Spatiotemporal Data Analysis for Flood Risk Assessment in NCR India

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Abstract: **The aim of this study is to develop a consistent method to determine the areas which are vulnerable to floods occurring in Gurgaon Haryana region. Floods are results of climate change and heavy rains which are more prevalent in spring-summer season. In recent years there were many notable events due to floods. We are developing a methodology due to which we will be able to predict upcoming floods in near future for the region which will lead to better preparations for disasters conditions. We can identify regions which will be vulnerable to floods using hydrologic analysis but they require highly accurate date (land cover, temperature, vegetation, rainfall data, and discharge data) which is difficult to obtain. But it could be prepared by preforming spatial analysis in software like QGIS, SAGA and the results are useful to be applied on the test areas.**

Keywords: **Flood vulnerability, spatial analysis, SAGA**

I. INTRODUCTION

The importance of flood modelling is increased over the past few years because of abrupt climate changes over the time. The global hydrological cycle comes out to be intensified and shows that there's an increase in precipitation globally. With this type of information one can easily predict that the instance of flood will be more often in future. Since the cities in India are generally unplanned and consists of impervious surfaces, they are more prone to these floods (Hapuarachchi et al., 2011. Hapuarachchi, P. and Wang, C. J., 2008). Hence it is necessary to study risk management occurred by these floods which will help us to prepare for flood risk management. GIS helps us in simulating floods of a particular catchment area. We can identify regions which will be vulnerable to floods using hydrologic analysis but they require highly accurate date (land cover, temperature, vegetation, rainfall data, and discharge data) which is difficult to obtain as they are not available to public. But it could be prepared by preforming spatial analysis in software like QGIS, SAGA (QGIS 2012, Olaya 2004) and the results are useful to be applied on the test areas.

II. DATA

Temporal Analysis

To start with flood modelling, we first started with yearly average and seasonal average rainfall which helped us in understanding the trend of rainfall in Gurgaon region. Then we found out moving mean so as to remove fluctuations and discrepancy in data. We also analysed the return period of rainfall so as to get an idea about amount of rainfall expected in future. Further we conducted analysis on evapotranspiration and infiltration, subtracting which will leads to the amount left for runoff. Table 1 shown below data used in this study and with their sources.

Table 1 *Data used and sources*

Data type	**Sources**
Hydrometerological data (e.g. Rainfall, temperature)	India.gov.in
Digital Elevation Map	bhuvan.nrsc.gov.in

A. Precipitation: The precipitation data used in this work varied from year 1981-2010. Since the data period is substantially large, more accurate estimates of return periods were obtained. Monthly data over the period was plotted in figure 1 to get an overview of quarters that received the maximum rainfall which help in flood preparedness.

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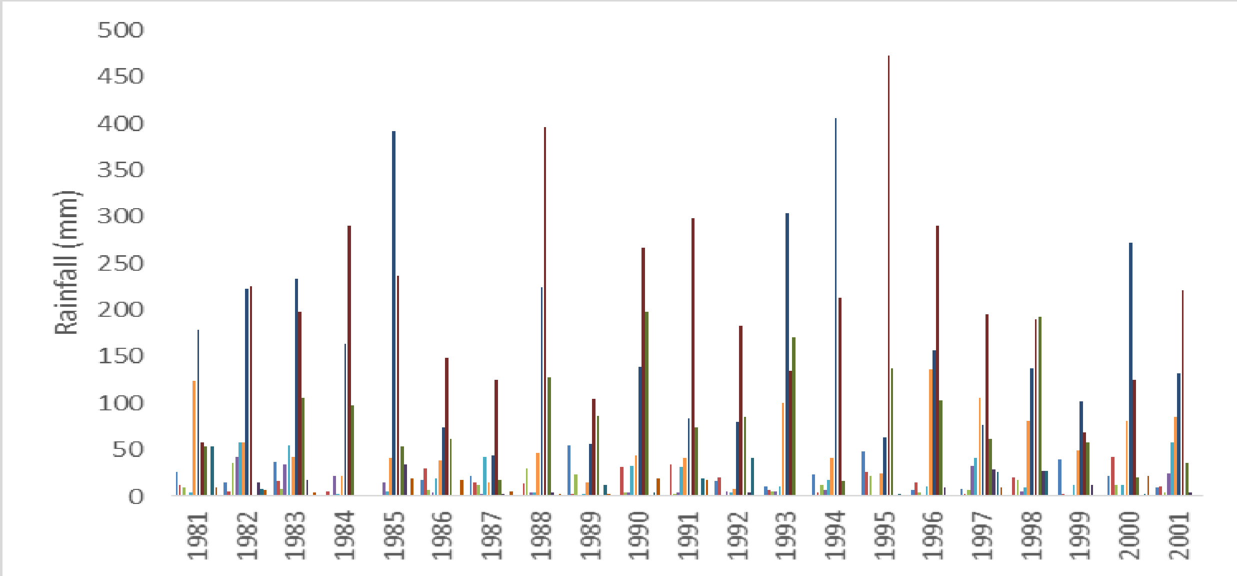

