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DEMARCATION OF CATCHMENT AREA USING GEO-INFORMATICS: MORNI SUB WATERSHED, HARYANA

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Abstract: Proper watershed management is a pre-requisite to efficient water use in an area. For this purpose suggesting proper water harvesting sites and demarcation of their catchment area is required. Therefore, an area with a very undulating topography in the Morni Hills of Haryana was selected. The aim of the present study is to calculate catchment area for suggesting water harvesting sites using RS and GIS techniques by integrating various thematic information. The sub watershed comprises of rocky surface and several types of faults and fractures. Use of remote sensing data along with GIS, topographical maps, collateral information and limited field checks, has opened new avenues and made it easier to establish the base line information for water harvesting zones. ARCGIS 10 and ERDAS IMAGINE 11 software's were used for analysing and interpretation of remote sensing data. About 88 water harvesting sites were suggested by overlaying several maps viz. LU/LC, contour, slope, geology and geomorphology, drainage network, stream order, road network and groundwater quality. Based upon the specific criteria provided in the literature various water harvesting structures Nala bund (17), Check dam (12), Inverted/Recharge well (18), Desilting tank (2), Recharge pit (1), Storage tank (38) etc. were suggested on identified WH sites. Results show that about 15.28 km² area contribute direct runoff towards suggested WH structures. Out of this catchment area contributing water towards Nala bund, Check dam, Inverted/Recharge well, Desilting tank, Recharge pit, Storage tanks is 11.02%, 0.35%, 15.51%, 72.99%, 0.05% and 0.08%, respectively.

Key words: DEM, Land use/land cover, stream order, WH site & structure.

1. INTRODUCTION

Water, one of the most essential resources in our day-to-day life is depleting faster in rural as well as urban areas mainly because of increase in agricultural and domestic demands respectively. A watershed is an area that drains surface water to a common outlet. Watershed analysis refers to the process of using DEMs (Digital Elevation Models) and raster operations to delineate watersheds and to derive topographic features such as stream networks (Kang, 2008). Therefore water catchments area is determined on the bases of topographical landscape of the area (William, 2000). Catchments and watersheds define drainage areas of the land surface that contribute flow to particular edges on the Hydro Network. Extensive hydro geological studies have been carried out by several workers in delineating groundwater potential zones in hard rock terrain (Agarwal et al., 1992; Rao et al., 2001). Remote sensing and GIS technology have opened new paths in water management studiesThe catchment area map is a systematic effort and has been prepared considering major controlling factors, which influence the water runoff. The techniques used for delineation of the catchment area by surface drainage (stream network) are ultimately dependent on topographical information generated in a local neighbourhood on the DEM. Advances in the analysis of flow direction and flow networks from DEMs have led to several automated methods for watershed and stream delineation (Jenson and Domingue, 1988; Tarboton, 1997). In the present study, an attempt has been made to calculate the catchment area of the watershed contributing direct runoff towards suggested water harvesting structure in Morni subwatershed of Panchkula district based on remote sensing and GIS techniques.

2. STUDY AREA

The present study (fig. 2.1) was carried out for Morni sub watershed in Panchkula district. It is located at latitude 30°40'17"- 30°46'10"N and longitude 77°00'01"-77°09'52"E covering an area of about 6551.40 ha. The study area is divided in 7 micro watersheds named as M1, M2, M3, M4, M5, M6 and M7. The climate of Morni sub watershed is having, hot summers, cool winters and good monsoon rainfall. The average annual rainfall for six year (2008-2013) was found to be 720.68 mm, out of which 80% of annual rainfall is received in June to September months and also receives some rainfall in winter months due to western disturbances. Despite heavy rains in the area, water retention is very low because of steep slope which develops high surface runoff. The relief of the area ranges from the lowest of 448.15 m to the highest elevation of 1453.43 m. Morni hills constitutes the highest point of Panchkula as well as of Haryana. The sub watershed consisted of sandstones/conglomerate, red stones, purple shale, grey to greenish sandstone with clay intercalations & purple shale, Quartzite, stromatolite, limestone and dolomite formation constituents. Also Valley fill shallow, Piedmont Alluvial Moderate and Structural Hill (Less, moderate and highly dissected) were observed in the study area. Different types of soils were noted in the area viz. fine loamy, clayey loamy, loamy and coarse loamy.

