EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 4 Number 5 (May-2016) pp. 51-65

Journal home page: http://www.ijcrar.com

doi: http://dx.doi.org/10.20546/ijcrar.2016.405.007

Pluvial Flooding in Kolkata: A Case Study of the Major Streets in Northern, Southern and Central Kolkata

Deblina Mitra[1] and Suranjana Banerji[2*]

[1]Research Scholar, Department of Geography, Presidency University, Kolkata-700073, India
[2]Assistant Professor, Department of Geography, Presidency University, Kolkata-700073, India

Corresponding author

KEYWORDS

Urbanisation, pluvial flooding, concretization, siltation, sustainable management.

A B S T R A C T

Pluvial flooding in urban areas is a cause of recurrent stress in modern cities. With growing urbanisation, there have been unsustainable land use changes leading to a decline in the infiltration rate and a considerable increase in the surface runoff. In megacities, extensive cementation of natural cover has made periodical inundation by rainwater impossible to manage and Kolkata is no exception. Kolkata, has experienced unplanned expansion and rampant concretization as a result of large scale influx of population, making it prone to pluvial flooding. The problem is aggravated further by the natural sloping pattern of the city. In addition to these, clogging of drainage lines, siltation of the existing canals and shrinkage of the wetlands in the eastern part of the city which act as the repository of Kolkata's storm and sewage water have worsened the scenario. In this study the major streets of North, South and Central Kolkata have been selected where water logging is a major problem during the monsoon months. Qualitative and quantitative methods along with remote sensing and GIS techniques have been used for conducting the research work. Further, measures have also been suggested for a sustainable management of the problem.

Introduction

Urban growth in most of the developing and developed countries of the world has taken place in an unsustainable way, where resources as well as the demand for energy, water, sanitation, public services, health care, and education suffer from excessive pressure (UNDESA, 2013). With increasing influx of population, it has been often found that localities and the supporting infrastructure become too overloaded to cater to the needs of the people. Such trends develop all over the world, when people often settle first, after which associated infrastructure develop. But the opposite is also true where areas are planned first, followed by administrative policies allowing

population to settle. In either of these cases a time comes where unpredictable population increase disrupts the pre-established urban metabolism which in turn proves disastrous to economic and public health sectors. Urban pluvial (surface water) flooding – a flooding phenomenon in urban areas occurs when intense, prolonged rainfall allows surface water to collect in places once the capacity of the drainage system exceeds. This is one of the principal hazards in modern towns and cities (Tucci, 2007). Such flooding results in major economic losses and irreversible social and environmental problems. Thus solving it is a challenge in our towns and cities.

Pluvial flooding is a sudden and localised consequence of rainfall in urban areas due to the high proportion of tarmacked and artificial surfaces, which restrict the process of infiltration and increases surface runoff. Often the wake of urbanization is responsible for altering the natural drainage routes. Further, the growing urban population and degree of urbanisation pressurizes the human laid drainage networks thereby reducing the discharge of the excess water. In the urban areas of the world almost 2 million people living in settlements, housing more than 10,000 people, face a 0.5 per cent ('1-in-200 year') annual probability of facing pluvial flooding. This represents around 5 per cent of the urban population, and around one-third of flood risk from all sources (Donald Houston *et al*. 2011). In this context it has been found that in the period 1994–2004 alone, Asia accounted for one-third of 1562 flood disasters most of which were common in urban zones.

In the world many areas suffer from pluvial flooding. One such example is the town of Rafina in Greece which faces problems with river flooding (Rodríguez, *S.O. et al., n.d.).* As in London, pluvial flooding takes place due to a number of conditions such as the storm surges from the sea, river floods, as well as excessive rainfall in urban areas (Zhou, 2012). Pluvial flooding tendencies further increase here when the flow capacity of storm water drainage systems in and around London gets restricted by the high water levels in the receiving rivers (Risk Management Solutions Incorporated, 2013). Local surface cover and sewer design also affects the overall level of risk. For example, in 2007 the sewer systems of Kingston upon Hull, in London were inundated resulting in the flooding of 6,500 buildings (Risk Management Solutions Incorporated, 2007; Falconer *et al*., 2009). Other than these, Newcastle upon Tyne, Cotting Burn in Morpeth (1982), Berkshire, Northumberland and Durham are places which suffer greatly from sudden flooding in England (Risk Management Solutions, 2013; Archer, Parkin and Fowler, 2014; Archer & Fowler, 2015). In the Northern and Southern Europe and the Atlantic, pluvial flooding is a cause of significant concern, as a result of sea level rise. Developing defences against such situations is not only expensive but a long drawn process, leaving many individuals at risk (Intergovernmental Panel on Climate Change, 2014). Vulnerability in this context, exists in countries such as Malaysia, Netherlands, Denmark, Turkey, France, Belgium, Spain, Portugal, Italy etc, and are heavily burdened by high damage costs due to such pluvial flooding (Campana & Tucci, 2001; Mcleod *et al*., 2010;). Thus sustainable and cheap solutions, in all aspects, are essential in these places.

In the Indian context, states of Assam, Gujarat, Bihar, Odisha, Chhattisgarh, and Uttarakhand witness floods of various intensities during the monsoons. Some semi-arid regions of Rajasthan have also been

affected by 'flood-like situations' because of unpredictable and sudden heavy showers in the region (Patra, 2011). In the Indian megacities situations of both water scarcity in summer and excessive urban flooding in the rainy months, exist simultaneously. Mumbai flood in July 2005 followed by other major cities of South Asia like Dhaka, Islamabad, Rawalpindi also suffer from urban pluvial flooding (Wakodel, 2012; Gupta and Nair, 2011). In Kolkata areas such as Rashbehari, Tollygunge, Kalighat, Shyambazaar, Cornwallis Street, College Street, Dalhousie, Bowbazaar and others are the worst affected areas where pluvial flooding is the norm of the rainy season (Bhattacharya, 1992; Statesman News Service, 2013). Flood waters in Kolkata rise up to knee height. Since about 800 mm of rain is received by 1 square km area, approximately in a year, it is difficult to channelize the flow along these roads. Pluvial flooding in the city is a result of increased concretisation, indiscriminate rubbish dumping clogging the drainage lines, and the natural slope of the city. This greatly affects the transportation systems, the economy in the surrounding areas, as well as public health.

Study Area

The city of Kolkata, and its pluvial condition is controlled by the city's site specific locational attributes and its climate. Situated in a part of the Indo-Gangetic plain, Kolkata rests on the floodplains of the Hooghly River along the eastern and western flanks. In the geological perspective, the city is situated over the 'Bengal basin', a 'pericratonic tertiary basin'. The quaternary sediments consist of clay, silt, and several grades of sand and gravel. These sediments are trapped between two clay beds: the lower one at a depth of 250–650 m (820–2,130 ft); the upper one 10–40 m (30–130 ft) in thickness (Das and Chattopadhyay, 2000). Thus compression by urbanisation has led to compaction of the sediments allowing the development of the city at an average elevation of around 9m from sea-level (NASA, 1999). The city's climate, on the other hand is a majorly tropical wet-and-dry climate with monsoons in the summer. The mean temperature is annually 26.8 °C (80 °F), while the maximum temperatures may often exceed 40 °C (104 °F) during May–June. During the monsoons, i.e., between June and October, it is the Bay of Bengal branch of the south west monsoon which brings the maximum amount of rainfall which is around 306mm in August while the average annual rainfall experienced by the city is almost around 1600 mm. Other than this tenure spells of rainfall often provide the residents with relief during the Nor'westers in the month of April.

