SELECTION OF SUITABLE SITES FOR WATER HARVESTING STRUCTURES IN A CATCHMENT USING REMOTE SENSING AND GIS

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***Abstract**: Water is one of the most precious natural resource and due to its limited supply and growing demand, it is declining at an alarming rate. Water harvesting structures are important to conserve water in a catchment to fulfill the demands whenever required. Remote Sensing and Geographic Information System techniques can be effectively used to manage spatial and non spatial database that represent the hydrologic characteristics of a catchment as realistically as possible. In the present study, an attempt has been made to select suitable sites for water harvesting structures using Remote Sensing and Geographical Information System in Upper Kangsabati catchment which lies mostly in Puruliya district and partly in Bankura district, West Bengal India. The various thematic maps such as land use map, slope map, drainage map and hydrological soil group map, have been prepared from satellite image of IRS-P6 LISS-III, georeferenced topographic maps and National Bureau of Soil Survey and Landuse Planning (NBSS & LUP)respectively. These maps were integrated in a GIS environment nd criteria was assigned for selecting suitable sites for construction of water harvesting structures. GIS technique helps to create thematic maps and integrate all the layers and perform analysis in an efficient manner. Fourteen suitable sites were found for check dam that may serve the purpose of soil and water conservation to help in sustainable development of the catchment. The proposed check dams can be very useful as supplementing irrigation during the dry season.*

***Keywords:** Water harvesting, Remote Sensing, GIS*

1. Introduction:

Water harvesting is defined as the process of collecting and concentrating runoff water from a runoff area into an area where the collected water is directly applied to the cropping area and stored in the soil profile for immediate use by the crop or stored for further uses such as domestic use, livestock watering, aquaculture and irrigation. Water harvesting structures are extremely important to conserve precious natural resource like, soil and water, which is depleting day by day at alarming rate. The collected water can also be used for groundwater recharge. Out of 2.5% global fresh water, only 1% is available for human consumption. According to the World Bank report (Anon., 2002), India will be in water stress zone by the year 2025 and water scare zone by 2050. The land availability level is shrinking day by day. The per capita land availability is in reducing trend and it is estimated that only 0.1 hectare per capita land will be available by the end of 2025 (Sarangi *et al.*, 2005). The water table is rapidly falling with unregulated over exploitation of groundwater. Majority of the surface water ultimately goes to the sea despite of construction of large dams, reservoirs, check dams, water-harvesting structures etc. (Sharma and Paul, 1998). The precipitation in India is highly variable over time and space due to monsoon climate and land - mountain topography. Over time, about 80% of the annual rainfall is received within three monsoon months and the rest 20% in nine dry months with a highly scattered distribution. The need and importance of water harvesting and water conservation has been stressed in national water policy and national agricultural policy of Government of India. The various rainwater-harvesting structures viz., check dams, farm ponds, harvesting bunds, nalla bunds, percolation tanks etc. are constructed at appropriate site that check flood and provide irrigation to downstream. This holistic approach within a watershed in conserving soil and water resources by selecting the suitable site specific soil and water conservation structures will not only conserve soil and water resources but also enhances the crop yield. Location and type of the structures is dependent on many watershed parameters like land use, soil, slope, etc.With a suitable structure it is possible to harness

maximum amount of water from the watershed. Remote Sensing technology can augment the conventional methods of locating structures to a great extent. Satellite data can be interpreted to derive thematic information on landuse, drainage etc. which when combined with the other collateral data (like soil map) and elevation information from topographic maps can be integrated in GIS framework to find the suitable sites for water harvesting structures. Singh et al [1] reported a study in Soankhad watershed, Punjab where they applied information technologies such as Remote Sensing and Geographical Information System (RS-GIS) where fourteen check dams and six percolation tanks were proposed for the construction as per Integrated Mission for Sustainable Development (IMSD) guidelines. The water balance study of the Soankhad watershed was also computed with monthly mean temperature and rainfall data. A case study has been conducted by Bothale et al[2]who used decision support system for identification of suitable sites for water harvesting structures. Different layers were integrated in Arc/Info environment to find the suitable sites. Jabr et al [3] applied a methodology for siting water harvesting reservoirs in a 300 km^2 area of Lebanon characterized by low and erratic precipitation to improve the agriculture potential. The literature sited that the application of RS and GIS is helpful in identification of suitable water harvesting structures. With a suitable structure it is possible to harness maximum amount of water from the watershed. Remote Sensing technology can augment the conventional methods of locating structures to a great extent. In the present study, an attempt has been made to select suitable sites for water harvesting structures in Upper Kangsabati catchment in West Bengal using Remote Sensing and Geographical Information System.

