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Watershed Modeling Using HEC-HMS and Geographical Information System

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Abstract: -- **Water is unquestionably the foremost vital resource. Use of water and its management is one among the main challenges for humanity. The demand for water is endlessly increasing thanks to growth, the intensive urbanization and also the development of business and agricultural activities. Within the direction of accelerating pressure on this important resource, it's needed to line up the ample instruments to make sure a rational and well-organized management of this resource. During this context, the hydrological modeling is basically used as an instrument to access these resources. The objective of this paper is to simulate runoff using HEC-HMS hydrological model and SCS-CN method in Brahmani-Baitarni basin. The mappings were prepared by using SRTM-DEM of 90m resolution map, soil map, and land use/land cover map. In this paper, water balance part runoffs are computed and its result is calibrated and validated and eventually, the performance of the model is evaluated.**

Keywords:- **HEC-HMS, Runoff simulation, SCS Curve Number, GIS.**

I. INTRODUCTION

Water is one of the major considerable innate resources found on the earth's surface and has an incredible association with the earth's constituent. The atmosphere of any place can be accredited to the constant phase of reorganization of water through the hydrological cycle. Surface runoff is a portion of precipitation which occurs as surplus rainstorm water, melt water or other sources of flow over the earth's surface. Geographic Information System (GIS) serves as an important implement to gather round information and data's for hydrological modeling. GIS has the feature to forecast or determine rainfall, snowstorm, soil dampness, and evapotranspiration and water quality spatially. As well, satellite images can provide information on property of watershed (e.g. geography, tributary system properties). Precipitation is a most important section in the hydrological cycle and remote sensing has the capacity to provide rainfall evaluation where rain gauge observations are inadequate . There is a variety type of remote sensed methods to evaluate the precipitation like SWAT methods, Artificial Neural Network methods. The geographical information system (GIS) is also combined with Arc Geo-HMS and HEC-HMS in turn to analyze various forms of data with the same geographic state. Remote sensing can give the desired data used for GIS, and then the analyses can be accomplished . HEC-GeoHMS is a HEC-HMS interface with ArcGIS and provides additional provisions for a user to deal with the hydrological problems. For example, spatial data similar to soil, DEM, and land use can be feed into the interface model throughout the GIS. Recently, HEC (Hydrologic Engineering Center) has led object-oriented programming on HEC-1 and developed a window mode.HEC-1 evolved into HEC-HMS (Hydrologic Modeling System). HEC-GeoHMS model have been used for runoff simulation modeling in Brahmani-Baitarani River. In this paper evaluate precipitation, cumulative precipitation, precipitation loss, the cumulative precipitation loss, respectively at the Sub-basin of W480 for year 2000 to 2016. by using HEC-HMS model.

II. STUDY AREA

A. The Brahmani and Baitarani River Basin

The both basin of Brahmani and Baitarani basin extends over state Odisha, Jharkhand, Chhattisgarh (as shown in F ig.1) having a vicinity of 51,822km that is sort of 1.7% of the whole region of the country with a most length and dimension of 403 metric linear unit and 193 metric linear unit. It lies between 83º55' to 87º3' east longitudes and 20º28' to 23º 38' north latitudes. The basin is finite by the Chhotanagarpur upland on the north, by the ridge separating it from Mahanadi basin on the west and therefore the south and by the Bay of Bengal on the east.

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The Brahmani sub basin covers 51,033 sq. km and incorporates a long sausage form. The Baitarni sub basin extends over 12,789 sq. km and is roughly circular in form. The Brahmani, called South Koel in its higher riches, rises close to Nagri village in Ranchi district of Jharkhand at an elevation on regarding 600m.