Though many areas of Kolkata suffer from severe water logging during the monsoons, this study emphasizes on the major streets of North, South and Central Kolkata, such as Bidhan Sarani (formerly known as Cornwallis Street), Chittaranjan Avenue, Park Street, Suhrawardy Avenue, Syed Amir Ali Street, Amherst Street, Rashbehari Avenue, Camac Street, Cornwallis Street, and Sankar Ghosh Lane. Bidhan Sarani a prime North-South thoroughfare, named after the first Chief Minister of West Bengal, Bidhan Chandra Roy, starts from Shyambazar five-point crossing and extends till Mahatma Gandhi Road, after which the street continues as College Street. Bidhan Sarani includes the areas of Shyambazar, Hatibagan, Hedua, Shimla, Thanthania and College Street. In the northern section of Kolkata, lies Chittaranjan Avenue, Sankar Ghosh Lane, where water logging during the monsoon months is a major problem. Central Avenue

or Chittaranjan Avenue is an arterial road maintaining north-central connection in Kolkata. Sankar Ghosh lane lies across Cornwallis Street and is well known for its location near an age old temple. The area around it is also well known being one of the only places where rescue boats ply as a result of waist high waters during heavy showers. Towards the southern stretch of Kolkata, lies the Rashbehari Avenue (earlier known as Main Sewer Road or Ballygunge Avenue), one of the most prestigious and important avenues of South Kolkata, where the prime shopping and aristocratic residential neighbourhood of south Kolkata exist. To its east, lies the Eastern Metropolitan Bypass and has another continuation which extends ahead of the Flyover and is commonly called the Rashbehari Avenue Connector (Figure 1).

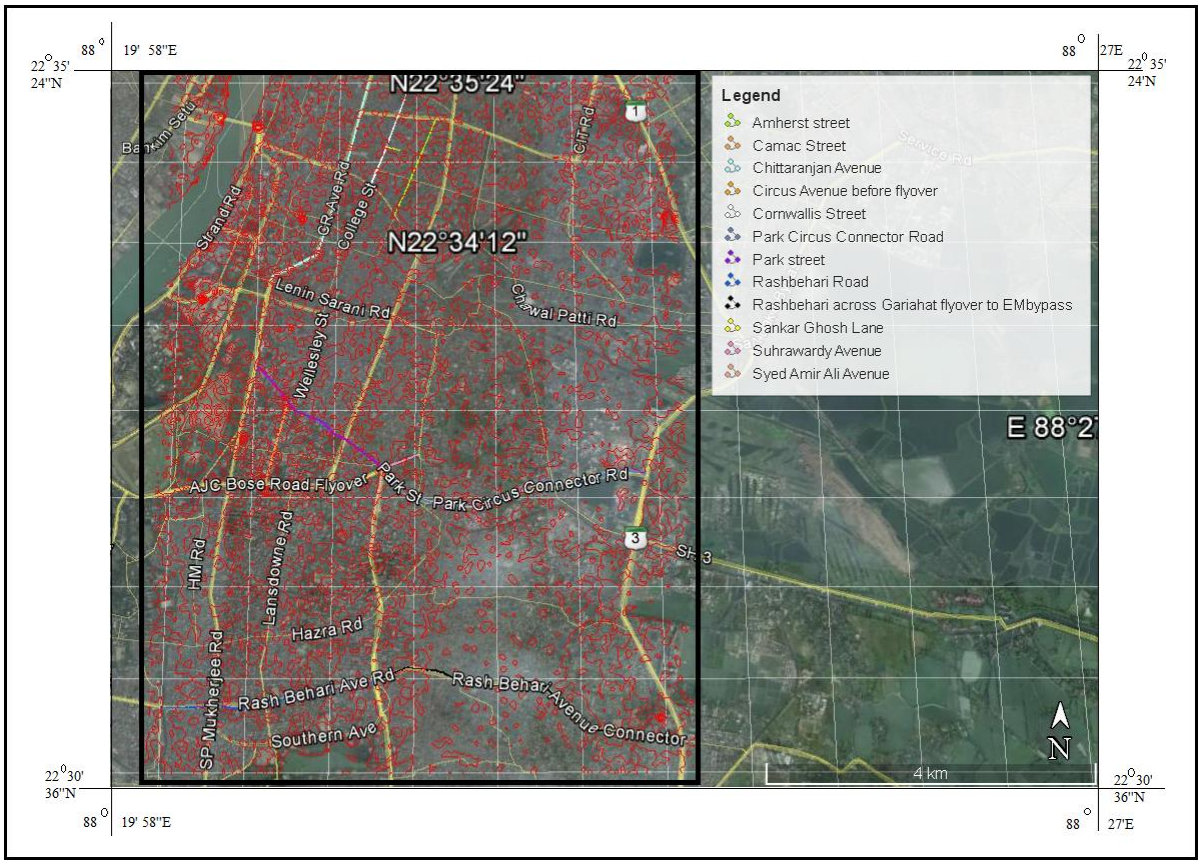

Figure.1 The study area

The above mentioned streets most of which were built during the British era still have old pipe lines having a finite capacity for draining out excess water. As literature suggests, since the past 7 years, these streets and their neighbourhood have been a victim of pluvial flooding during the monsoon months. Once the amount of rainfall increases to about 100 cms, a situation arises where the street begins to allow accumulation of water.

The main objective of this paper is to delineate the most pluvatile regions in North, Central and South Kolkata, frequencies of pluvial flooding in the area, outline the natural slope of the land which aggravates water logging and lastly to suggest measures for sustainable management of the problem of water logging in the city.

The Pluvial nature of the streets in Kolkata have been studied on the basis of two main methodologies, one being qualitative and the other being quantitative in nature. The Qualitative materials such as news paper articles, and online articles from journals, have been processed with the help of Nvivo 11 software, at different levels. The Quantitative part, on the other hand, including the analysis of spatio-temporal data in satellite images have been analysed with the help of Qgis, Surfer 11, TCX Converter, and ARC GIS 10.2.2 softwares. Therefore, the methodology has been subdivided into delineation of the study area, done with the help of Google Earth, and Arc GIS softwares; measuring the frequency of flooding using Nvivo 11; and the general slope of the region.