2. Study Area:

The study area taken is a watershed is the Upper Kangsabati upper catchment portion which falls mostly in Puruliya district and partly in Bankura district, the downstream of which is Kangsabati reservoir. This study area lies between 23^0 and $23^030'$ North latitudes and $86^0$and $86^045'$ East longitudes. Total area of the catchment is 1471.21 sq.km. The area is falling under toposheets bearing no. 73I/3,73I/7, 73I/8, 73I/11, and 73I/12 published by survey of India (SOI) on a 1:50000 scale. The climate of the district is hot dry sub humid with mean annual rainfall of 1383 mm. Since the area is dry, construction of water harvesting structures will help in agricultural development and also help in soil and water conservation.

3. Methodology and Results:

Satellite Image of IRS-P6 LISS-III (acquired on 2006), Survey of India toposheets as mentioned above and National Bureau of Soil Survey and Landuse Planning Map[6] as collateral data have been used in the present study. The following criteria has been followed for making decision on selecting suitable sites for various water harvesting structures (mainly check dams) as per Integrated Mission for Sustainable Development (IMSD) guide lines.

(i) The slope should be less than 15 per cent.
(ii) The land use may be barrenland or shrub land.
(iii) The infiltration rate of the soil should be less.
(iv) The type of soil should be sandy clay loam.

3.1. Delineation of Catchment Area:

The Survey of India (SOI) toposheets for the study area have been procured, scanned and geometrically rectified so that each point represents correct geographical coordinates. Satellite Images of IRS-P6 LISS-III have been georeferenced with respect to toposheets and mosaiced. The catchment area has been delineated based on the drainage network of Kangsabati river. The catchment area is shown in Figure 1.

3.2. Preparation of Thematic maps:

Different thematic maps have been prepared from topographic maps, satellite image and other collateral data and the sites were selected based on the above criteria.

3.2.1. Drainage Map: The drainage network map of the study area has been prepared by delineating the river and its tributaries from the topographic maps and updated from satellite imagery. The entire drainage network of the study area was classified from first to sixth order following Strahler's classification system and shown in Figure 2.

3.2.2. Landuse map: Land use map has been derived from the IRS-P6 LISS-III satellite data by Supervised Classification technique. Nine different classes of land use have been differentiated. The classes are agriculture, dense sal, open sal, land, tributary, river, deep water, riverbed and settlement. The landuse map is shown in Figure 3.

3.2.3. Hydrological soil group map : The soil map consists of four different textural classes viz., Silt clay loam, Sandy clay loam, Clay loam, loam. The hydrologic soil group map (Figure 4) was prepared from soil map taking into account the infiltration rate of various soil textures from surface drainage map. Accordingly, the above soil classes were grouped under four categories viz. A, B, C and D.

3.2.4.. Slope map: Slope map was prepared from contours of the toposheets. TIN (Triangulated Irregular Network) is created from contour map. Slope identifies maximum rate of change, from each cell to its neighbors. The output slope grid theme represents the degree of

slope for each cell location. The slope map derived from the TIN is shown in the Figure 5.