Figure 1. Rainfall distribution over the period

We calculated return period (figure 2) as to find out the probability of reoccurring of an event. Finding out return period helped in estimating amount of rainfall to be expected in upcoming years.

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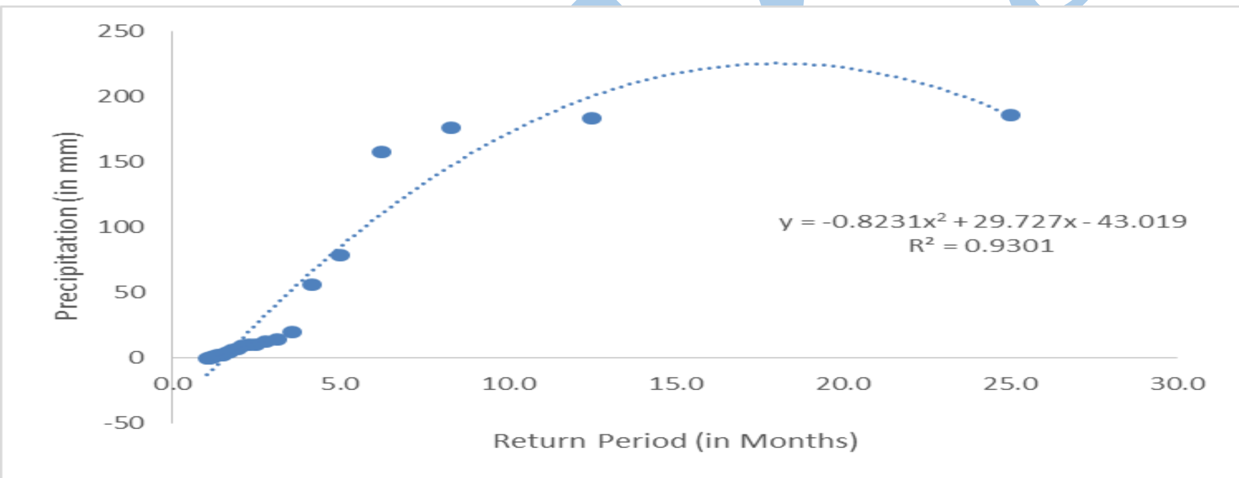


Figure 2. Monthly **r**ainfall return period

B. Estimating Evapotranspiration: Evapotranspiration (ET) is the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere (figure 3). Evapotranspiration helps in finding out what amount of water percent is evaporated which helps us in finding runoff of the area. We used following equation to find PET values over an year (Shukla, A. and Rajsi K., 2015).

$$PET = 16\left(\frac{L}{12}\right)\left(\frac{N}{30}\right)\left(\frac{10\,T_a}{I}\right)^{\alpha} \quad [1]$$

where PET is the estimated potential evaporation (mm/month)