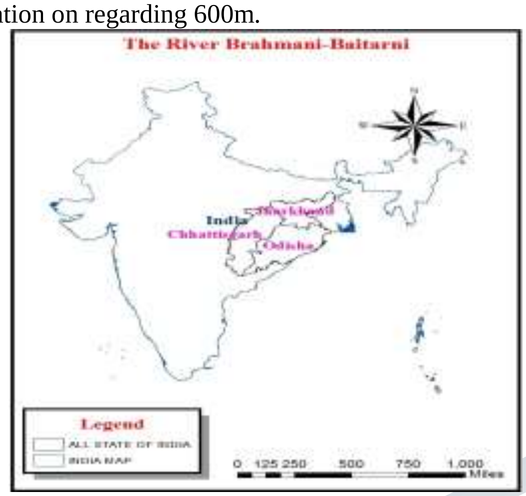

Fig.1 Study area of Brahmani-Baitarni Basin over Odisha

B. Soil Characteristics

The main soil varieties found within the basin square measure red soil, red and yellow soils, red sandy and loamy soils, mixed red and black soils and coastal deposit. The coastal plains encompass fertile delta space extremely suited to intensive cultivation. The soils square measure classified supported the soil textural data as sandy, loamy, loamy skeletal, clayey and clay skeletal.

C. Flow Routing Phase

The second part of the simulation of the geophysical science of a watershed is that the routing part of the hydrologic cycle. It consists of the movement of water, sediment and alternative constituent (e.g. nutrients, pesticides) within the stream network. Two choices square measure obtainable to route the flow within the channel network, the variable storage and Muskingum strategies. The variable storage volume, whereas the Muskingum routing methodology models the storage volume in an exceedingly channel length as a mix of wedge and prism storages. During this study Muskingum routing Methodology is adopted.

D. Land-use/Land-Cover

The major portion of the basin is roofed by forest (31.9%), followed by crop space (29.15%) and then current fallow (28.25%). The remaining portion of the basin is roofed by settled land, plantation, littoral swamp, grassland, gullied land, and country and water bodies. The crop land is additional classified into Rabi only, Kharif only and Zaid only.

III. METHODOLOGY

Model Setup

The model set-up was finished the assistance of HEC-GeoHMS interface package that runs below ArcGIS surroundings. The found out consisted of preparation of the input file, delineation of watershed exploitation the Digital Elevation Model (DEM) knowledge, soil data, slope, land use and land cowl knowledge, rainfall-runoff knowledge and eventually a check run of the model. It's followed by activity and validation of the info thought-about.

