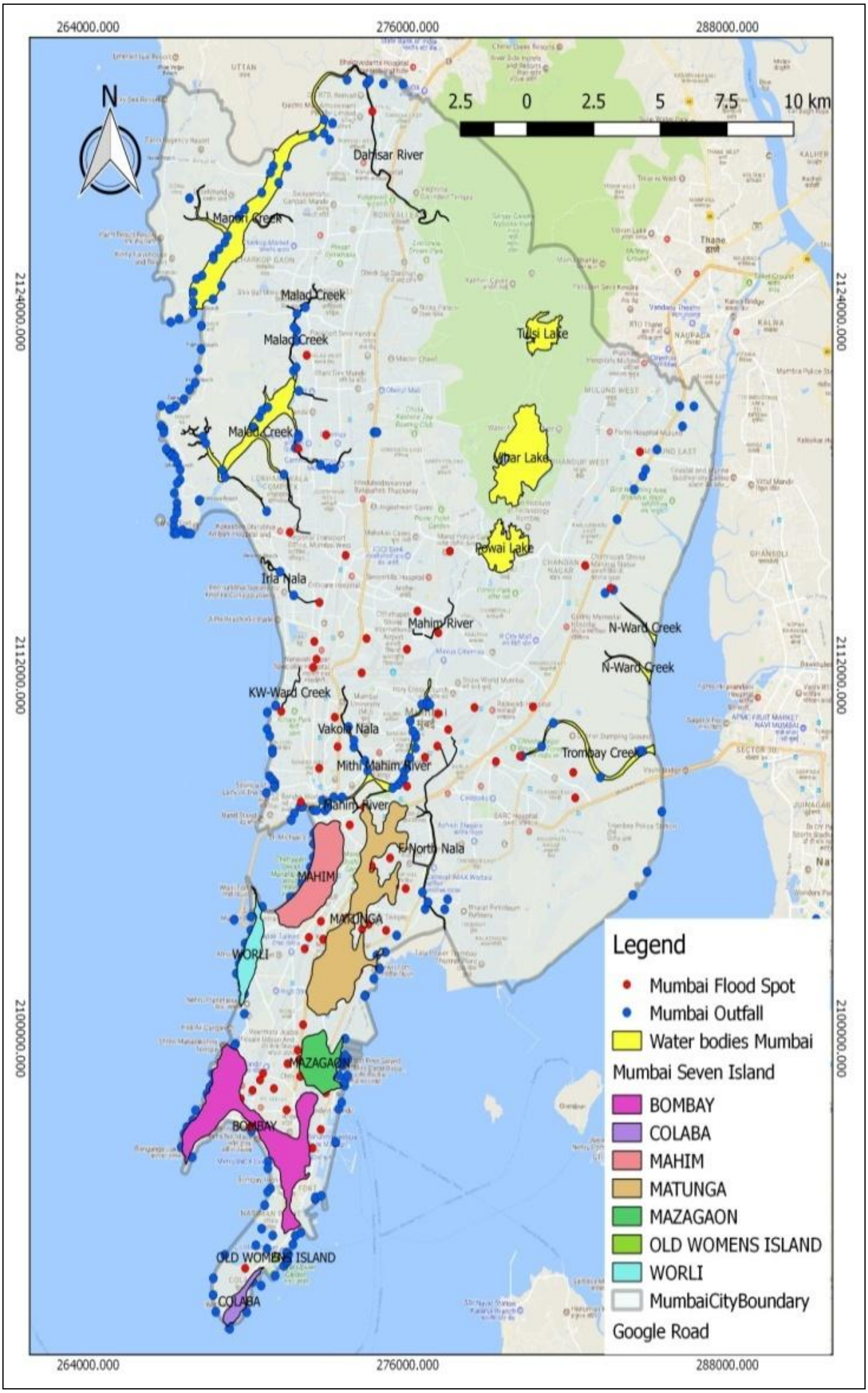

Figure 4: Thematic Map for Mumbai and its suburban area which shows Seven Island, major water areas and Storm water Outfall

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III. METHODOLOGY

The information collected with reference to the study area encompasses satellite images and surveyed field data from USGS, toposheet and the field surveyed data. Survey of India toposheet no. A-47/16 for the year 1966 was used for reference for analysis. QGIS software was utilized to develop the base map and the contours by taking 1m contour interval in the software and flood spots were marked on the digitized map using point layer. Water logging due to flash flooding is a natural calamity and cannot be prevented. In order to find an alternative solution for these areas Pervious concrete with its type, mix design and application is suggested according to the ground data. Data pertinent to the study area were easily obtained by by clipping the boundary of Mumbai city from the satellite image. The seven islands, water bodies, river, nallas and ward were digitized by using polygon layer. These wards are so digitized that one can get the data about ward name, ward no, ward area, geographic location, number of water logging, landslide spots, vulnerability settlement, dilapidated buildings, open gardens, grounds, fire station ,police station, bus depots, hospitals, parking lots , rain gauge stations, roads and its lengths, major and minor nallas, Outfalls, topography ,city type just by clicking on that particular ward for the year 2018.