Delineation of the study area

The streets under study, such as Chittaranjan Avenue, Park Street, Suhrawardy Avenue, Syed Amir Ali Avenue, Amherst Street, Rashbehari Avenue, Camac Street, Cornwallis Street, Sankar Ghosh Lane are the most important streets of Kolkata. These roads span across the northern and southern sections of Kolkata and are most vulnerable to flooding tendencies. So to demarcate this stretch of land, Google Earth was used to digitise the length of the roads into a kml file. It was then saved as a snapshot and contours superimposed upon it to provide a clear perspective about the locale around the study area.

Measuring the frequency of flooding and its temporal scale

To understand the rate of flooding and its impact, a study was conducted where all the essential material or literature data was analysed with the help of the Nvivo 11 software where the frequency of flooding, the main causal agents and its associated consequences were extracted. For this purpose the literature data was imported and the recurrence of terms related to pluvial flooding was recorded. This helped to develop separate charts so as to get an idea about the primary agents causing pluvial flooding, and the months associated with such flooding tendencies.

The natural slope of the region aggravating flooding tendencies

Although newspaper articles, online articles from journals and other literature data particularly emphasize on the urban bottlenecks such as insufficient infrastructure, indiscriminate waste dumping, silting of the drainage systems etc., the slope of the land being a cause of flooding has never been realised. For this purpose elevation data from Google Earth as well as SRTM images from the earth explorer website have been taken. The first source, i.e., the kml file was converted with the help of TCX converter. The end product was then imported with the help of the Surfer software so as to develop a wireframe impression of the streets. To establish this further, a contour map of the region was developed to create a profile of the landscape. This would predict whether or not pluvial flooding is a result of the natural morphology of the concerned area. Other than this method the streets have been superimposed as a vector layer on the contours developed at an interval of 6m in Arc Gis10.2.2. This was done to predict that over time pluvial conditions have intensified due to the morphology of the roads and its surroundings, and not just indiscriminate waste dumping or infrastructural faults.

Result and Discussion

The various Qualitative and Quantitative data and its analysis developed on the basis of the methodology adopted have led to

conclusive results. These have been analysed to get a firm understanding as to what leads to flooding in this region. Thus it has been studied in phases, one being the degree of flooding and rainfall occurrence and underlying natural morphological assumptions.

Flooding intensity and rainfall occurrence

Flooding intensity in Kolkata has been a recurrent phenomenon as the data reveals. Analysed with the help of Nvivo11 software, it was found that the flooding intensities increase in the month of June, and is more frequent till the mid of the same month (Figure 2).

At this time areas along Cornwallis Street get knee deep water every year causing transport bottle necks everytime it rains. Sankar Ghosh Lane and Thanthania areas experience waist deep water, whereas Rashbehari Chittaranjan avenue, Suhrawardy avenue and others get knee deep water affecting transport and communication. But almost in 70 per cent of the occurrences, there has been torrential rainfall along with an annual amount of 800 to 1000mm. These flooding intensities increase twofold when dirt and waste matter accumulate along the mouth of the drains. This is what has been put forward with the help of the cartograms represented in Nvivo. According to newspapers and the administrative officials, the main causal agents have been silting of the old drains &sewer blockades which are in need of intense clearing (Figure 3). This is followed by problems of garbage dumping clogging the drains, brick sewers, lack of maintenance, drain channel constriction and collapsing problems, excessive rainfall, problem of old pipelines, administrative delays, fund crunches, outdated designs, power failures, pumping problems, slackness of labourers, road pits, and setbacks in JNNURM projects.

