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Use of Digital Elevation Model to compute Storm Water Drainage Network

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Abstract

Often planners and engineers are faced with various options and questions in storm drainage network design e.g. topography, flow pattern, direction and therefore size of drain or scenario after a road, airfield or building has been constructed. In most instances planning without drainage in mind has caused failure or extensive damage to property including the storm water drains which channel the water away. With the advent of GIS tools this problem can be averted. The Bhimrad area of surat city (Gujrat, India) had no storm drainage network for persistent flooding. This paper describes a method of assessing the effectiveness of storm drainage networks by a Digital Elevation Model (DEM). The DEM was generated from .dwg contour map and the data imported into ArcGIS, The 141.91hactor basin was then delineated into sub-catchments using ArcGIS Hydro extension tools. Also to derive impervious land cover, arial image of study area (Bhimrad) was accessed through ArcMap's built-in base map function. The roads, buildings, canal, creek, water body existing land use were obtained by digitizing arial image. By overlaying the natural flow lines derived from the DEM with the reconstructed physical drains a comparison of the flow direction and the orientation of the drains was achieved. It is particularly useful for new areas where development is being contemplated.

Keywords: Storm Drainage, Digital Elevation Model (DEM), ArcGIS.

Introduction

Storm water drainage is part of the essential infrastructure of a modern city. In new urban area of Surat(Gujrat, India) city, a separate system is essential for the collection and disposal of storm water. In Surat, life and property are under the threat of flooding due to heavy rainfall within frequent time interval. The average annual rainfall of Surat city is about 1143 millimeters, which is spread of 3 to 4 months. Rainfall distribution is seldom uniform spatially and temporally and remarkable extremes in storm rainfall are also experienced. Therefore provision of a comprehensive system of storm water pipelines in the new urbanized areas.

For that same, by superimposing the existing contour of the study area in ARC GIS and prepare DEM, also using hydrology application in GIS containing automatically generate flow lines and the orientation of the drains as well as catchment area of each proposed drain is assessed for effectiveness. As well as to know the impervious land details land use mapping of the study area was done using ArcGIS.

For the purposes of this analysis, "catchment" refers to all land that drains to a specific point (in this case, to a single stream junction), while "watershed" includes all of the catchments that drain to intermittent stream, While the Physical drainage includes numbers of recognized streams. The pathway followed by streams was found by visually comparing the storm water lines hydrograph imagery GIS layers. Sections of these streams marked as "unknown" are beyond the study area. The "unknown" sections are all classified as intermittent in the DEM. Without this DEM and GIS Stream shape map storm water infrastructure is not clear whether these sections flow naturally or through manmade infrastructure.

Description of Study Area

Bhimrad, situated on the outskirts almost 10 Kms away from the main city, with Latitude

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21°8'59"N and longitude 72°47'46"E. RL of Bhimrad is 3m-7m & RL of SH-5 is 9 m, defines that Bhimrad is a low lying area. Therefore because of change in level Bhimrad is more prone to water logging in both heavy and light rainfall. The TP-42 & 43-Bhimrad are being prepared and finalized gradually which have area about 141.91hactor, the road networks are also finalized, and Problems with management of urban rainfall have their roots in concentration of population on a relatively small area. In order to make living and transportation possible large impervious area are constructed.

At present, the study area under this RPS does not have any storm water drainage system. For overcoming of water logging and flooding problems in this area, it is proposed to provide storm water drainage system of adequate capacity in the TP-42 & 43-Bhimrad of SMC area; so as to disposed off the flood water, safely.

Creation of the DEM

It is a quantitative, 3-D presentation of earth's surface derived from the elevated data. It provides basic information regarding terrain characteristics. Primary attributes derived from DEM are slope, profile curvature. The surface produced was converted to a raster DEM. The next step involved filling pits or ponds, which are cells where water would accumulate when drainage patterns are being extracted. Pits are a sign of error in the DEM due to interpolation. Their frequency is affected by grid cell size. The command fill under "Hydro" in spatial analyst does this step. After filling the sinks the next step was to determine flow accumulation grid from the DEM and finally to delineate the watershed.

1) To create a TIN file in ArcGIS.