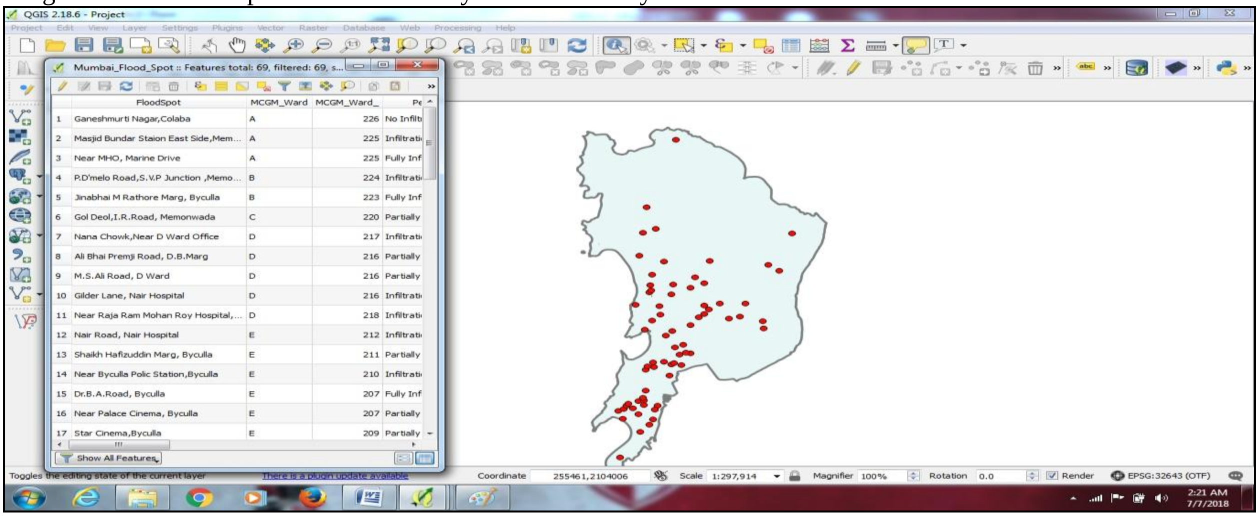


Figure 5: Image of Mumbai and its suburban area which shows

Ward wise Flood Spots

From all the previous data of Map and Attribute Table and its analysis the above map was created by using Point Layer in QGIS software. The spotted areas shown (Fig:5 & Fig: 6) in Red have been found to be the most flood prone areas in the Mumbai and its Suburban .The attribute table of this map clearly specifies the exact location in terms of latitude and longitude, Ward Type, Ward Number, Contour Value, and Topography of the flood spots. These marked points are so digitized that one can avail following information regarding just by clicking on the respective flood spots.