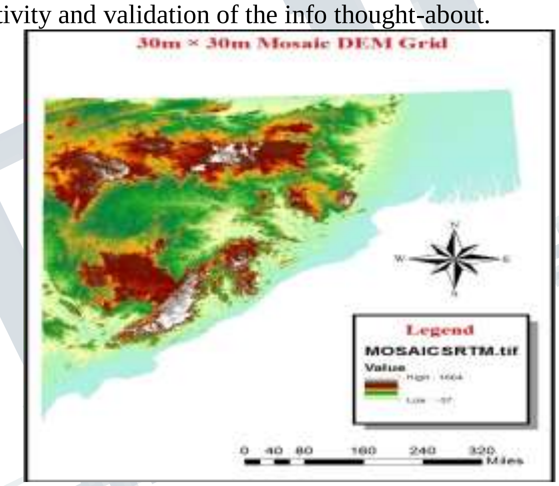

Fig.2 30m × 30m Mosaic DEM grid

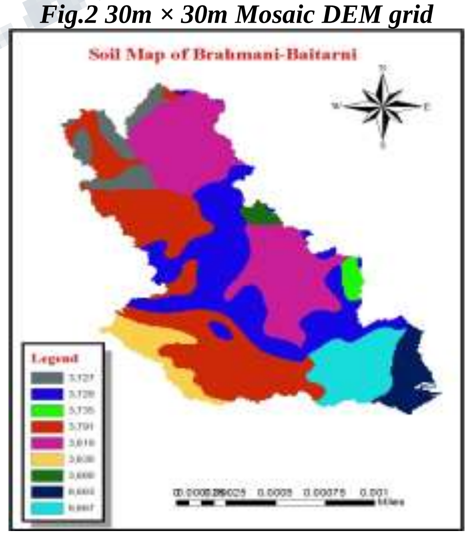

Fig.3 Soil map of the study area

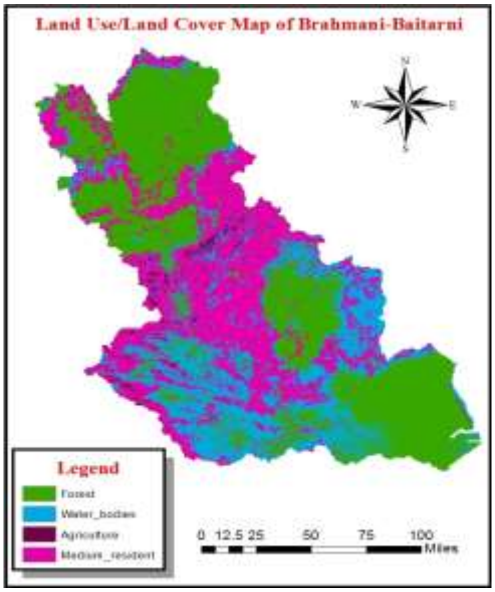

Fig. 4 Land Use/Land Cover map of the study area.

IV. MODEL SIMULATION

A. Arc Hydro

Arc Hydro could be a geospatial and temporal information model for water resources. It's an associated set of toolset developed together by ESRI and CRWR that operates within the ArcGIS platform. The Arc Hydro toolset populates attributes of the options within the information framework, interconnects options in several information layers and supports hydrologic analysis (Maidment, 2002). The Arc Hydro framework consists of a geo database with feature dataset, feature categories, geometric network and relationship categories.

B. Terrain Processing

Terrain preprocessing is that the delineation of watersheds by mistreatment existing DEMs information. Terrain preprocessing should be completed in consecutive order before any HEC-GeoHMS process functions will be processed. The step comprises computing the fill sinks, flow direction, flow accumulation, stream definition, catchment grid delineation, drainage line processing, drainage point processing and watershed delineation.

C. FilSink

The FilSink DEM is formed by filling the depressions or pits by increasing the elevation of Hell cells to the extent of the encompassing terrain. The pits are typically thought-about as errors within the DEM as a result of re-sampling and interpolating the grid as Fig.5 shown below.

Fig. 5 FilSink of river Brahmani-Baitarni.

D. Flow Direction:

Flow direction map generated mistreatment Hydro DEM (Fill) as input file, which defines the direction of the steepest descent for every terrain cell as shown in Fig.6.

Fig.6 Flow Direction of river Brahmani-Baitarni

E. Flow Accumulation

Flow accumulation map determines the quantity of upstream cells exhausting to a given cell, mistreatment flow direction knowledge as input. Upstream catchment areas at a given cell are often calculated by multiplying the flow accumulation worth by the grid cell area as shown in Fig. 7 below.

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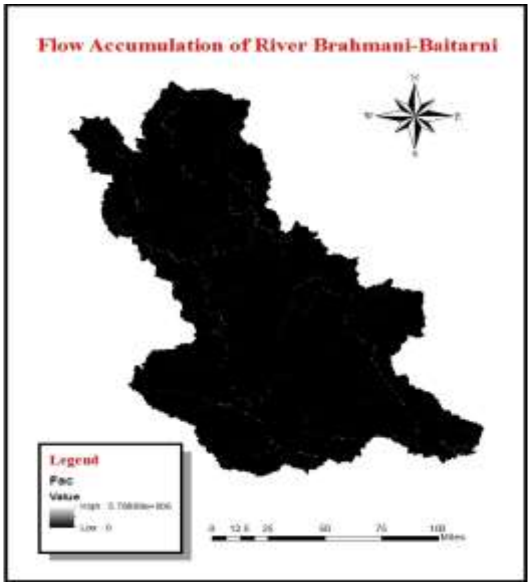

Fig.7 Flow Accumulation of river Brahmani-Baitarni

F. Stream Definition

This step classifies all cells with a flow accumulation larger than the user-defined threshold as cells happiness to the stream network. The user such threshold could also be such as a part in distance units are e.g., sq. km. The flow accumulation for a selected cell should exceed the user-defined threshold for a stream to be initiated. The default is common fraction (1%) of the biggest geographical region within the entire DEM. Fig. 8 shows the stream definition.

