Analysis:

1. Biophysical Modelling

The megacity of Kolkata is located on the east bank of river Hooghly, at the tail end of river Ganga, approximately 180 km away from Bay of Bengal, with an average elevation of 9 meters above mean sea level.

As a first step towards understanding climate change effects, rainfall data for Kolkata was obtained from Indian Meteorological Department (IMD). The sixty-year long term data (1949-2009) was grouped into two subsets (1949-1969 and 1969-2009). Figure 2, shows the increasing long term average rainfall on the one hand and increasing variability on the other, based on the assessment of two long term periods. The preliminary analysis indicates the increasing vulnerability in terms of extreme weather events and also exposure to risk factors.

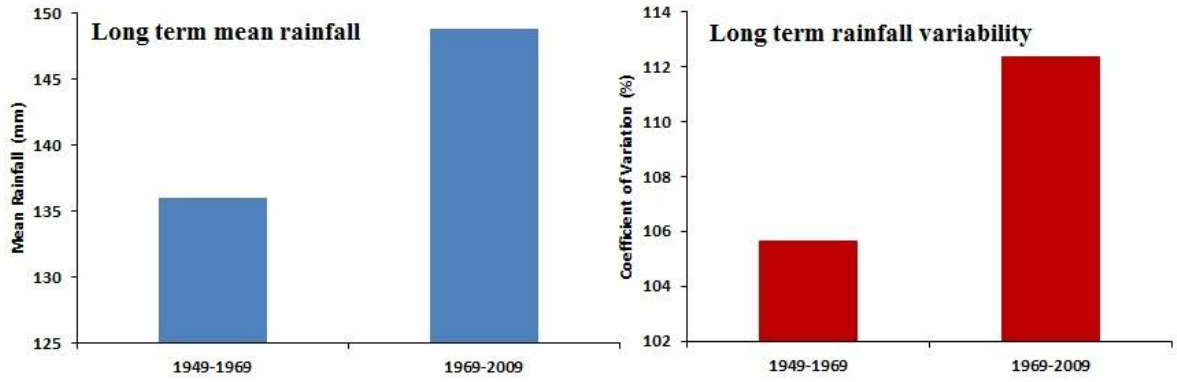
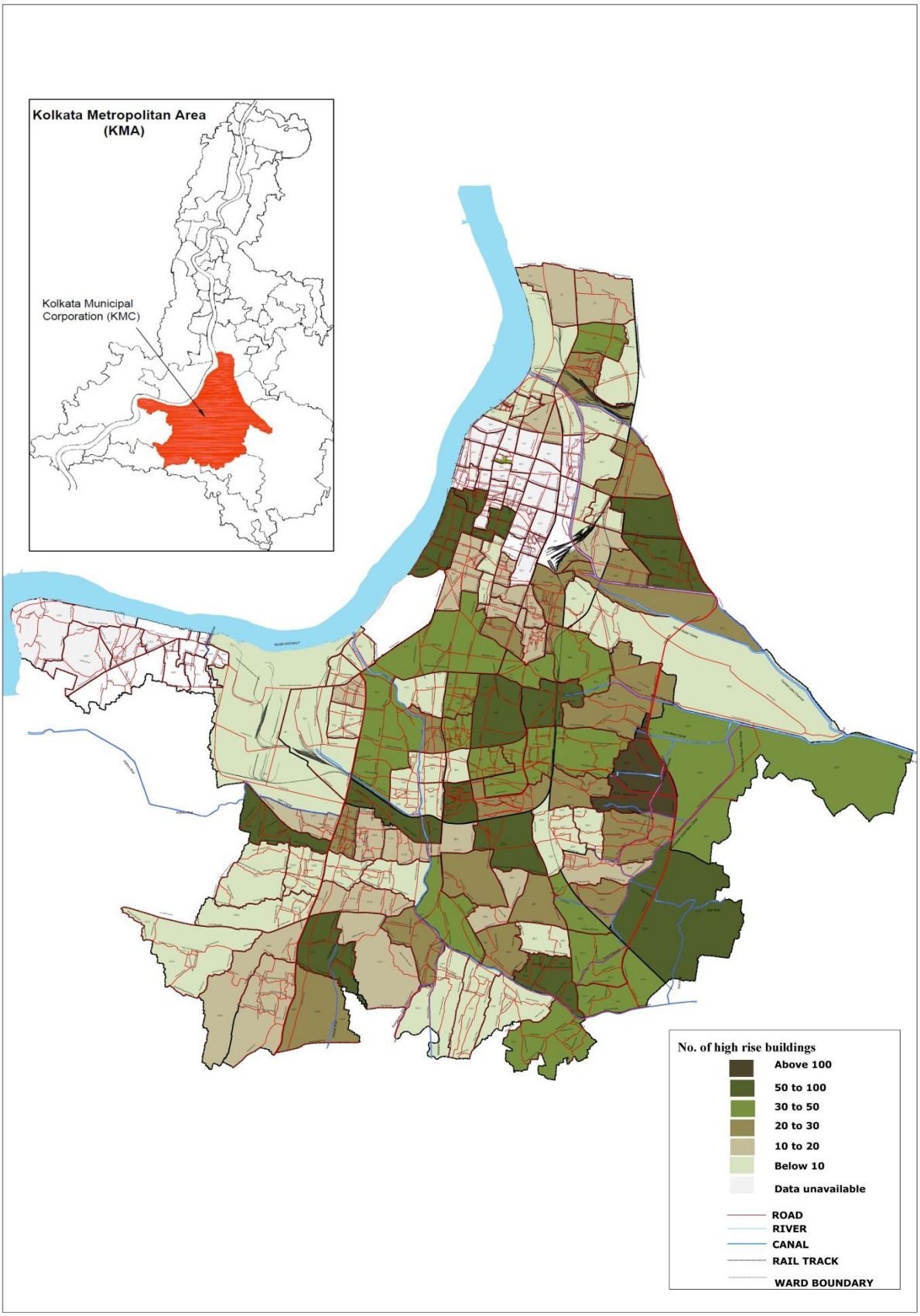