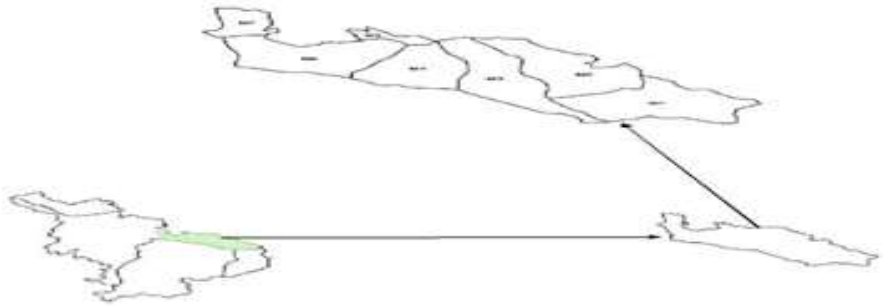

Fig. 2.1 Study Area

3. METHODOLOGY AND TOOLS USED

Survey of India (SOI) Toposheet No. 53F/03 on 1:50,000 scale were used to delineate the study area. The scanned maps were rectified with already geo-referenced image of **LISS-IV satellite data**. Then, final boundaries of sub watershed and micro watersheds were digitized from rectified maps. Very high resolution data from WORLDVIEW-2 satellite with 8 band multispectral capabilities of April 11, 2012, June 11, 2012 and June 12, 2012 on 1:2500 scale were used for digitization of land use/land cover map. Stereo imagery (WORLDVIEW-2) products by means of advanced image processing photogrammetric tools were used to extract DEM. Tie points were demarked manually on the stereoscopic images in LPS command of ERDAS IMAGINE 10 software. Errors were reduced after completion of tie point demarcation using triangulation report.

3.1 Identification of Potential Water Harvesting Sites

Different parameters were used for the identification of potential water harvesting sites such as land use/land cover, drainage network, contour, Flow direction, Stream Order, Groundwater quality, Road network, Geology, Geomorphology and Fault/Fracture to identify potential water harvesting sites.

3.2 Specifications for Different Water Harvesting Structures

Six types of water harvesting structures were suggested such as check dam, Nala bund, storage tank, inverted well/recharge well, percolation tank and recharge pit. Except storage tank, criteria recommended for all other structures were as given in "Groundwater prospects mapping for Rajiv Gandhi National Drinking Water Mission (2008)". For site selection criteria of Storage tank "Soil & Water Conservation Engineering (R. Suresh,1993)" was followed.

3.3 Demarcation of Catchment Area of Suggested Water Harvesting Structures

Based upon the identified potential water harvesting sites , suggested water harvesting structure and stream order, catchment area of each site was manually digitized and then area of each digitized field was calculated.

4. RESULTS AND DISCUSSION

Morni sub watershed has a total geographical area of 6551.40 ha. It consists of 7 micro watersheds. M1 is the biggest micro sub watershed and M4 is the smallest micro sub watershed. Scrub forest is the predominant land cover with in the classification of forest land, accounting about three fourth (77.23%) or 5059.76 ha of total geographical area. Terrace cultivation covered almost 16.26% of total area or 1065.38 ha (Fig.4.1).