Fig.8 Stream Definition and Stream Segmentation

G. Stream Segmentation

Flow direction and stream grids are used to divide the stream grid into segments. Streams segments, or links, are the sections of a stream that connect 2 consecutive junctions, a junction associated an outlet, or a junction and therefore the drain divide as shown in above Fig.8.

H. Catchment Grid Delineation

The watershed is delineating in sub-basins for each stream segment exploitation flow direction and stream link grids as shown in Fig.9.

H. Catchment Polygon Processing:-

A vector layer (polygon sub-basin layer) of sub-basin is formed exploitation the structure grid as shown in Fig.9.

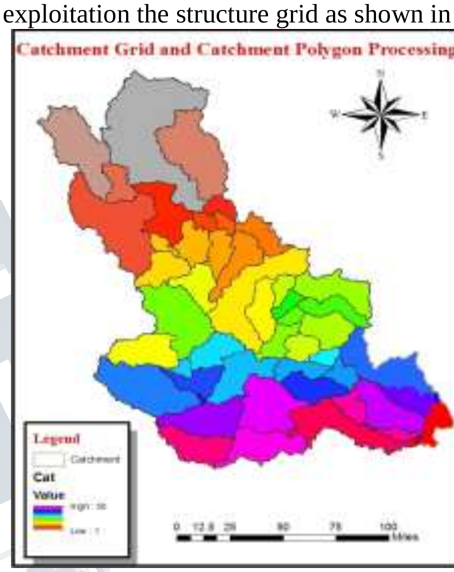

Fig.9 Catchment Grid and Catchment Polygon processing

J. HEC-GeoHMS

The geo-spatial Hydrologic Modeling Extension (HEC-GeoHMS) could be a software system package to be used with the ArcGIS Geographic information system. GeoHMS uses ArcGIS and spatial Analyst to develop variety of hydrologic modeling inputs. Analyzing digital terrain data, HEC-GeoHMS transforms the drain ways and watershed boundaries into a hydrologic system that represents the watershed response to precipitation. Additionally to the hydrologic system, capabilities include the event of: grid-based information for linear distributed runoff transformation, the HEC-HMS basin model, physical watershed and stream characteristics, and background map file. HEC-GeoHMS provides an integrated work setting with information management and customized toolkit capabilities, which incorporates a graphical interface with menus, tools, and buttons. The program options have terrain-preprocessing capabilities in each interactive and batch modes.

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Hydrological Processing: - Hydrologic method is usually accountable for hydrological model construction and setup. HEC-HMS project space is generated process the outlet of the watershed. Once process the downstream outlet new datasets MainViewDEM, RawDEM, HydroDEM, flow direction grid, Flow accumulation grid, stream grid, stream link grid, catchment grid, sub-basin, project purpose and stream are created for brand new project.

Basin Processing: - After the Terrain Processing is completed and a replacement project has been created, basin processing is employed to revise the sub-basin delineations. Basin process includes basin merge, basin subdivision, stream merge, and stream profile, extract physical characteristics of stream sub-basins, develop hydrologic parameters and develop HMS inputs. . Sub-Basins and river of Brahmani-Baitarni is given in below Fig. 10.

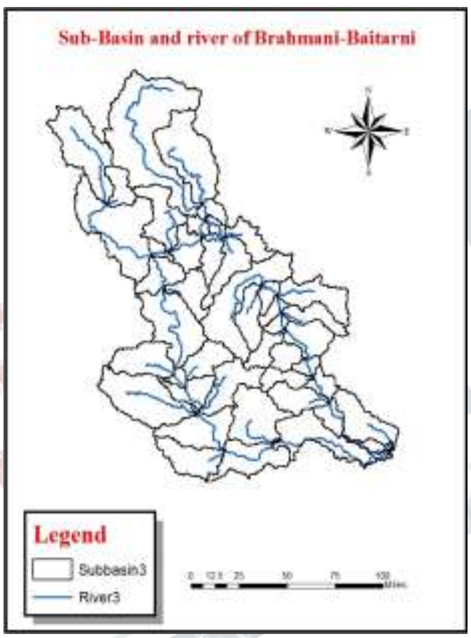

Fig.10 Sub-Basins and river of Brahmani-Baitarni

V. RESULTS

A. Basin Model

The Brahmani-Baitarni basin divided into 47 nos. Of sub-basins.