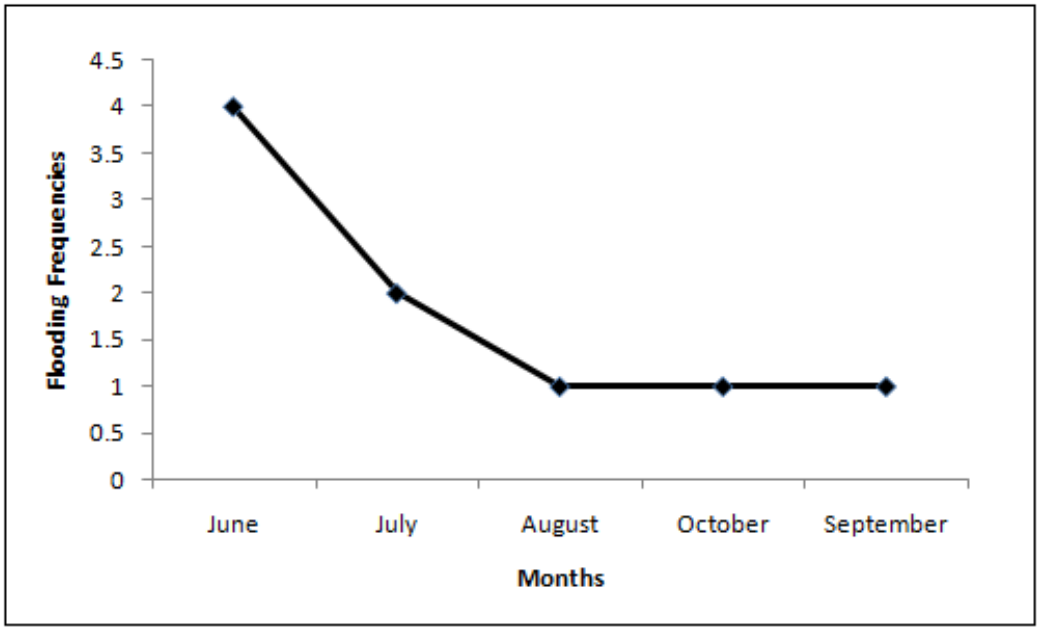

Figure.2 Annual recurrence of pluvial flooding

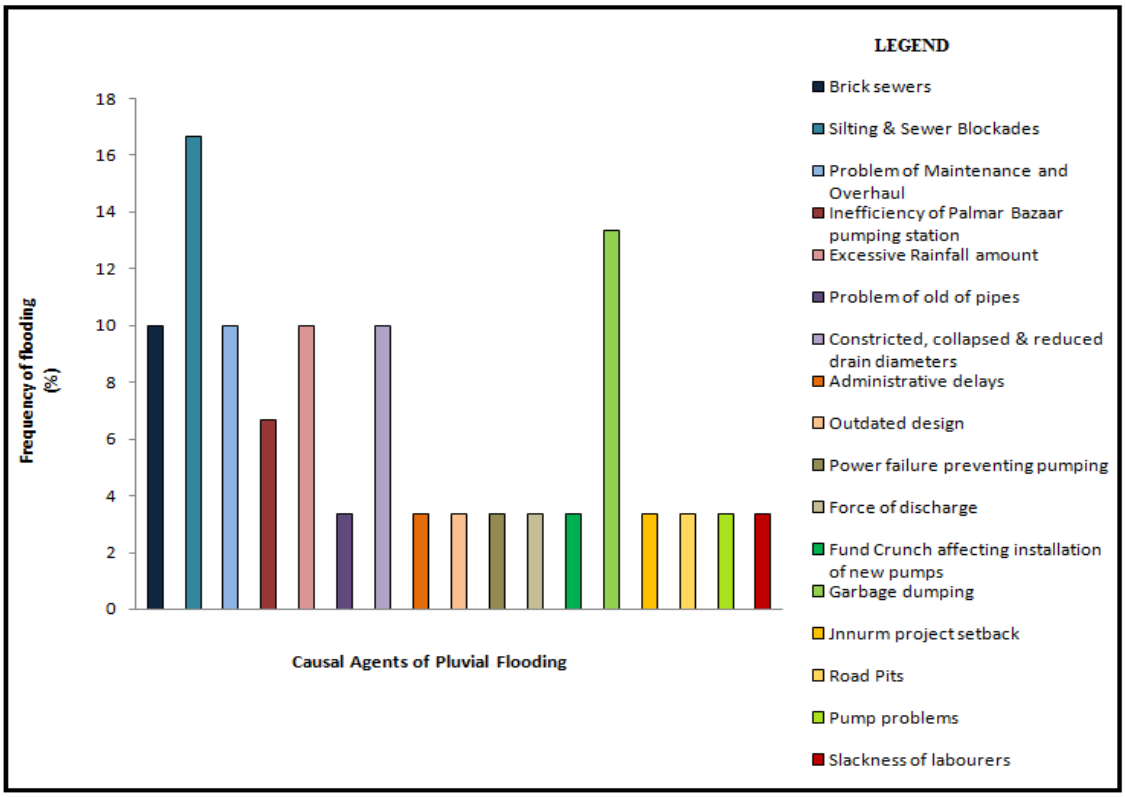

Figure.3 Prime agents causing water logging

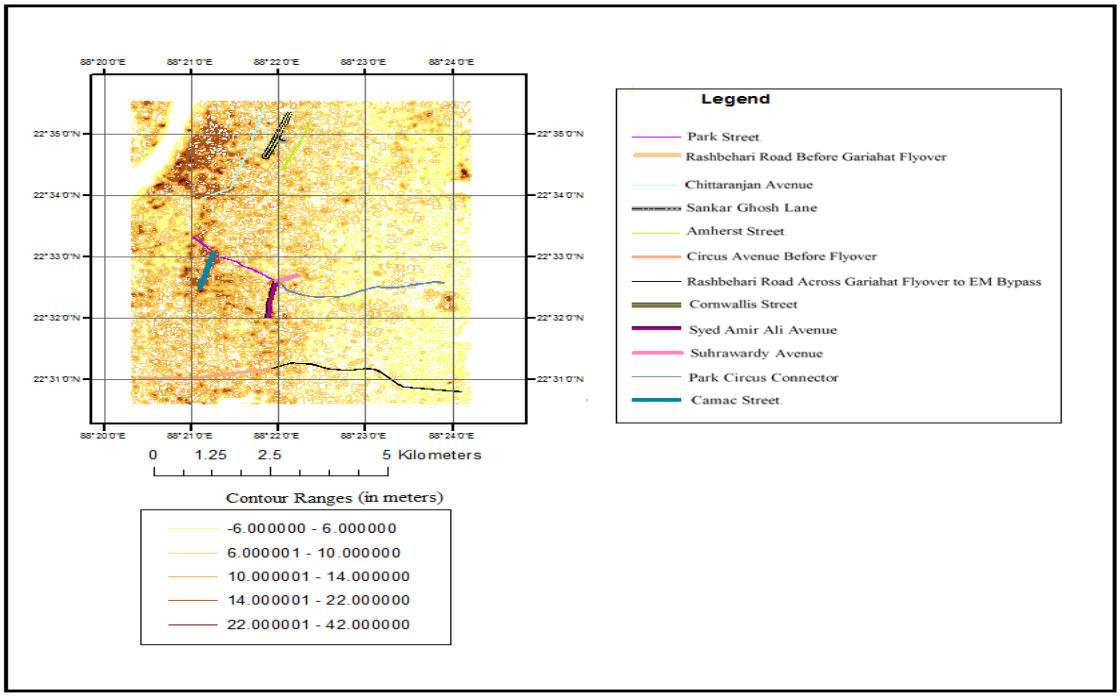

Figure.4 Contour Plan of study area, and the concerned roads

Therefore, this shows that this area needs immediate redressal. Proper mechanical clearing, silt stone removal, garbage clearance, adequate channel diameter is essential for diverting the flow and allow fast clearance of flood waters.

Slope of the city and its streets

Chittaranjan Avenue, Park Street, Suhrawardy Avenue, Syed Amir Ali Street, Amherst street, Rashbehari Avenue, Camac Street, Cornwallis street, Sankar Ghosh Lane, as the analysis suggests are all endowed with undulations. According to the contour maps, the profile of Kolkata has a general slope from west to east, with certain abrupt changes along the surface. This has been shown in the following figure where the streets of Kolkata have also been super imposed (Figure 4).

Such abrupt undulations allow sudden pluvial flooding. As soon as the rain water flows along these streets, the water flows into these so called depressions. Since the drains along these roads are along the sides of the roads, the accumulated water along their midsections do not get the adequate slope to trickle out as the roads have not been built in a ridge like fashion. This has been presented in the following images (Figures 5 to 14).