T_a is the average daily temperature

N is the number of days in the month being calcukated

L is the average day length (hours) of the month being calculated

I is heat Index

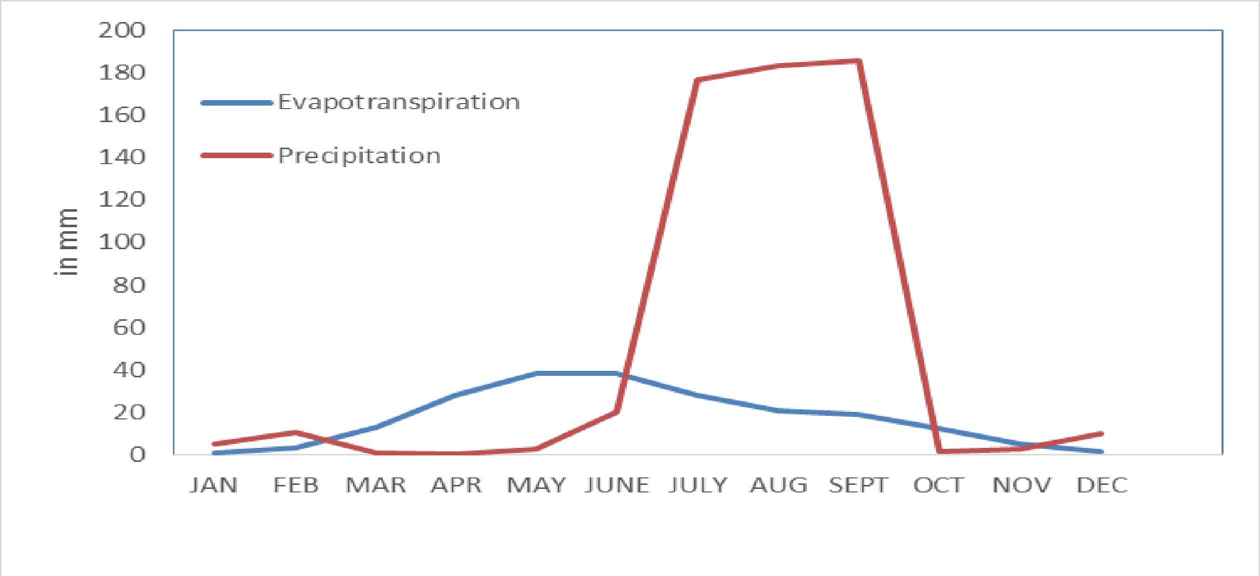
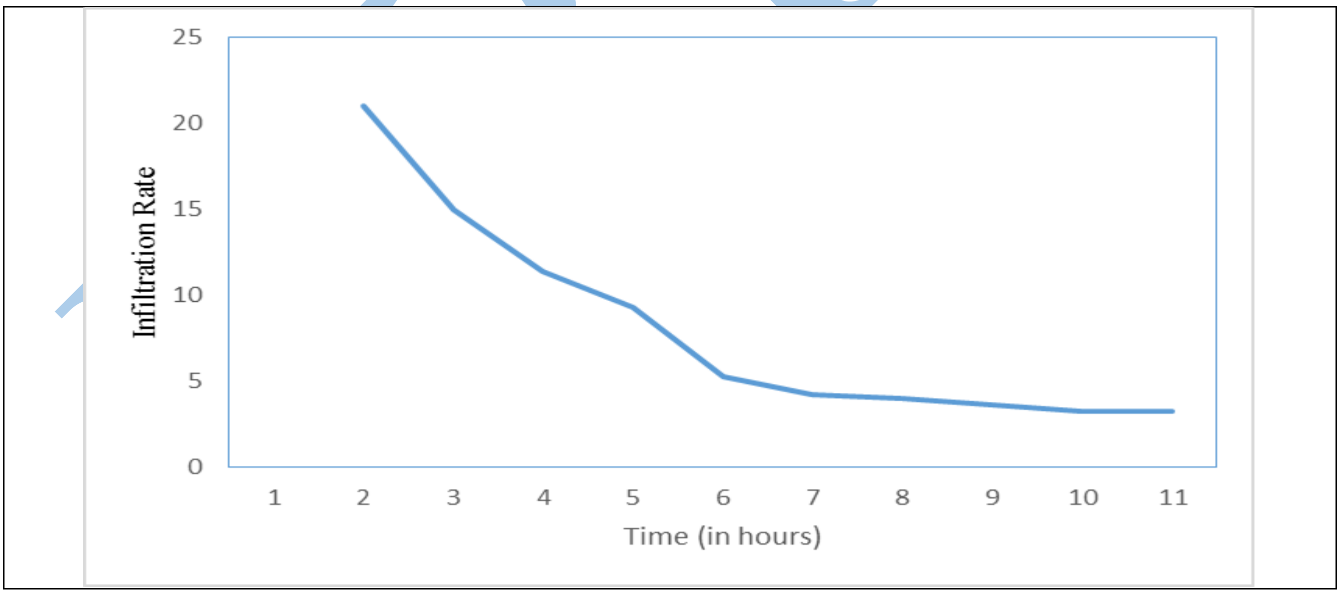