Each sub-basin connected to Reach element.

Finally one Sink to collect all the water from watershed

The Fig. 11 represents the basin model and the hydrological components like Sub-basin, reach, and sink of the basin model.

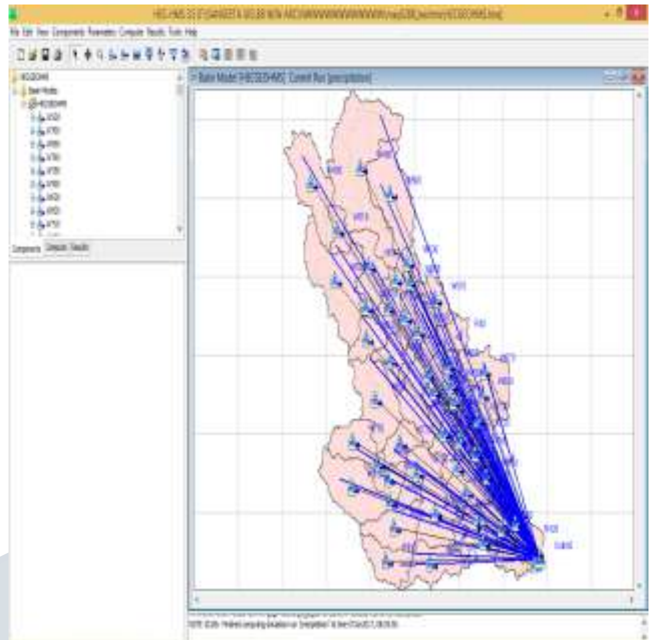

Fig.11 Basin Model

B. Results for Sub-basin

Fig. 12 to Fig.15 shows the precipitation, cumulative precipitation, precipitation loss, the cumulative precipitation loss, respectively at the Sub-basin of W480 for year 2000 to 2016.

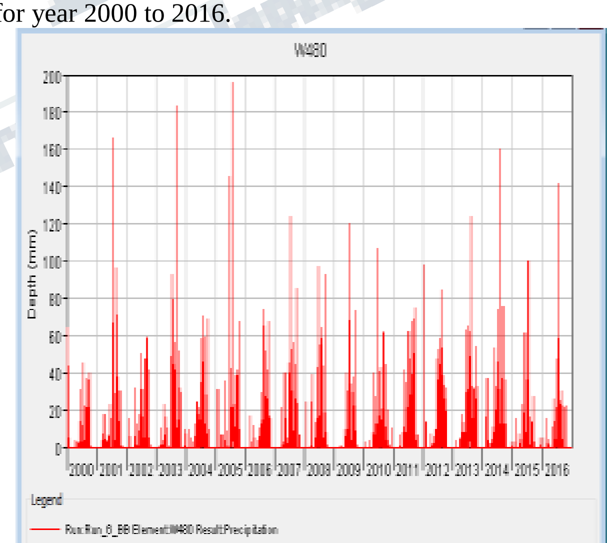

Fig.12 Precipitation in sub-basin W480

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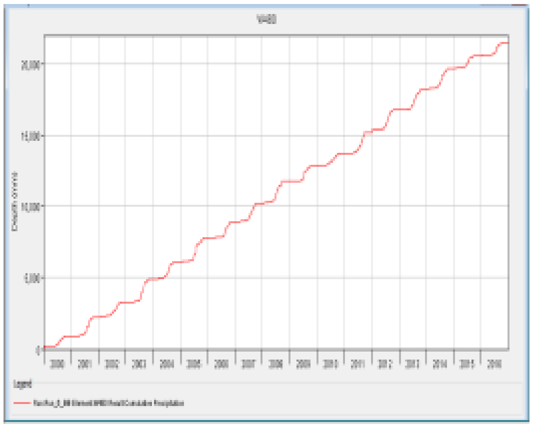