3.3. Selection of Suitable Sites:

Landuse map and Hydrological Soil Group map have been overlaid on each other to find features which satifies the criteria of suitable landuse (land, open sal) and poor infiltration rate (HSG C or D) and also the soil type of sandy clay loam. Now, slope map was overlaid on the above map and the areas having gentle slope have been selected. Check dams have been selected on the drainages of order 2 to 4. The attribute table is shown in Table 1 which depicts the stream order, landuse and hydrological soil group. The sites are shown in Figure 6.

4. Discussion and Conclusions:

The Puruliya district area of West Bengal possesses soil and water management problems. The good cultivable areas are in the upper Kangsabati catchment which is selected for planning suitable sites for construction of water harvesting structures using remote sensing and GIS techniques**.** The suitability of check dam sites can be confirmed as the site is located on lower order drainages and satisfies the criteria. One of the site is coinciding with the reservoir site. Fourteen suitable sites were found for check dams that may serve the purpose of soil and water conservations and groundwater augmentation. The check dams proposed at appropriate sites will in turn benefit the soil and water conservation and groundwater recharge to help in sustainable development of the watershed.

5. References:

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Table 1. **Attributes of suitable sites**

Attributes of Finalsite1.shp

Shape	Stream_ord	Landuse	Soil_group	Soil_type	Length
PolyLine	3	River	C	loamysand-sandyc	58.217
PolyLine	2	Land	C	loamysand-sandyc	383.086
PolyLine	2	River	C	loamysand-sandyc	34.896
PolyLine	3	Land	C	loamysand-sandyc	321.948
PolyLine	2	Land	C	loamysand-sandyc	175.478
PolyLine	3	Land	C	loamysand-sandyc	137.072
PolyLine	3	River	C	loamysand-sandyc	29.327
PolyLine	4	Land	C	loamysand-sandyc	73.298
PolyLine	4	Open Sal	C	loamysand-sandyc	27.496
PolyLine	2	Land	D	loamysand-sandyc	348.369