Figure 3. ET calculated over a year

C. Infiltration: Infiltration is the process by which water on the ground surface enters the soil. *Infiltration rate* in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. We measure infiltration capacity using Horton's equation (Bauer, S. W., 1974) as shown in figure 4 below.

$$f_t = f_c + (f_0 - f_c)e^{-kt} \quad [2]$$

Where, f_t is the infiltration rate at time t;
f_0 is the initial infiltration rate or maximum infiltration rate;
f_c is the constant or equilibrium infiltration rate after the soil has been saturated or minimum infiltration rate
k is the decay constant specific to the soil.



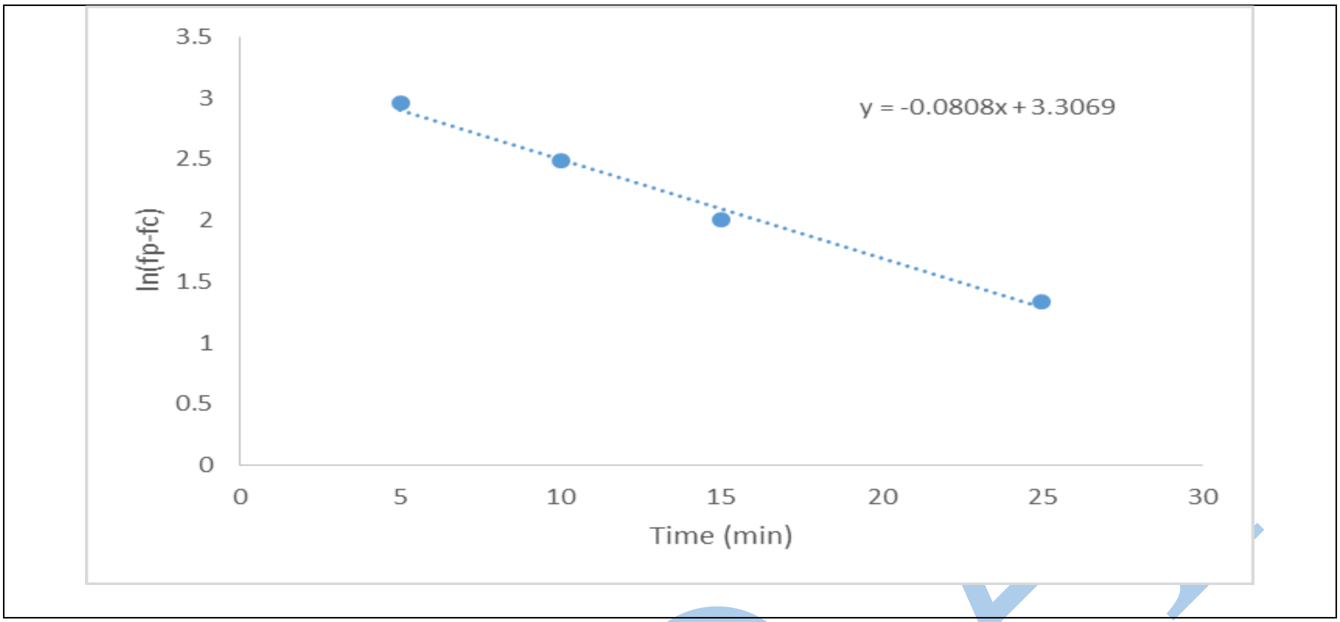
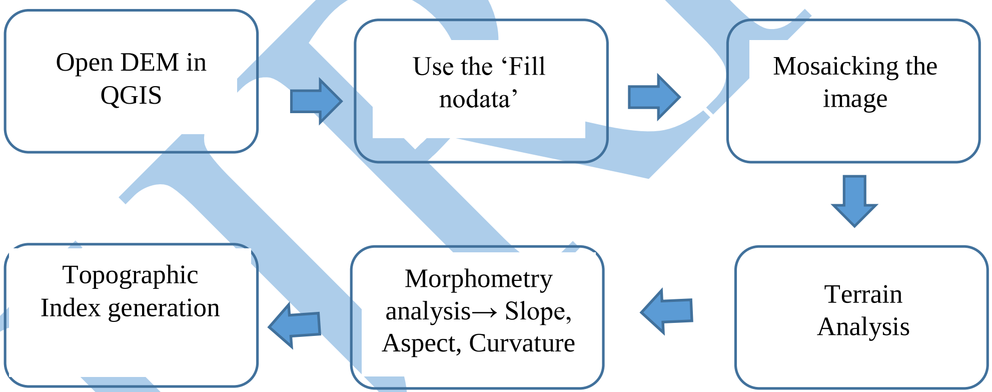