Figure 2a: Represents long term monthly mean rainfall for Kolkata, **2b**: represents long term rainfall variability [Source: www.imd.gov]

The Land surface details of Kolkata city, like the rivers, canals, and infrastructures (roads, railways) that can provide barriers or channels for flood water, and also morphology of the city such as conglomeration of high raise buildings is shown in Figure 3.



(Data Sources: KMC, and Applying GIS to Urban Issues in Kolkata by G. Tapas)

Figure 3: Land surface details of Kolkata city

2. Flood Modelling

Threat of coastal vulnerability due to flooding is very high in the low-lying areas of Kolkata city. The meteorological, tidal conditions and coastal defence systems are process drivers for proper assessment of coastal flood risk of the city. Based on a study by World Bank (2010), 9 wards out of 141 wards of the Kolkata city are highly vulnerable to flooding. These are vulnerable because of inadequate infrastructure, unplanned land use, and poor socioeconomic and environmental conditions. There are a few other wards which are highly vulnerable due to their topography.

The importance of a suitable numerical model that performs reasonably well during flood is therefore an essential pre-requisite to evaluate the extent of coastal inundation. It can be a recommended tool for early warning to low lying areas guiding evacuation and rescue operations.

Hydrological scenario

Hooghly river experiences a rare and remarkable example of fluvial phenomena known as "tide bore", where the tide runs rapidly into the river. The tidal characteristic is semi-diurnal in nature with the neap and springvariations ranging from 2.0–5.0m. It receives its major share of freshwater flows from the Ganges through the river Bhagirathi. The tidal and wave action influence is very strong along the Hooghly River.

The water level variation is very high (about 2.5 m) during flood tide and low (about -2.2 m) during ebb tide in the Hooghly River. The wind induced water level variation varies between 0.34 m to -0.5 m along the Hooghly River. Similarly strong currents observe in Hooghly River basin due to tidal forcing. The tidal currents vary in between 0.5 to 2.5 m/sec and 0.2 to 1.6 m/sec during flood and ebb phase of tide respectively. The wind induced currents also play prominent role during flood scenarios and vary in between 0.2 m/sec to 0.5 m/sec. The combined effect of tide, wind and wave action in the symmetric phase increase the risk of flooding on the low lying area of the city. Therefore, evaluation of coastal flood risk is a key requirement in hazard management and planning.