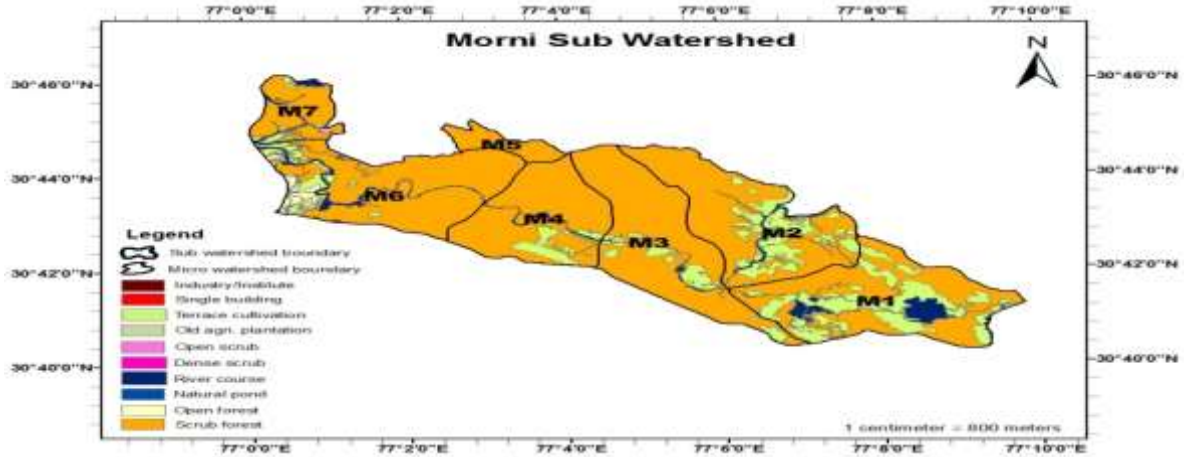

Fig. 4.1 Land Use/Land Cover of Study area

Digital elevation Model (DEM) was extracted from the WORLDVIEW-2 (black and white image) satellite data using 3 ground control points (GCPs) and 117 tie points with maximum reduction in error. Elevation of high quality generated DEM ranges from 448.15m to1453.43m with mean elevation of 925m and has a higher resolution of 2m as shown in fig. 4.2 (a, b). Result shows that topography of study area has a series of hills and ridges towards northern and southern east part of the area whereas western part has less undulating topography.