Figure 4. Infiltration curves

Spatial Analysis

The study is being carried out in stages shown in flowchart below. For the study of Flood vulnerability and Risk assessment of Gurgaon area, following tasks in phases were adopted.

The DEM will open in QGIS as a grey square with white patches near the middle as shown below. The white patches are the parts of the DEM without any data and generally referred as the holes or sinks which cause problems in analysis if they are not filled. These sinks are filled by interpolating the pixel values from the neighbourhood pixels (Leidig, M., and Richard T., 2016) (figure 5 and figure 6).



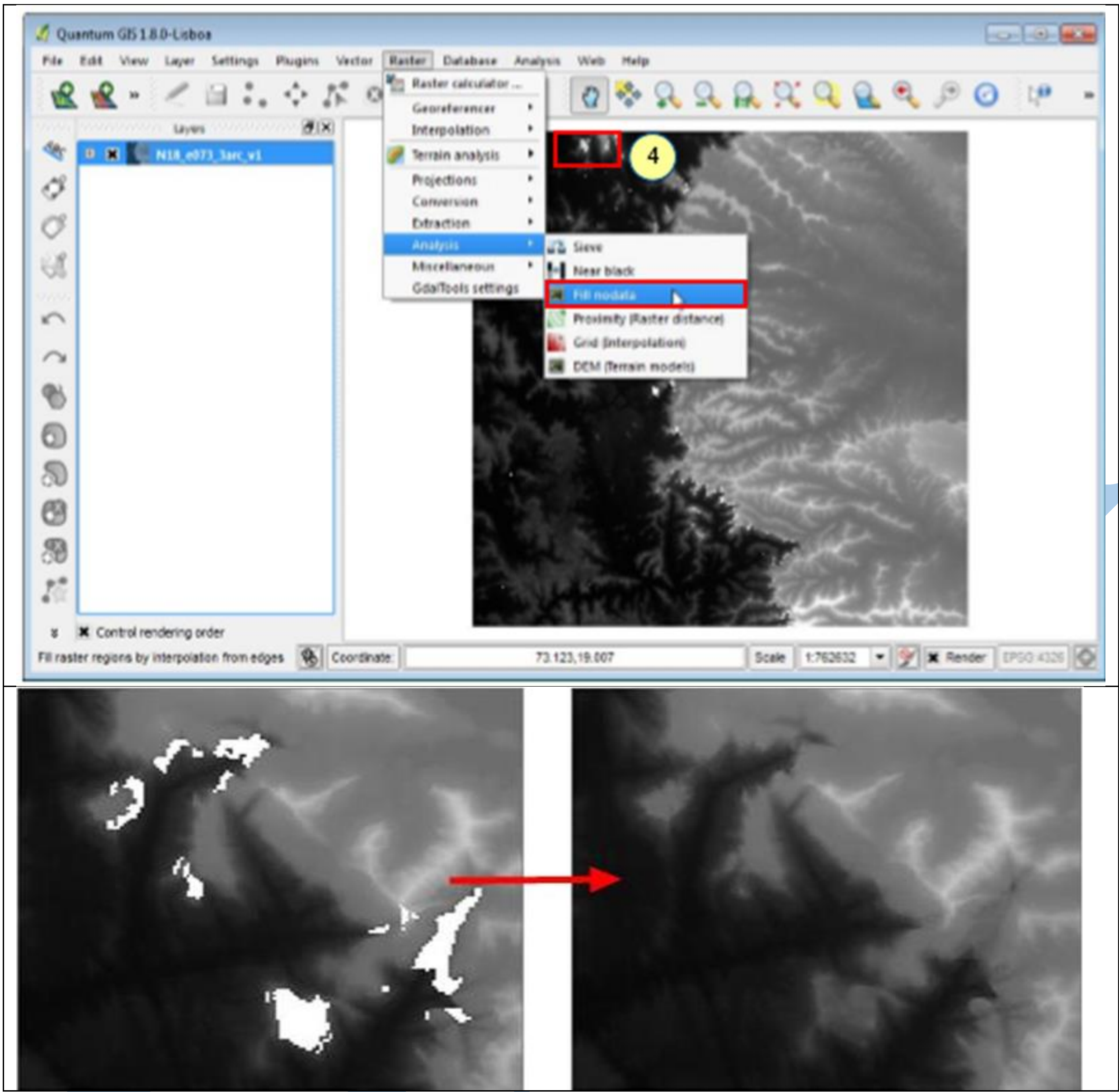


Figure 5. DEM opened in QGIS. White patches near the middle filled by ‘Fill-nodata’ operation