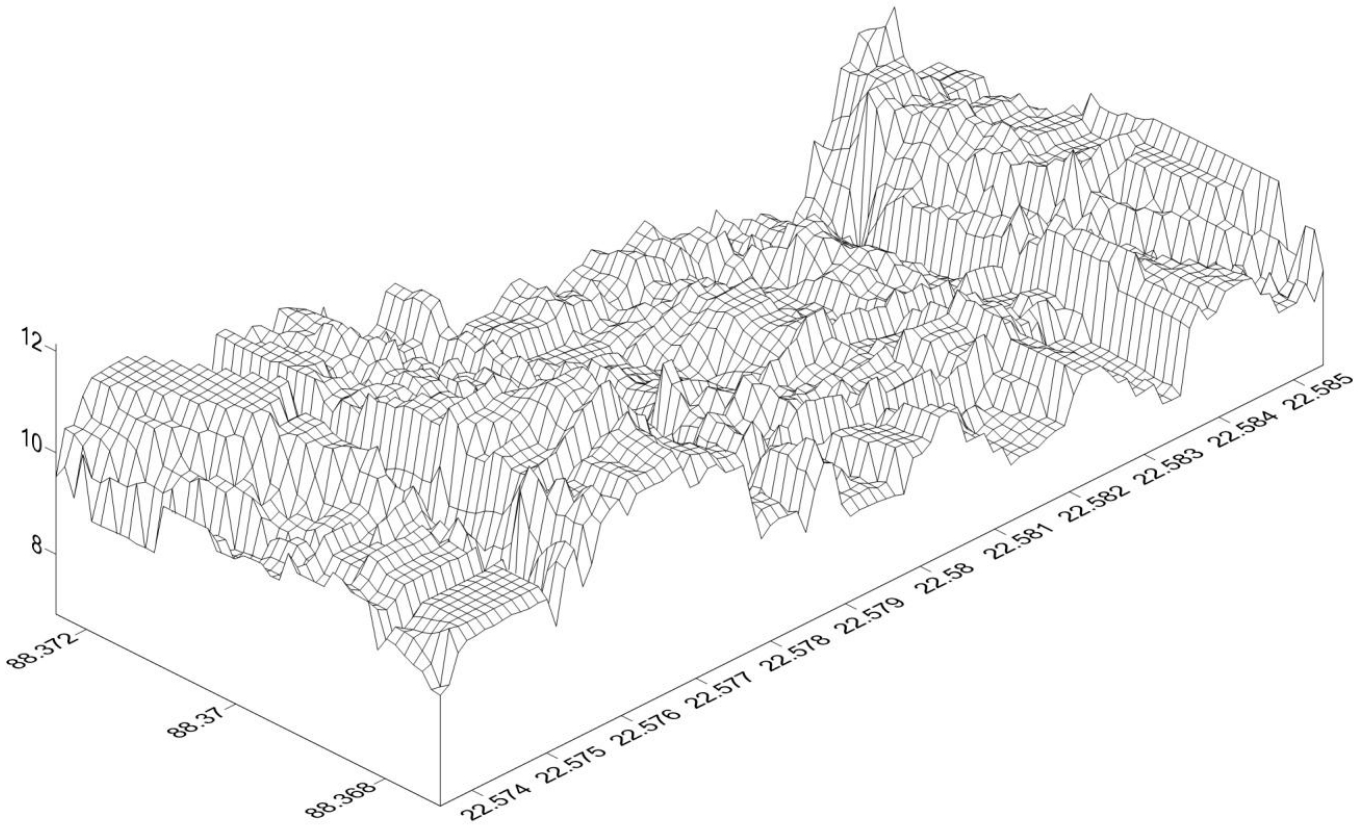

Figure.5 Profile of Amherst Street

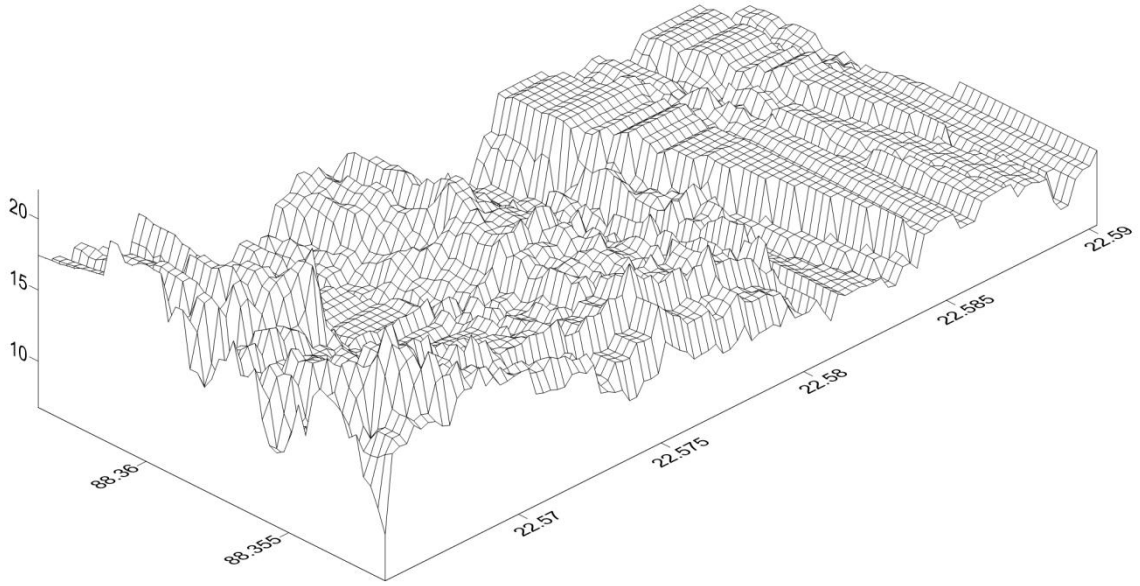

Figure6 Profile of Chittaranjan Avenue

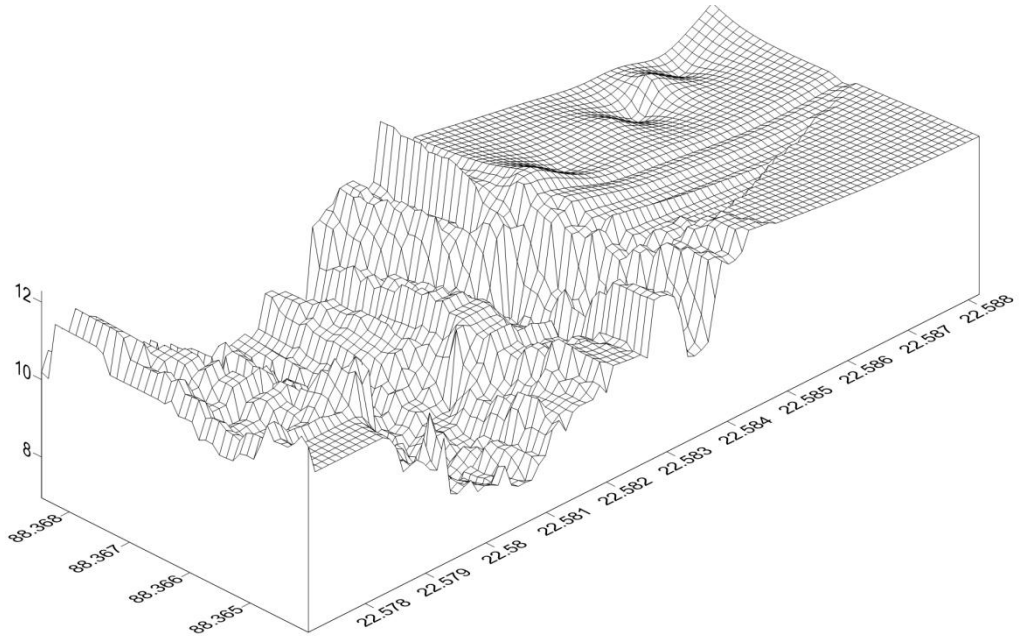

Figure.7 Profile of Cornwallis Street

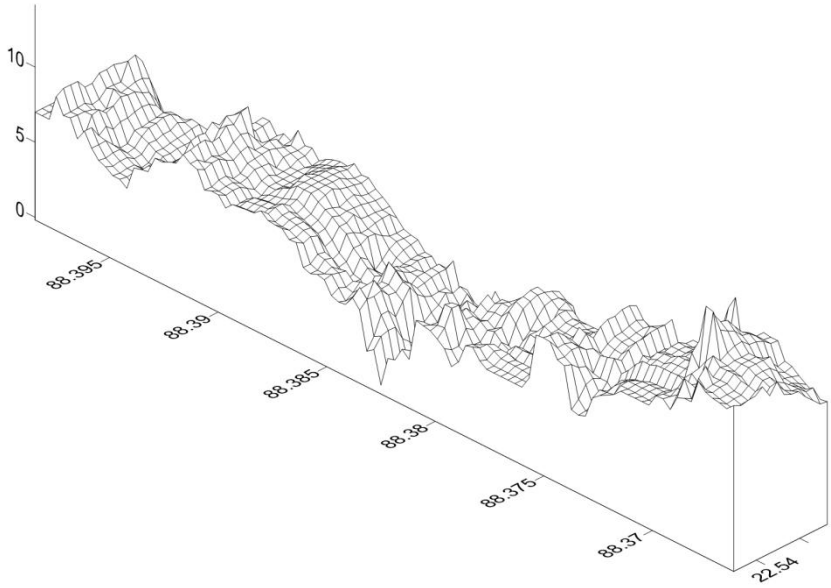

Figure.8 Profile of Park Circus Connector

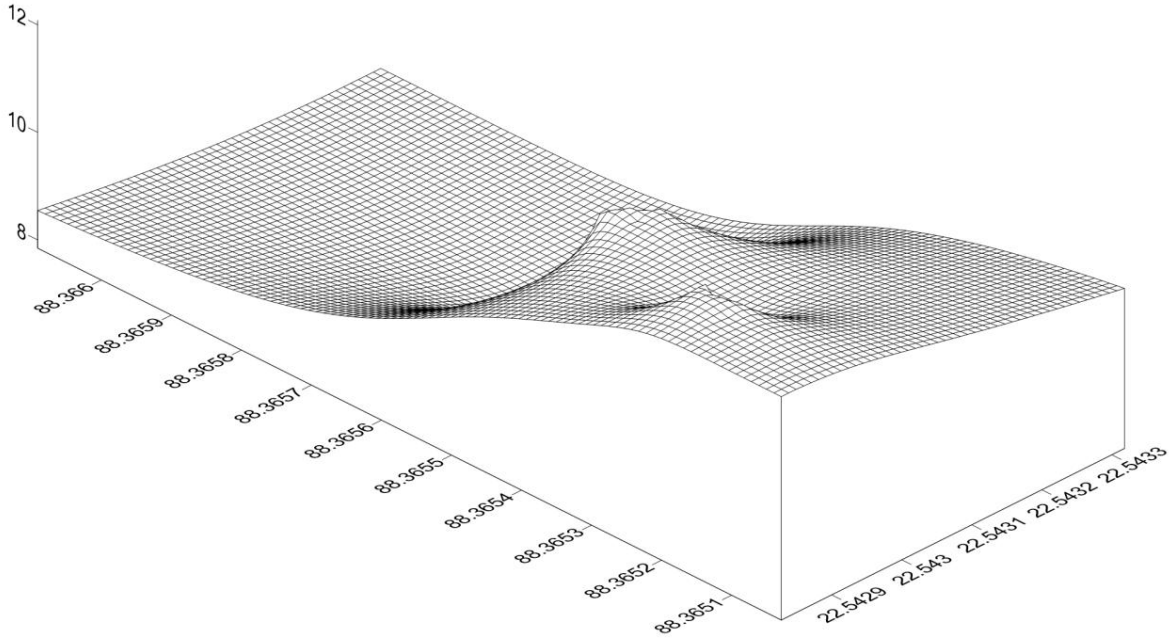

Figure.9 Profile of Circus Avenue Before Flyover

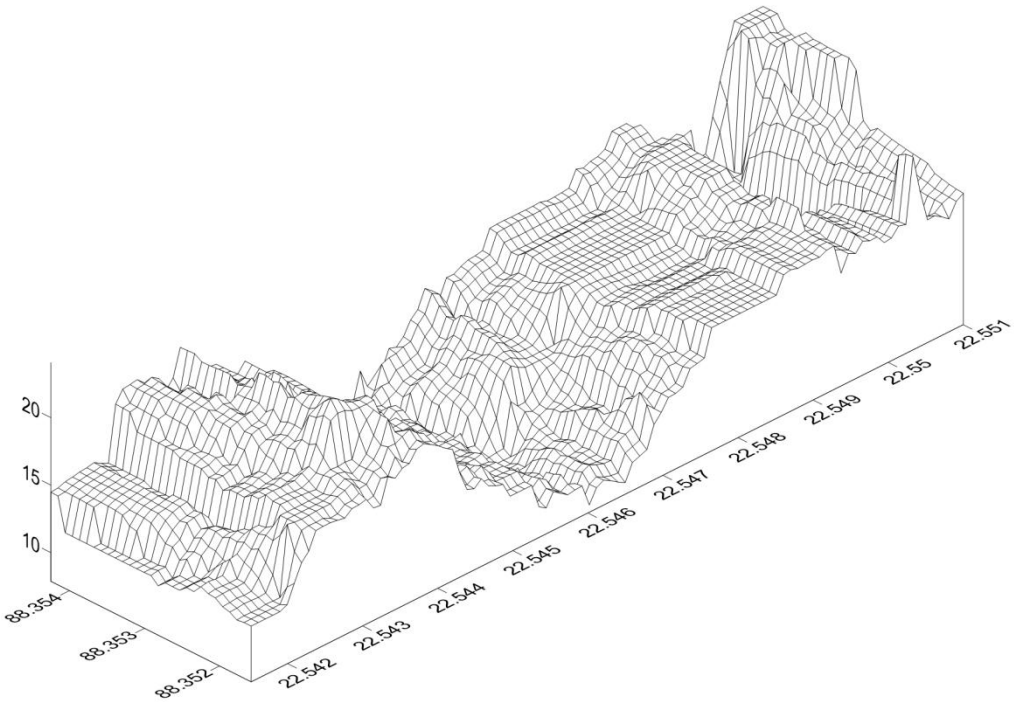

Figure.10 Profile of Camac Street

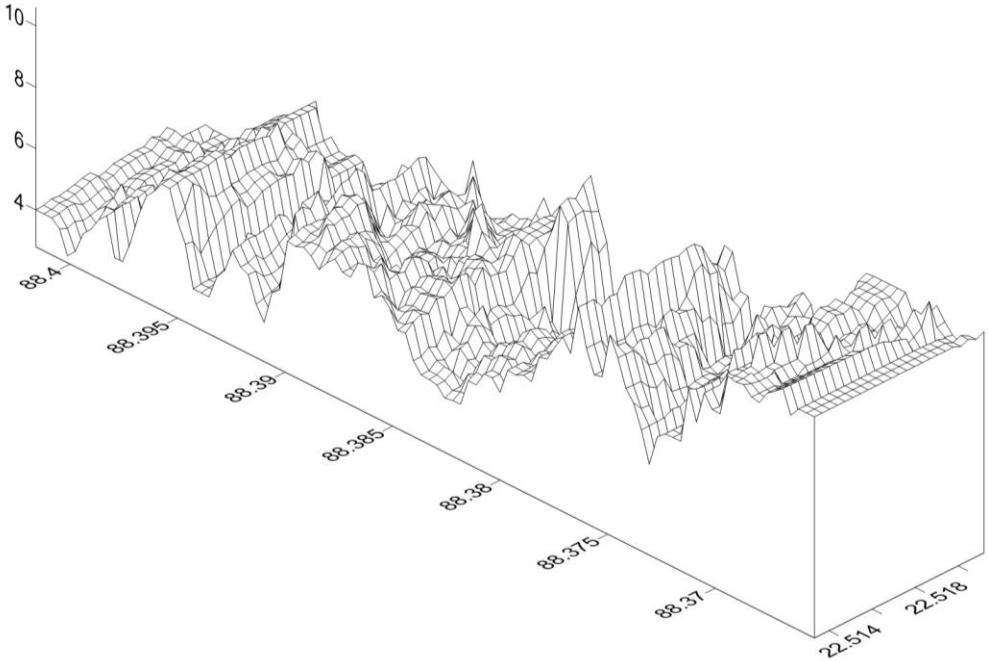

Figure.11 Profile of Rashbehari Road beyond Gariahat Flyover

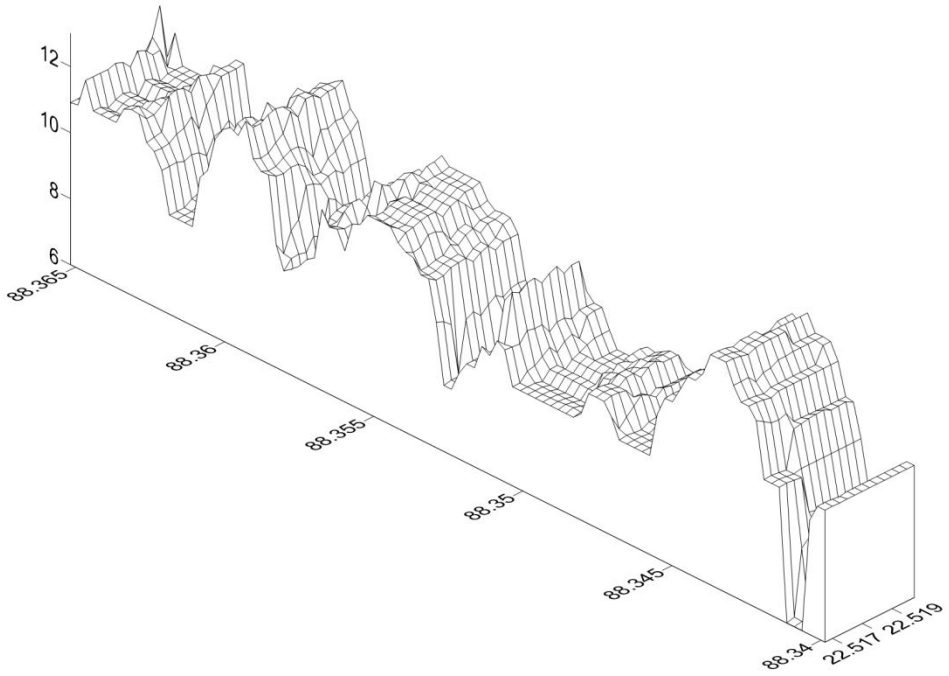

Figure.12 Profile of Rashbehari Avenue before Gariahat Flyover

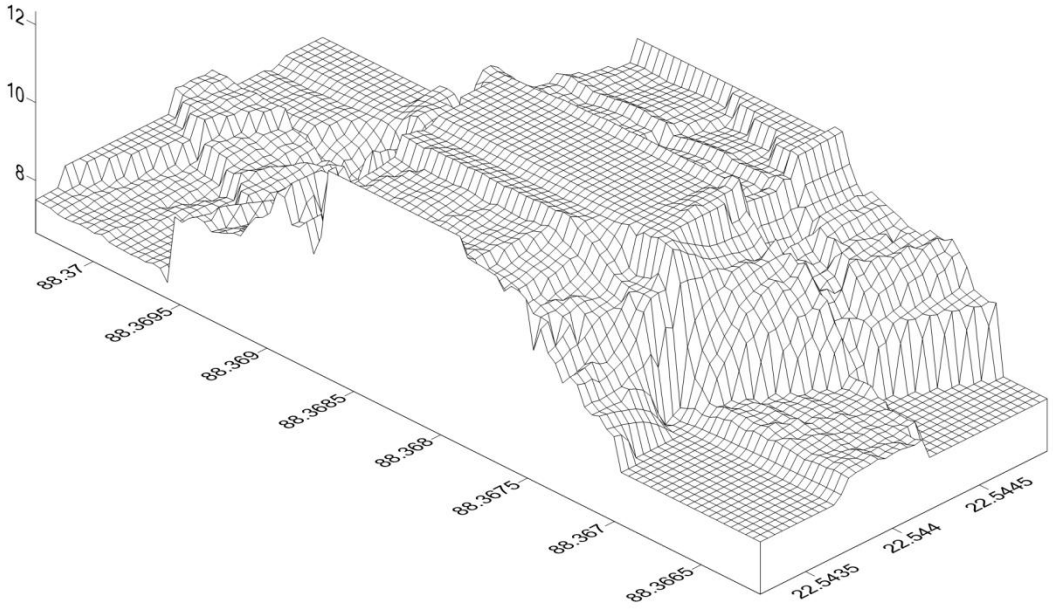

Figure.13 Profile of Suhrawardy Avenue

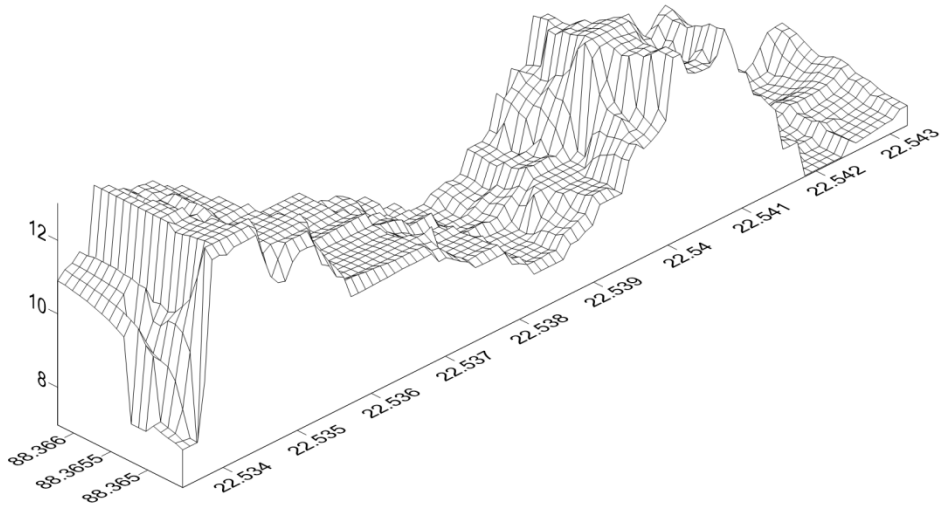

Figure.14 Profile of Syed Amir Ali Avenue

The preceeding figures depict the nature of the road profiles found along the major streets of North and Central Kolkata. As evident in Figures 7, 14 and 8, Cornwallis Street, Syed Amir Ali Avenue, Park Circus Connector the streets represent perfect U shaped profiles providing adequate proof that the area aggravates excessive interception storage along the road profile. In most of the streets elevations range between 15 to 25m from sea level, indicating the uneven profile of the roads. A notable feature exists along Suhrawardy Avenue. Here as the profile indicates, the problem of water logging will remain a persistent phenomenon, along either side of the road, unless the road structure is altered soon. This is because the mid section is elevated while the rest of the stretch is at a much lower elevation. Therefore to clear the water logging the lids of the manholes have to be removed, which is quite risky as people might fall into them.

Conclusion