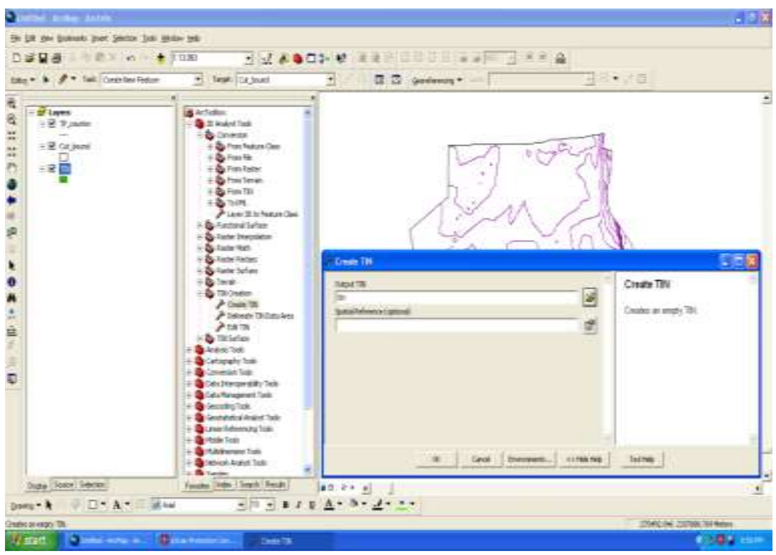

Figure 3 7: Create TIN

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2) To edit TIN option in ArcGIS.

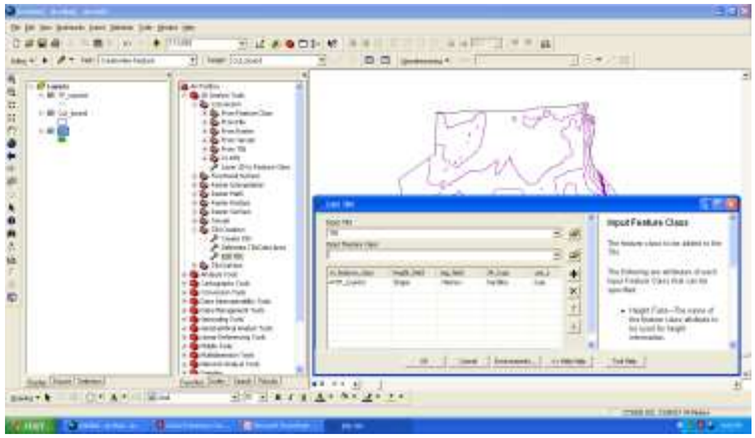


Figure 3 8: Edit TIN

3) Prepare file TIN to Raster.

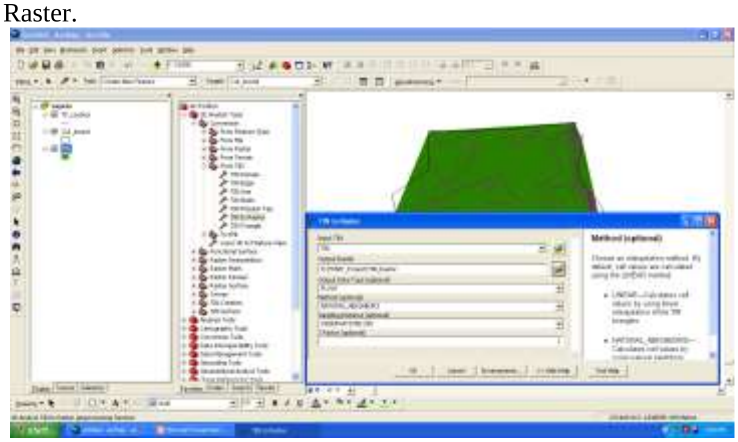


Figure 3 9: TIN to Raster

4) Applied FILL_DEM option.

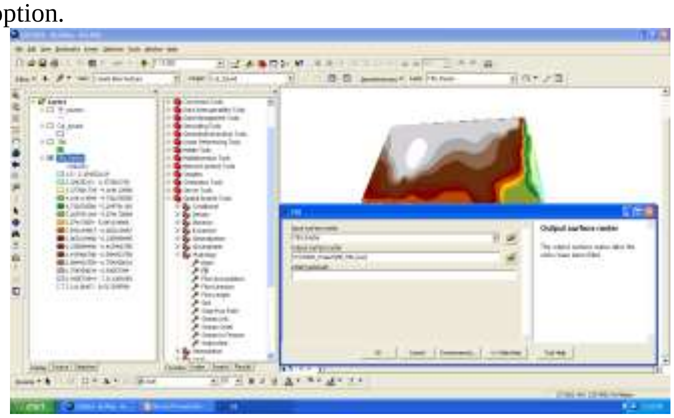


Figure 3 10: FILL_DEM 1

5) Show Flow_ Direction on DEM.