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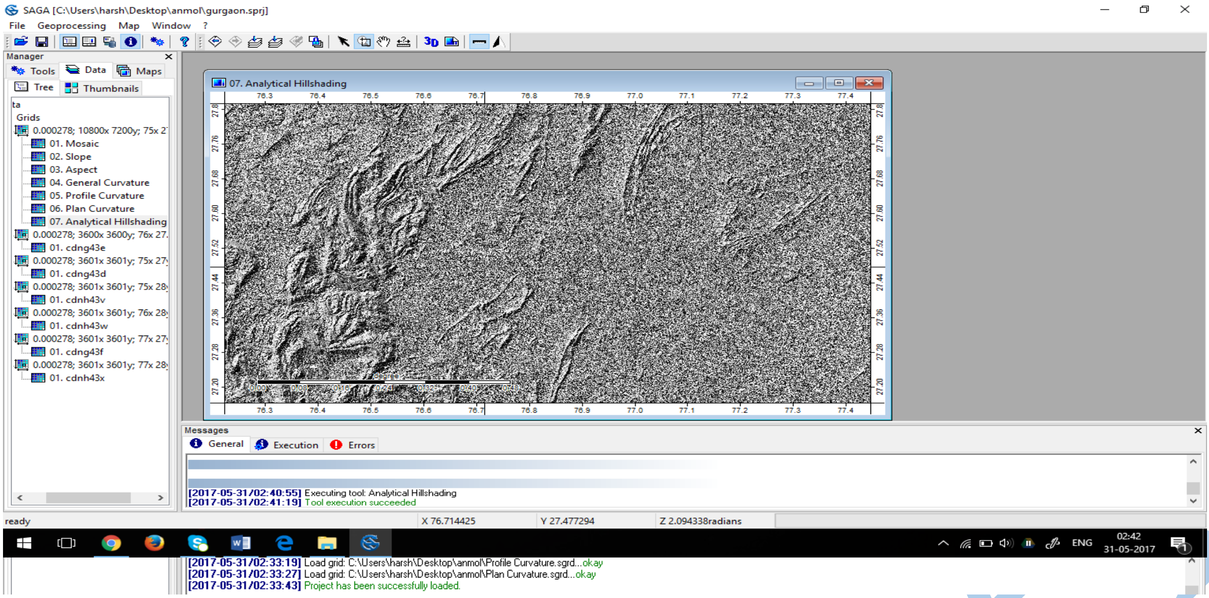

Figure 6. DEM patches over the study area and mosaicked DEM

Topographic characteristics, such as slope, slope curvature, analytical hill shading, helps us in understanding where the flow of water will occur. **Slope** is defined as the change in elevation per unit distance. Slope is widely used for terrain analysis in hydrology. **Aspect** is the compass direction of the slope and affects the direction of water flows. **Curvature** is the change in slope per unit distance and is useful to understand the surface water flow. The pixels with positive curvature indicate the flow dispersal and negative values indicates the flow accumulation (figure 7).