Water logging or in other words pluvial flooding, is a problem in any urban landscape. It hinders the urban metabolism. Since urbanisation brings with itself the development of artificial land cover, water logging becomes a common phenomenon, as infiltration is not allowed by metalled surfaces. Kolkata, one of the oldest developed megacities of the world, faces the same problem. Major areas of thoroughfare such as the streets of northern, central and southern Kolkata such as Central Avenue, Park Street, Rashbehari, Suhrawardy Avenue, Syed Amir Ali Avenue etc., are the worst affected areas within the city (Kolkata Metropolitan Corporation, 2014). Although the administrative authorities believe that water logging occurs due to siltation of the drainage pipelines, failure of pumps, the urban areas suffer from pluvial flooding also due to their morphological arrangement, which is the main subject of discussion in this paper. As has been discussed the structure of the roads and the adjacent placement of the drains is not in tune. People further aggravate the situation by clogging the mouth of drains by dumping rubbish. For proper management of the existing problem, certain measures may be adopted such as, changing the road structure

into a ridge like pattern where water slopes down from the mid sections to the mouth of the drain at the sides, proper cleaning of the pipes and its dredging, developing underground reservoirs to aid rainwater harvesting systems at various institutional and household levels. Beside these, further shrinkage of the East Kolkata Wetlands which act as the repository of Kolkata's rain and sewage water should be stopped and conserved. All these may provide a better management of the problem of pluvial flooding discussed above.

References

Archer, D., Fowler, H. 2015. Characterising flash flood response to intense rainfall and impacts using historical information and gauged data in Britain. *J. Flood Risk Management*.