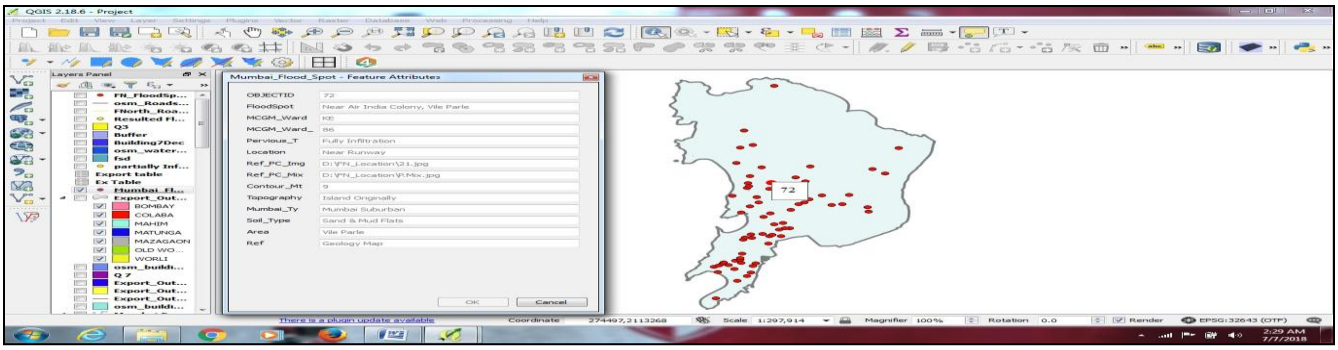
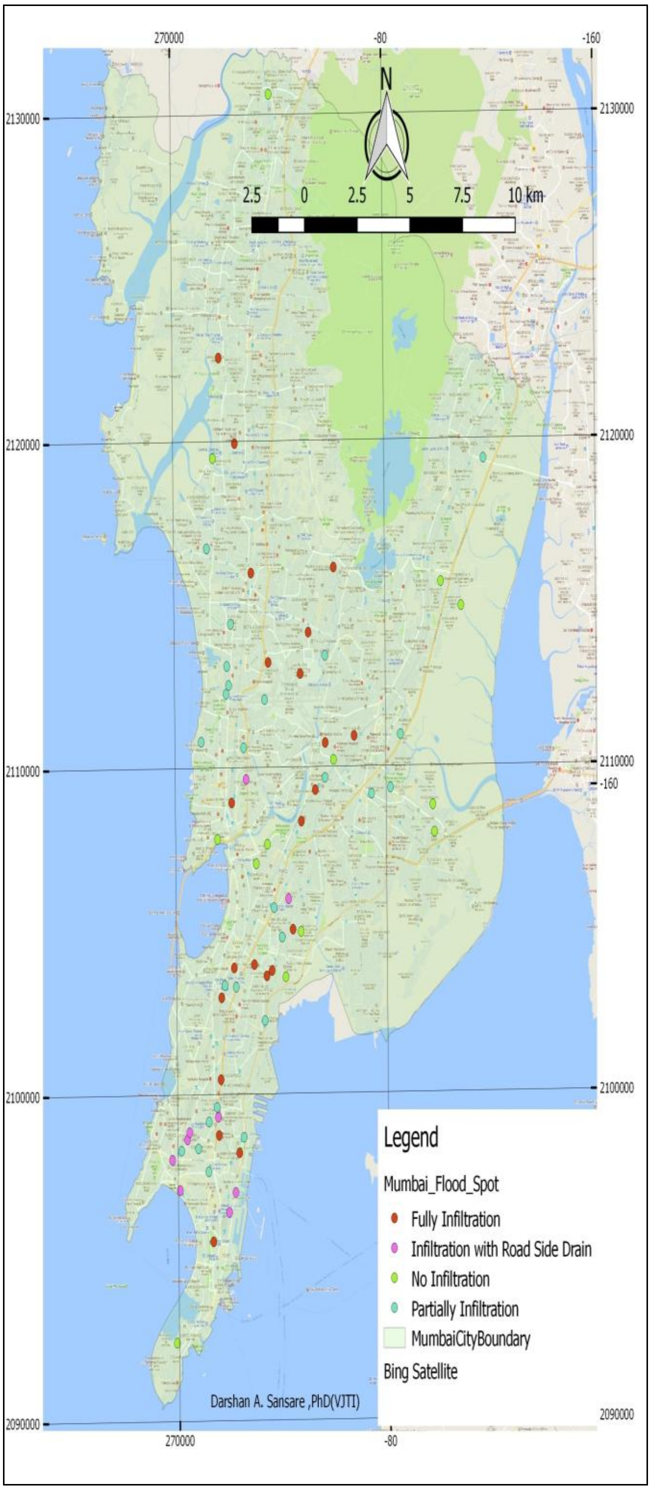


Figure 6: Mumbai and its suburban area which shows in detail information (data) of Flood spot.