Topographic scenario

The land elevation of Kolkata Metropolitan Area (KMA) ranges from1.5 to 11 meters above mean sea level (msl). Whereas, the elevationof Kolkata Municipality (KMC) area ranges from 1.5 to 9 msl with an average of 6 msl. The terrain elevation extracted from SRTM

topographic data sets (limitation with an error of ±30 m) for the Kolkata city is shown in Figure 4.

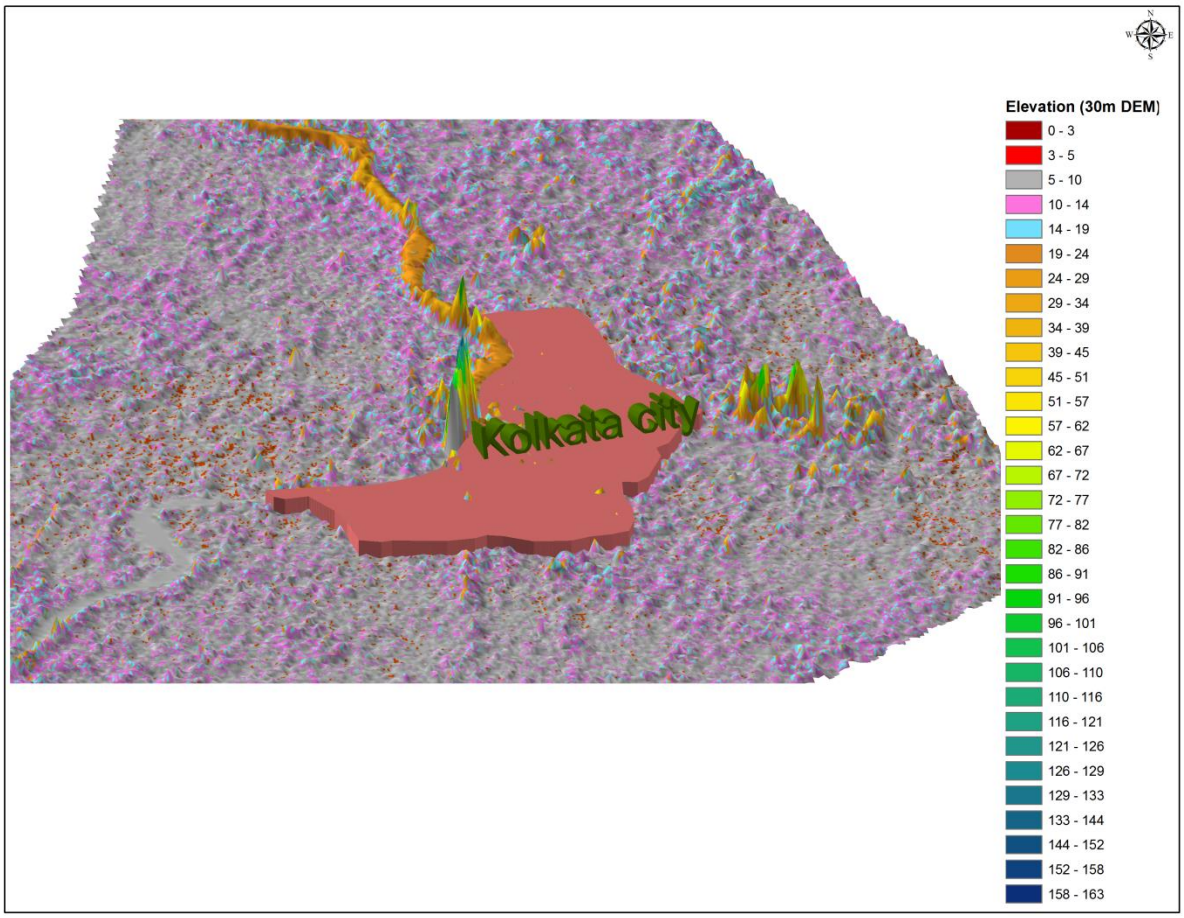


Figure 4: Terrain elevation of Kolkata city from SRTM topographic datasets