Figure 3 11: FLOW_DIRECTION

6) Gave option of Flow_ accumulation to DEM.

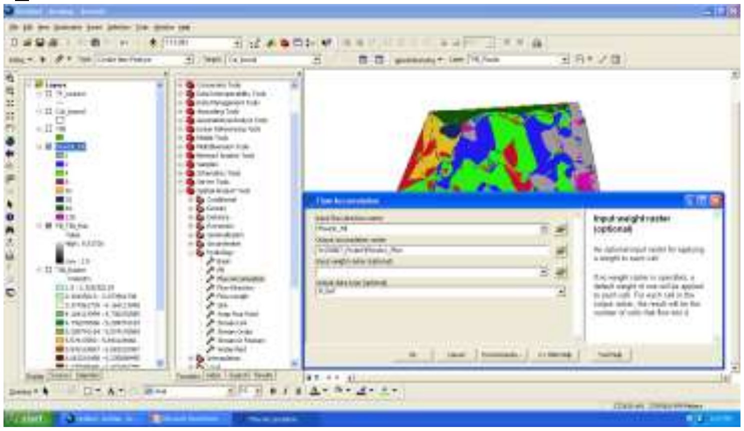


Figure 3 12: FLOW_ accumulation

7) Stream_ Link in ArcGIS on DEM.

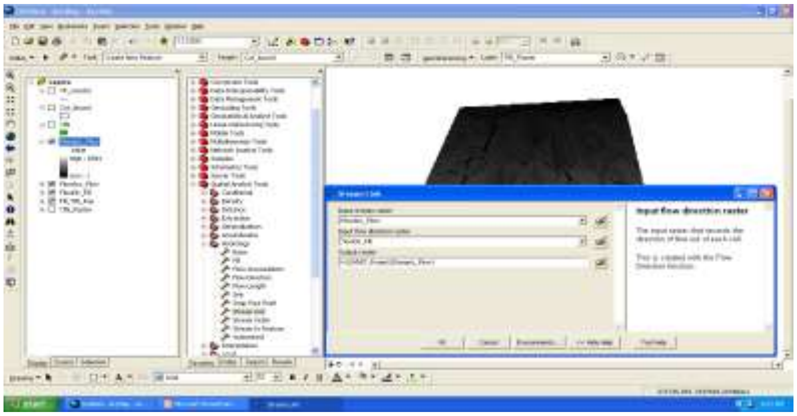


Figure 3 13: Stream_ Link

8) Create Conditional Stream-Con (con>300).

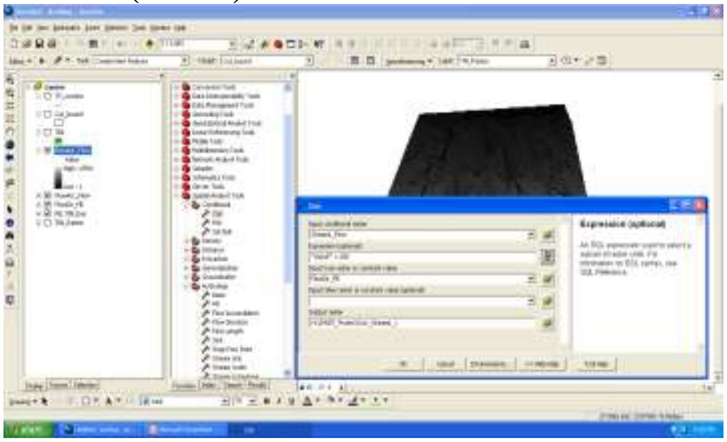


Figure 3 14: Conditional Stream

9) Gave command Stream Order in hydrology application.