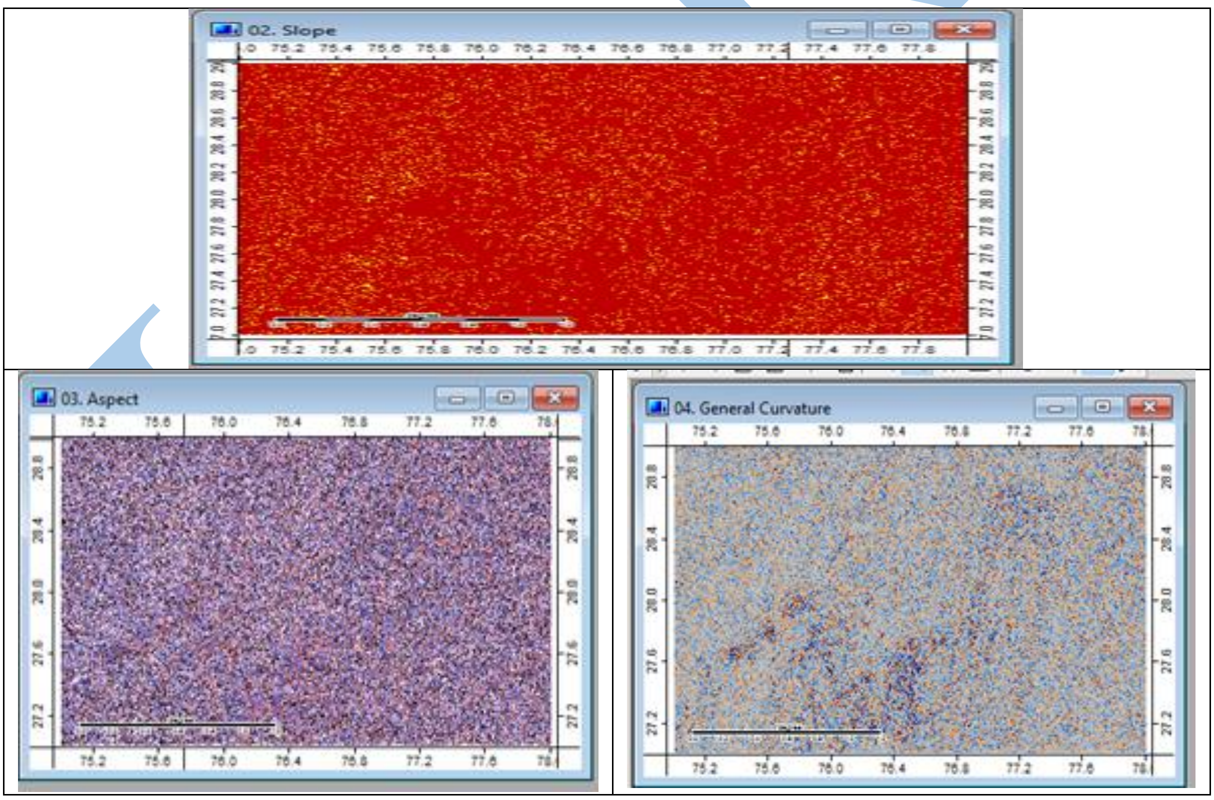

Figure 7. Slope, Aspect and Curvature map

Hillshading is a useful interpretation from DEM and its shaded relief raster gives a better visualization experience of the terrain (figure 8).

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Figure 8. Hillshade map

Using slope and aspect layers Topographic Index (TI) map was generated. Patches having higher TI values are more prone to Flash Flood.

CONCLUSION

Floods in an urban city like Gurgaon is a reason for concern and we may not get in depth after effects of floods. These data provides us valuable insights into the process happening at the time of flood. Such types of model should be involved into further planning of risk management systems. Similar type of work is done across the world to help mitigate the losses occurred due to floods (Youssef et al. 2016, Yin 2016, Elnazer et al. 2017). Modeling done in this research can be used to determine areas which may get affected during floods.

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