Archer, D., Parkin, G., Fowler, H. 2014. Assessing risks of flash flooding using historical information – three examples from northeast England. http://www.birmingham.ac.uk/Documents/college-les/gees/conferences/BHS2014/Session2(2)/Assessing%20risks%20of%20flash%20flooding%20using%20historical%20information%20three%20examples%20from%20northeast%20England.pdf

Bhattacharya, A. 1992. Waterlogging and Issues Relating to Drainage in Calcutta Metropolitan District. Discussion Paper No. 2. Center for Urban Economic Studies, Department of Economics, Calcutta University. http://www.caluniv.ac.in/academic/cues_urban/DP%202%20June%201992.pdf

Campana, N.A., Tucci, C.E. 2001. Predicting floods from urban development scenarios: case study of the Dilúvio Basin, Porto Alegre, Brazil. *Urban water, 3*(1): 113-124.

Das, D., Chattopadhyay, B. 2000. Characterization Of Soil Over Kolkata Municipal Area.

Douglas, I., Garvin, S., Lawson, N., Richards, J., Tippett, J., White, I. 2010. Urban pluvial flooding: a qualitative case study of cause, effect and nonstructural mitigation. *J. Flood Risk Management, 3*(2): 112-125.

Falconer, R., Cobby, D., Smyth, P., Astle, G., Dent, J., Golding, B. 2009. Pluvial flooding: new approaches in flood warning, mapping and risk management. *J. Flood Risk Management, 2*(3): 198-208.

Gupta, A.K., Nair, S.S. 2011. Urban floods in Bangalore and Chennai: risk management challenges and lessons for sustainable urban ecology. *Curr. Sci.(Bangalore), 100*(11): 1638-1645.

Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*: Cambridge University Press.

Kolkata Municipal Corporation. 2014. Action Plan To Mitigate Flood, Cyclone & Water Logging. http://wbdmd.gov.in/writereaddata/uploaded/DP/KMC%20DM%20Plan%202014.pdf