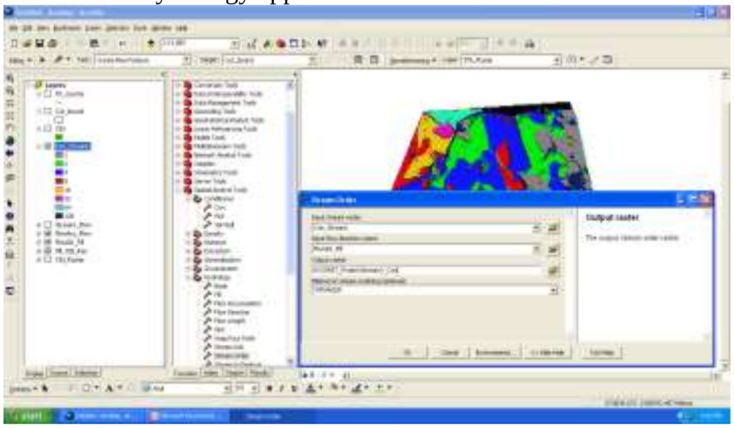


Figure 3 15: Stream Order

10) Applied Stream Order to Shapefile in ArcGIS.

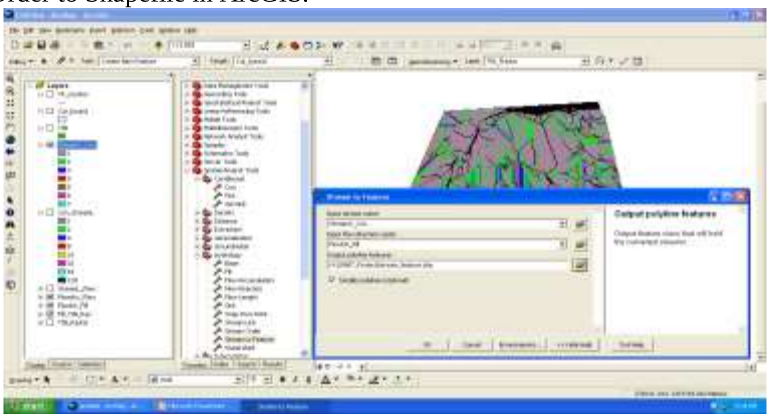


Figure 3 16: Stream Order to Shapefile

11) Extract by Attribute from DEM.

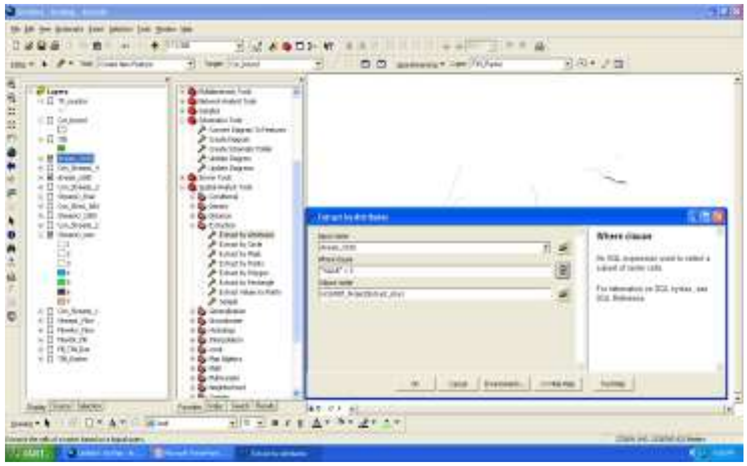
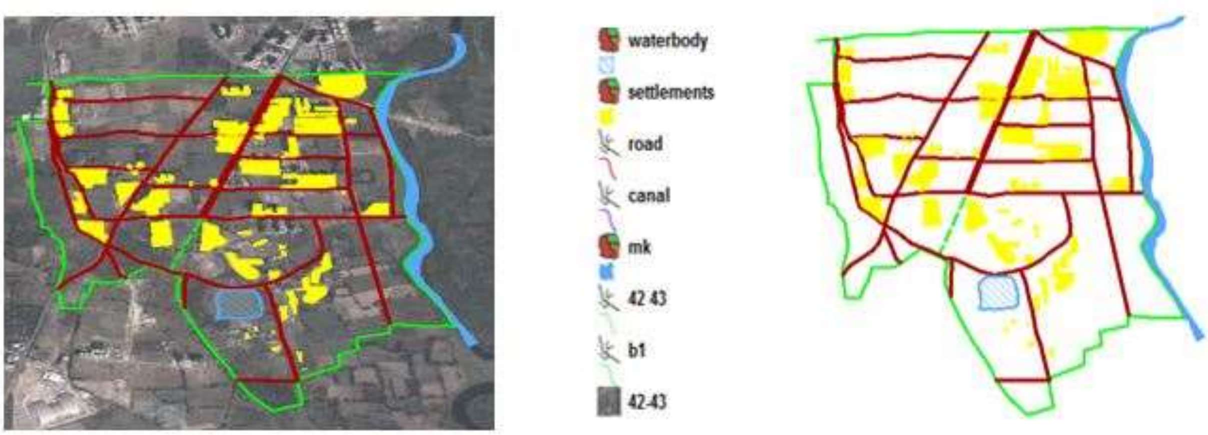