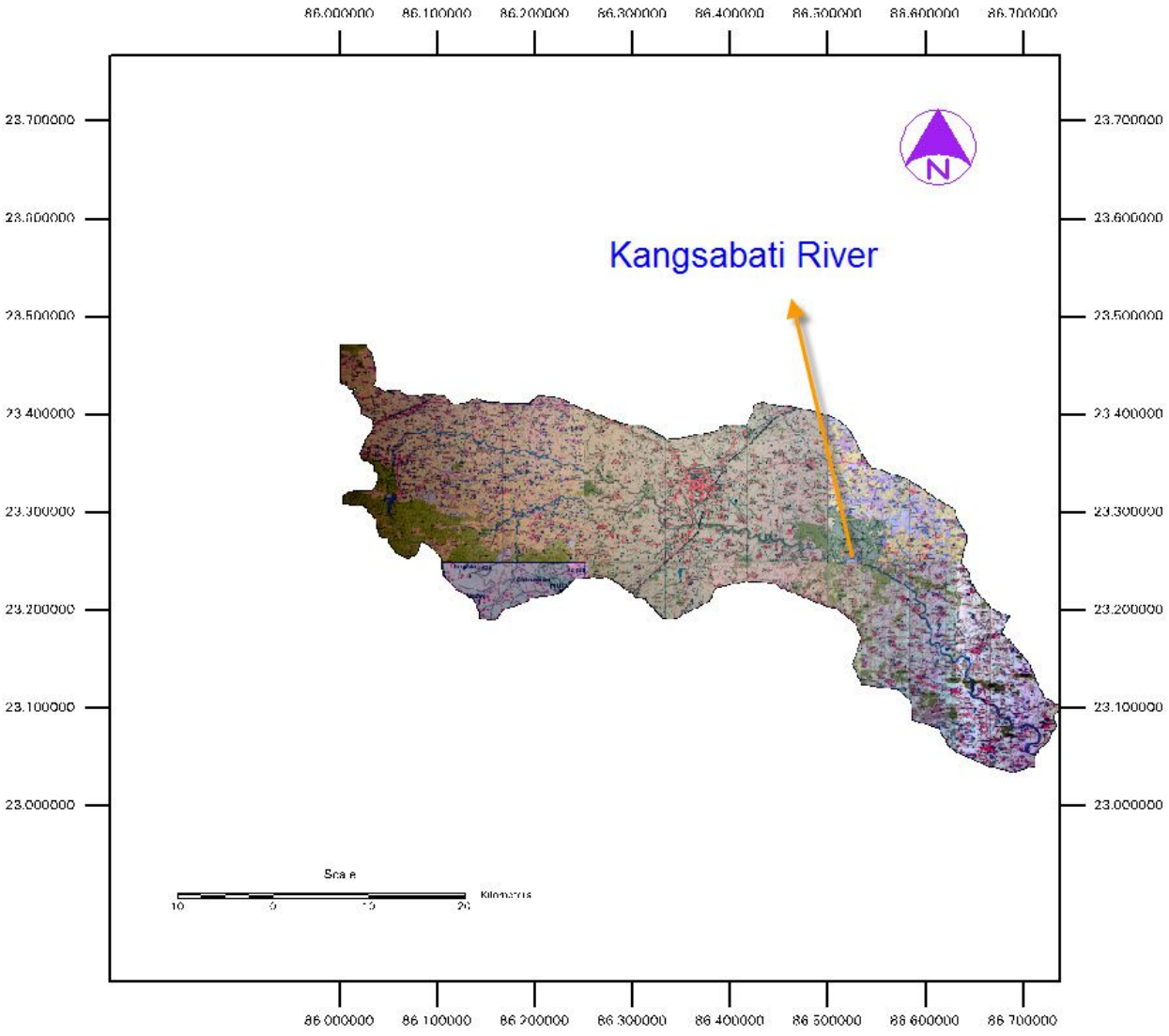

Figure 1. Study area of the catchment

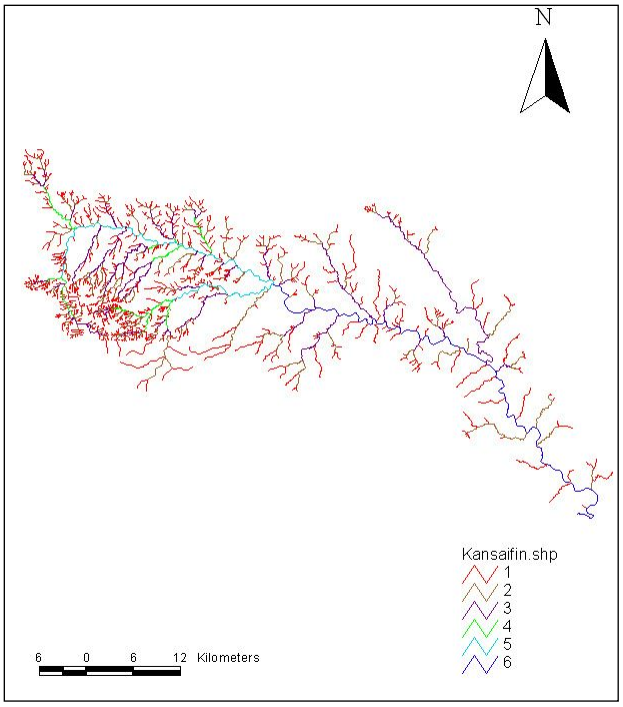

Figure 2. Drainage map of the catchment