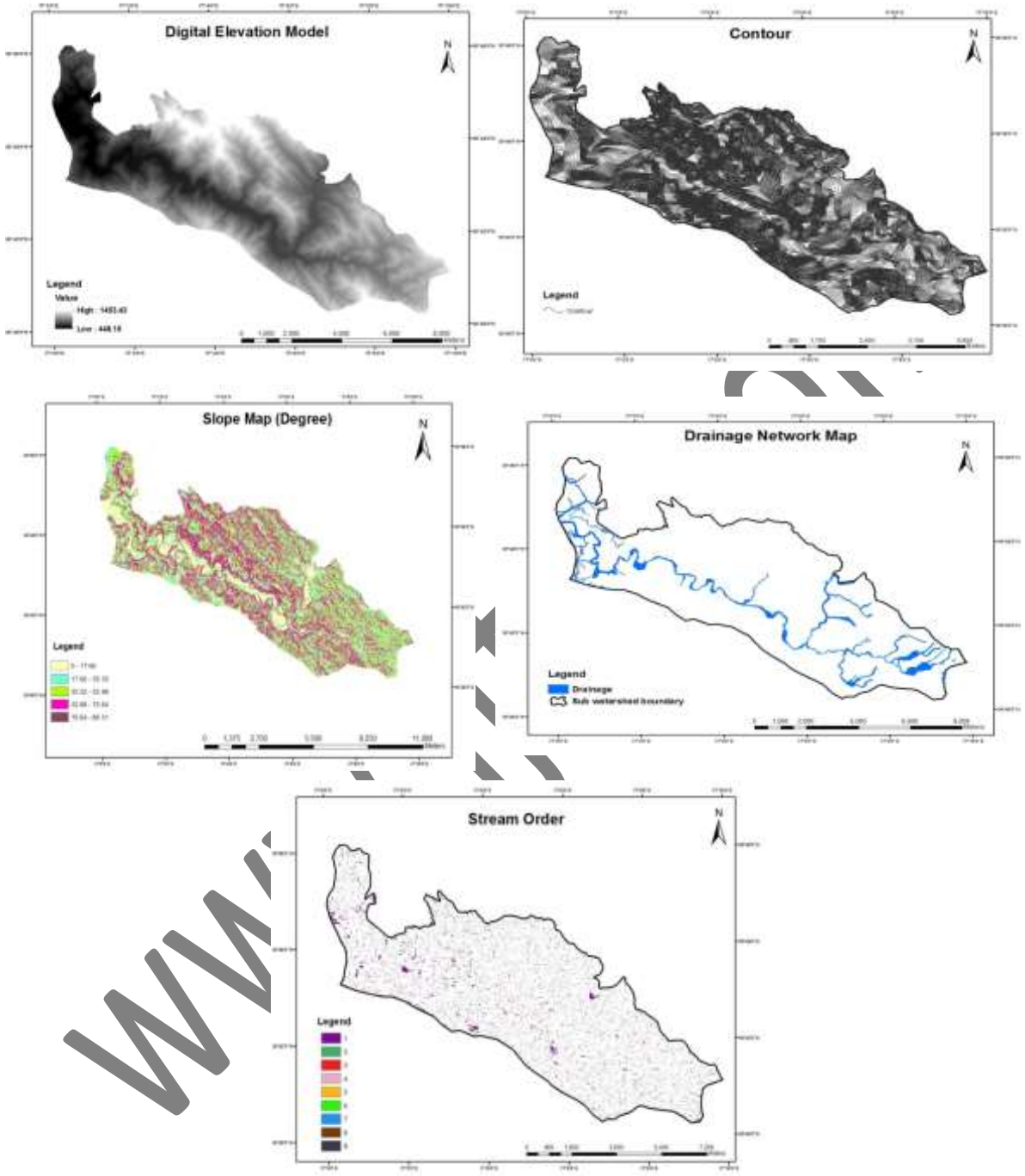

Fig. 4.2: (a)Digital Elevation Model; (b) Contour; (c) Slope map; (d) Drainage network; (e) Stream Order

Flow accumulation was derived to check the flow accumulating area whose pattern is same as flow direction. The water is accumulating in a main stream facing from west to southern east . Slope map (degree) showed that slope varies from 0° to 88.31° of the Morni sub watershed (fig. 4.2 c). A total 12, 10,741 tributaries were observed in the sub watershed. Out of which maximum no. of tributaries were of first order rank (697887) followed by second order rand (246721) and thirds order rank (122725) respectively. Number of tributaries goes on decreasing as rank of tributary increased. Hence result shows that rank order no. ninth (3104) has the minimum no. of water tributaries followed by eighth (7592) and seventh order (10920) respectively. It was found that all lower rank drainage tributaries terminate in respectively higher order tributary (Fig. 4.2 e, f).

Total 133 number of minor fractures/faults and only six trend lines were noted in the study area. But these minor faults were assumed to have negligible adverse effect on the research work but can help to suggest water

harvesting structures at identified sites. Morni sub watershed mainly consisted of four types of road network i.e District road, footpath in hill, pack tracks in hill and village roads. As the physiographic of the study area is hilly so it was observed that pack tract network is spread in almost area as a road network.

Location of WH sites and storage structures of Morni sub watershed is shown in fig 4.3. Based upon the specific criteria about 88 WH sites were identified by overlaying various parameters such as LU/LC, Contour, Slope, Geology, Geomorphology, Drainage network, Stream Order, Road network and Ground water quality. Water harvesting initiates with assumption based upon the fact that there is a huge amount of monsoon flow which remains uncaptured and eventually ends up in natural sinks. Considering the runoff potential of sub watershed, WH structures such as Nala bund (17), Check dam (12), Inverted/Recharge well (18), Desilting tank (2), Recharge pit (1), Storage tank (38) etc. were suggested on identified WH sites.

After suggesting potential WH structures for the study area, catchment area for each structure was calculated by overlying several maps. It was found that about 15.28 km² of area contribute direct runoff towards suggested WH structures. Out of this catchment area contributing water towards Nala bund, Check dam, Inverted/Recharge well, Desilting tank, Recharge pit, Storage tanks is 11.02%, 0.35%, 15.51%, 72.99%, 0.05% and 0.08%, respectively as shown in Fig. 4.