Fig.13 Cumulative precipitation in sub-basin W480

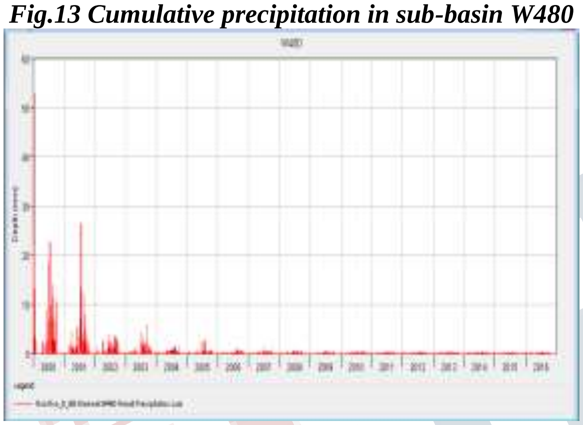

Fig.14 Precipitations Loss from Jan 2000 to Dec 2016 in sub-basin W480

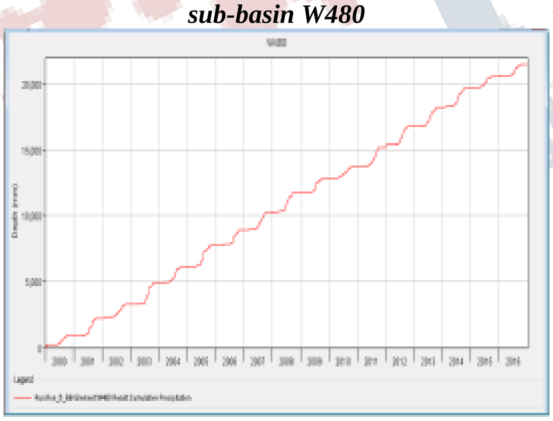

Fig.15 Cumulative precipitations Loss in sub-basin W480

C. River Profile

The watercourse profile is made by extracting elevation values from the terrain model on the stream line that provides data on slopes and grade breaks which will be useful for choosing delineation points. River profile is given in below fig.16 .

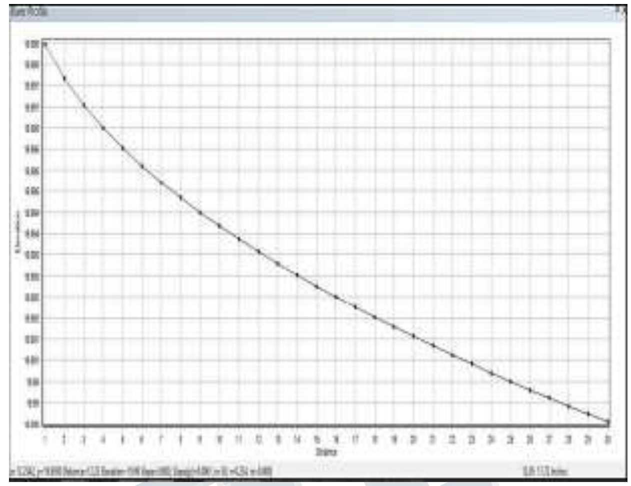

Fig.16 River Profile

V. CONCLUSION

The required precipitation data (2000-2016) and discharge data was collected for 14 years (2000–2014), together with the soil map, LU/LC map, and DEM of the study area. The input files for the hydrologic model was prepared using remote sensing and GIS techniques. For simulating discharge by the HECHMS model, the SCS unit hydrograph transform method was used to compute direct surface runoff hydrographs, the SCS curve number loss method to compute runoff volumes. The HEC-HMS hydrologic model was calibrated using the rainfall and discharge data of 2000 to 2016.

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