Figure 3 17: Extract by Attribute

Carried out storm water network and catchment area using ArcGIS and Surfer8

Under conventional development, urbanization tends to result in increased runoff, flooding, and pollution and decreased groundwater flow. Storm water control measures are structures or practices that are put into place in an attempt to control and manage storm water by promoting infiltration and ground water recharge, protecting or improving surface water quality, minimizing the use of potable water, and capturing runoff for reuse also. By providing storm water drainage system can reduce both the volume and flow rate of surface water, reduce flooding, peak storm frequency and duration, and associated effects like erosion, stream siltation, and streambed scouring.

To derive impervious land cover, google image of study area (Bhimrad) was accessed through ArcMap's built-in base map function. The roads, buildings, canal, creek, water body existing land use were obtained by digitizing google image. The land use impact boundary shape file was created. Any man-made surfaces that prevent water from infiltrating the ground like Rooftops, pavement, concrete, etc. Digitized from high resolution aerial photographs for the study area and four classes identified; Buildings, roads, canal, other impervious surfaces. Also non-impervious land cover allow for infiltration of rain water into the ground reducing water runoff. Wetlands and ponds capture storm water run-off that lands digitized from high resolution aerial photographs for the study area.



Digitizing shape file of impervious land cover

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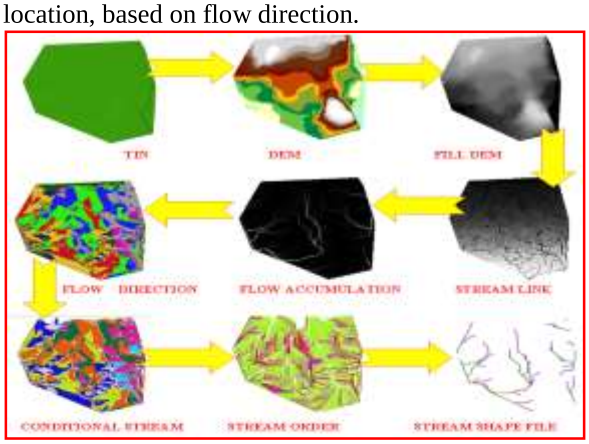
DEM and hydrology application results in ArcGIS

Catchments and pipe network were delineated based on the flow direction, flow accumulation, stream link, conditional stream, stream order and stream shape file shown below figure, which are all derived from a digital elevation model in ArcGIS. As storm water runoff from opposite sides of a stream can experience very different conditions, catchments were further subdivided by the drainage network layer, allowing land on each side to be examined separately in suitability analyses. Details drawing of storm water drainage network with catchment given below. Flow direction is based on a digital elevation model (Sown Figure) with stream locations imposed on it. From following image, one can see the watershed's drainage pattern, including ephemeral streams. Flow accumulation values represent the number of raster cells that drain to each location, based on flow direction.



Storm water drainage network derived from DEM

For the purposes of GIS models, Digital Elevation Models (DEM) is the most convenient means for representing the earth's surface. From this also we can judge pipe network as well as catchment of each pipe node.

Results and discussions

Data on terrain, land-use and hydrology of the T.P.-42 & 43 - Bhimrad was converted to information for storm drainage network planning. Contour .dwg file used to gather data for DEM creation because of the fast acquisition of data. As well as flow lines was created for judge proper location of pipe network and catchment area of each node point.

Thus, the purpose of providing Storm Water Drains is to carry over the rainfall runoff from the terraces, paved courtyards, footpaths, roads etc. of the developed areas; so that the occurrence of flooding reduced to the acceptable frequencies. Therefore, the storm water drains are designed according to the extent and type of tributary area to be drained and must be based on the intensities of the rainfall of study area.

Conclusions and recommendations

Today's stormwater utilities are discovering a wide variety of application areas of GIS technology. In particular, GIS information is critical to urban drainage system planning and analysis. The integrated system allows accurate urban drainage network and provides a reliable and effective means for decision makers to quickly assess and address the implications of alternative design and operational changes on system performance. As the current trend towards the creation of comprehensive geodatabases continues, the proposed decision support system would be even more useful for planning and managing storm water collection systems.

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