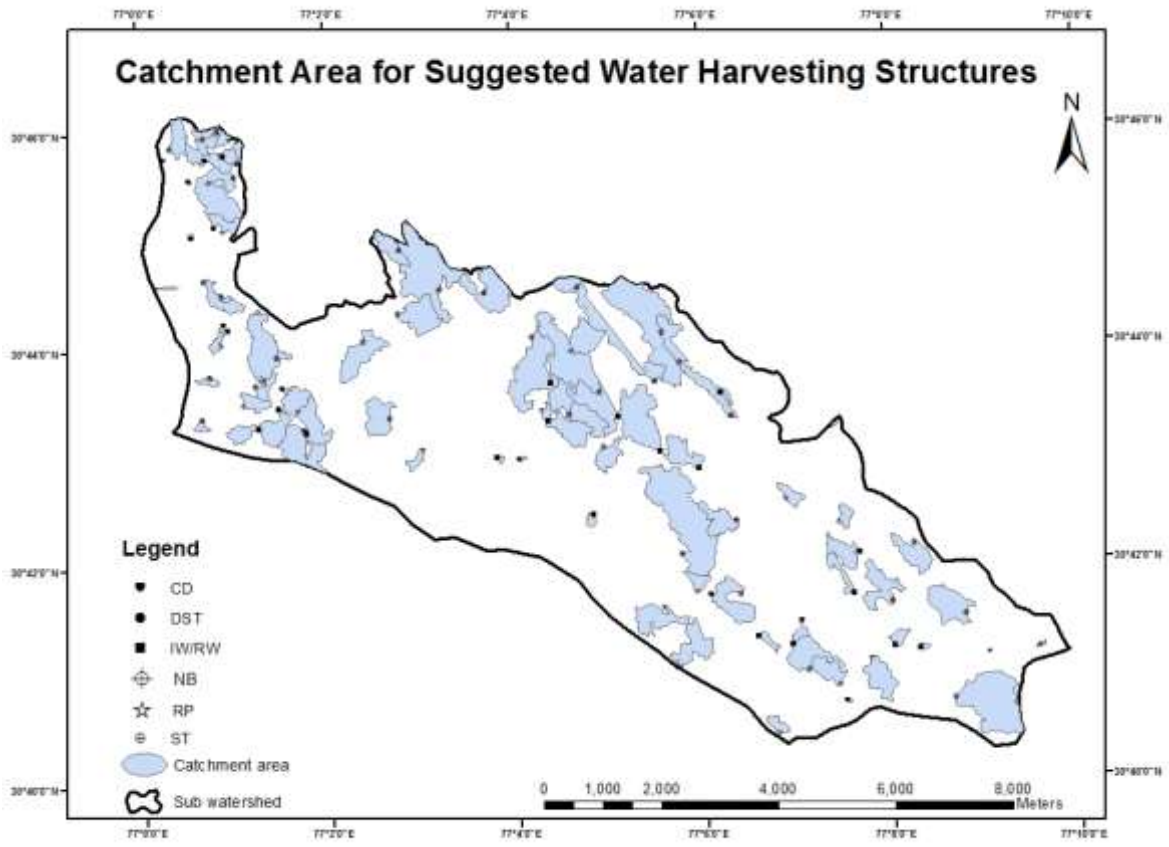

Fig. 4.3 Location of WH Sites and Delineated Catchment Area

CONCLUSION

From the obtained results, it was concluded that the baseline information generated on land use/land cover of the area would be of immense helpful in formulation of policies and programmes requires for the development planning. Successful application of remote sensing and GIS with multilayer integration viz. geomorphology, geology, drainage network, DEM, contour, slope, stream order, groundwater quality etc. gives useful information for site selection for WH structures and demarcation of catchment area in minimum time and efforts compared to the traditional methods. The area is having full scope of water harvesting sites and harvested water can be used to improve associative land units.

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