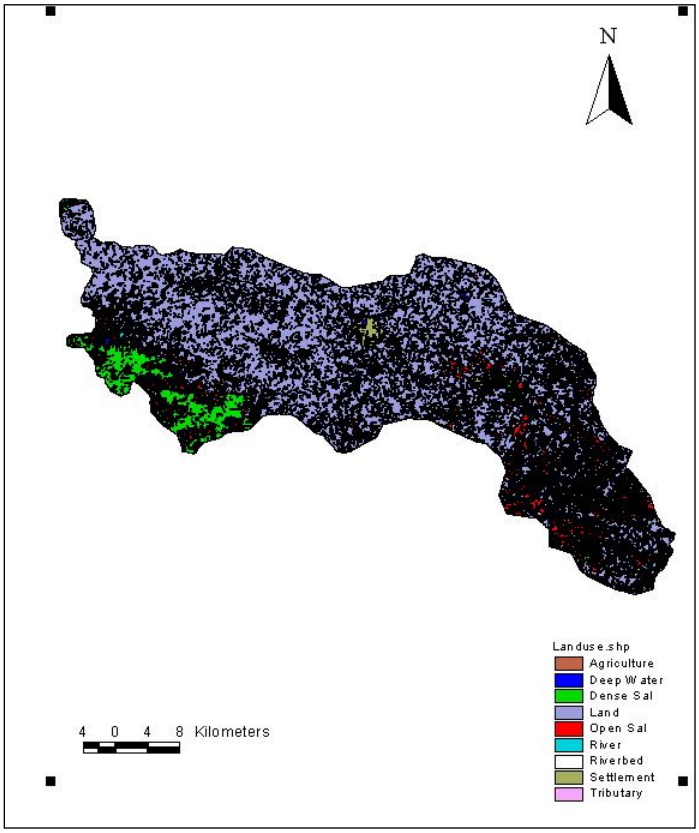

Figure 3. Landuse map of the catchment

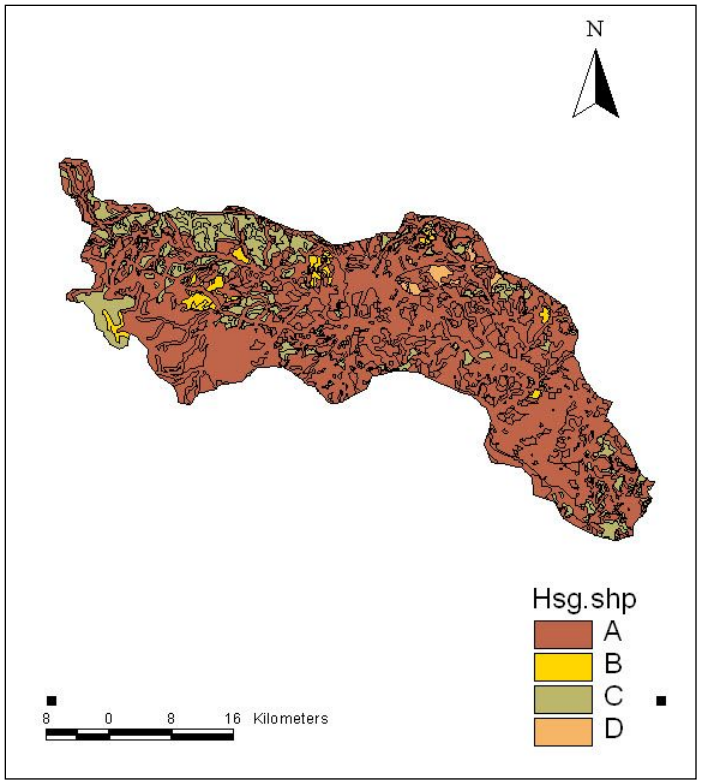

Figure 4. Hydrological Soil Group map of the catchment