Mcleod, E., Hinkel, J., Vafeidis, A.T., Nicholls, R.J., Harvey, N., Salm, R. 2010. Sea-level rise vulnerability in the countries of the Coral Triangle. *Sustainability Sci., 5*(2): 207-222.

NASA. 1999. PIA01844: Space radar image of Calcutta, West Bengal, India. Photojournal. Retrieved on: 15th January 2012. Accessed from: http://photojournal.jpl.nasa.gov/catalog/PIA01844

Patra, J. 2011. Climate and Development Knowledge Network, OPINION: Time to 'follow' the floods in India. http://cdkn.org/2014/10/opinion-time-to-follow-the-floods-in-india/

Risk Management Solutions. 2007. 1947 U.K. River Floods: 60-year Retrospective. Retrieved on: 4th April 2016. Accessed from: http://forms2.rms.com/rs/729-DJX-565/images/fl_2007_uk_summer_floods.pdf

Risk Management Solutions. 2013. The 2012 U.K. Floods. Retrieved on: 4th April 2016. Accessed from:http://forms2.rms.com/rs/729-DJX-565/images/fl_2012_uk_summer_floods.pdf

Rodríguez, S.O., Smith, K.M., Maria Aivazoglou, M., Pina, R., Mijic, A. 2012. Urban pluvial flooding and climate change: London (UK), Rafina (Greece) and Coimbra (Portugal). *Susdrain*, Floods in urban areas.

Tucci, C.E. 2007. Urban flood management. *WMO and Capnet*.

Wakode, H. 2012. Monsoon and Urban Flooding in Indian Megacities. Urbanisation and Water. Retrieved on: 8th April 2016. Accessed from: http://www.waterandmegacities.org/monsoon-and-indian-megacities/

Zhou, Q., Mikkelsen, P.S., Halsnæs, K., Arnbjerg-Nielsen, K. 2012. Framework for economic pluvial flood risk assessment considering climate change effects and adaptation benefits. *J. Hydrol.*, 414: 539-549.

How to cite this article:

Deblina Mitra and Suranjana Banerji. 2016. Pluvial Flooding in Kolkata: A Case Study of the Major Streets in Northern, Southern and Central Kolkata. *Int.J.Curr.Res.Aca.Rev.*4(5): 51-65. doi: http://dx.doi.org/10.20546/ijcrar.2016.405.007