IV. RESULTS AND DISCUSSIONS



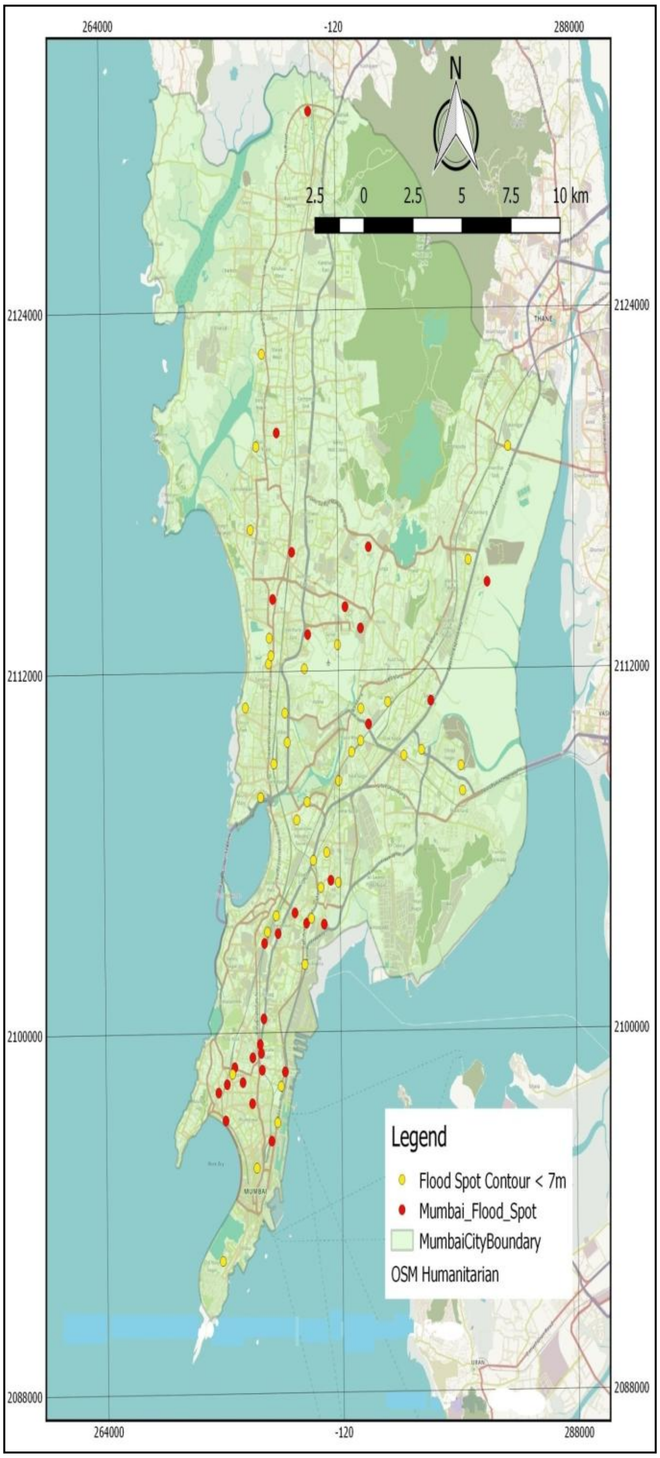


Figure 7: Thematic Map for Mumbai which shows Flood Spots have Contour value < 7 Meters.

The maximum elevation or the contour is 26m Behind SEEPZ, MIDC Marol, where as the minimum elevation or least contour is Near MHO Marin Drive which has contour value of -14m. Out of the total flood spots in the area for consideration about 57% or 39 flood spots are such areas where the contour value is less than 7m. This information was traced with the help of QGIS software and such areas are depicted with yellow dots on the Map(fig:7). This data acquired provides information to MCGM, Town planners and Disaster management committees on which areas are most prone to be affected by flash flooding for future prevention

Figure 8: Map (fig:8) for Mumbai and its suburban which shows Flood spots with suggested pervious concrete type.

So,by referring ample of literatures, pervious concrete satisfies the criteria to be used as a perfect solution for eradicating the problem of water logging and suggested pervious concrete types suitable to 69 major flood spot location in Mumbai.eg-

i) Fully Infiltration.
ii) Infiltration with roadside drain.
iii) Partially Infiltration.
iv) No Infiltration.

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V. CONCLUSION

Due to Urbanization, Industrialization and the enormous growth of population, most of the parts of Mumbai had gotten embedded in concrete. Rapidly changes in LULC, limitation of SWD and natural calamities like flash flooding which are responsible for water logging in Mumbai and it cannot be easily prevented; one has to search for alternatives. The percolation of water down to the ground is the better remedy. This percolation can be done by the use of pervious concrete. Its implementation is a better way to reduce the intensity of water logging created by Heavy rainfall and backwater effect. The impact of this concrete is analyzed and a comparative data base is created for the same. By clicking on the respective flood spots one can avail the information pertinent to that flood spot location in terms of latitude-longitude, ward name, ward number, location, contour value, topography, city type, pervious type, pervious mix design suitable to that location. This study gives an emphasis for the generation of database with the help of QGIS, which can be utilized by the municipal corporations, Disaster Management and Planning committees to mitigate the flood disaster and develop optimal solutions for ever-pervasive challenges of reckless flooding in Mumbai with Thematic Maps.

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