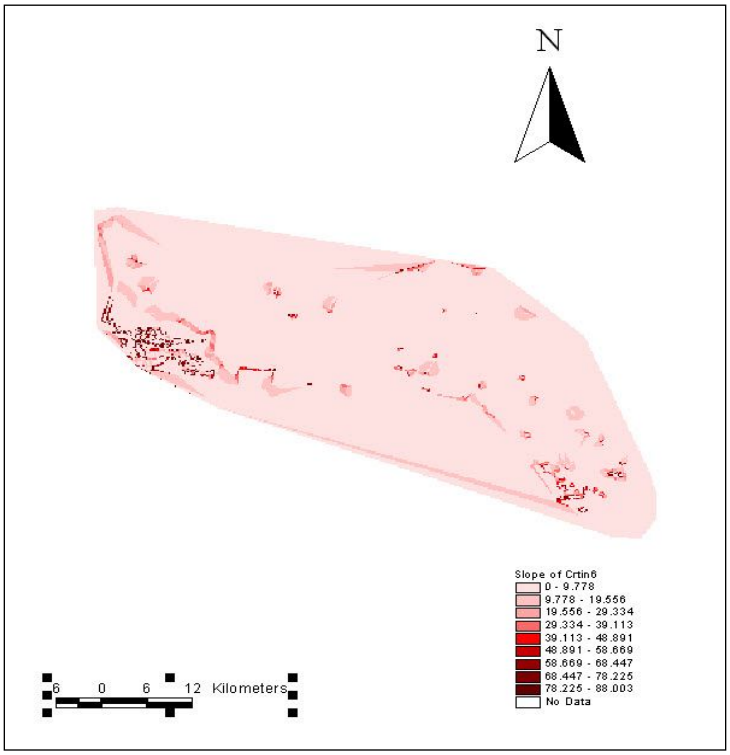

Figure 5. Slope map of the catchment

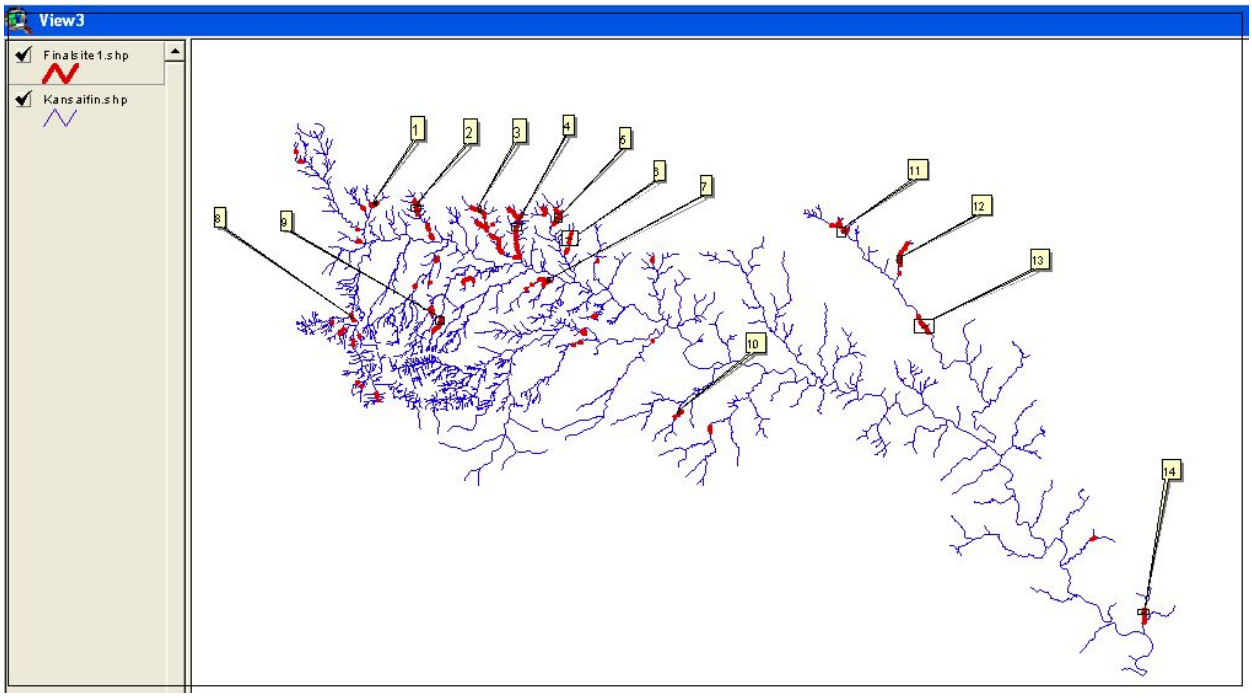

Figure 6. Selection of suitable sites for check dams