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Research Paper

Analysis of Flooding Pattern through Digital Elevation Model: An Appraisal on Amodar River Basin

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ABSTRACT
Amodar is a small significant river having huge local importance in agricultural sector and played a significant role in geo-hydrology of Kotulpur Block, Bankura. The river is non perennial in nature and in rainy season it becomes feurious one for Joypur and Kotulpur Block of Bishnupur Sub-Division, Bankura and Goghat Block of Arambagh Sub-Division, Hooghly. In this study, we used SRTM water body data and CartoDEM Version-3R1 data to analyse the area and making DEM of Amodar Basin. Seasonality of water existence has been also mapped through spatio-temporal perspective. Through DEM images, surface runoff pattern has been also analysed. Rainfall data is computed by using SPSS software. The study shows that there is a high elevation in lower riches of this river basin and number of small gullies and rills are well connected with this river. Rate of Sedimentation is comparatively high in lower portion as flowing through sedimentary surface. Unscientific Road Bridge is also becoming a significant factor to hampered channel flow of river in rainy season. It is also seen that surface runoff is intensifying very high in rainy season not only for heavy precipitation, but also existence lateritic hardpan. As a result, there is a huge amount of water supply in rainy season. Water stagnancy in basin area is not as dominant as the number of large scale water body is minimal. So, water holding capacity in the Basin of Amodar River is not very high. It also signifies that the maximum portion of precipitation over the basin area is channelized through small gullies and rills, which causes flooding situation in rainy season in each and every year. In this study, we want to explore what are the main causing factors behind the flooding condition in this basin and how DEM analysis will help to analyze flooding pattern.
KEY WORDS: *Geo-hydrology, Lateritic hardpan, Perennial, Spatio-temporal, Surface runoff, Tributary*

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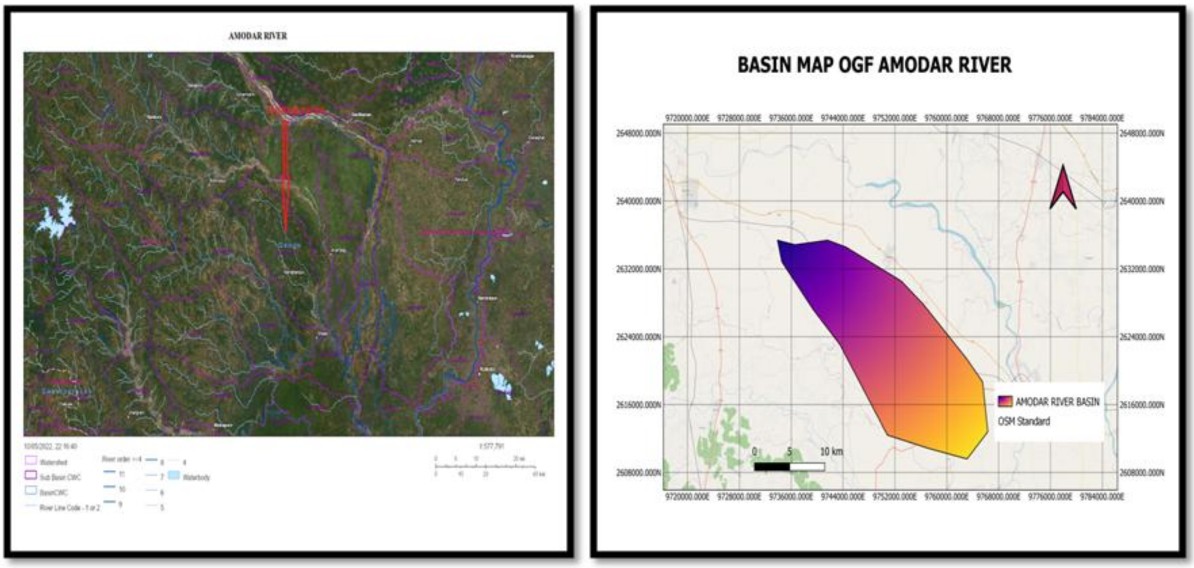
I. INTRODUCTION

All methods developed to automatically analyze and process raster digital elevation models (DEM) in order to measure and delineate the components of drainage basins and drainage networks are being categorized as a potential and valuable tool for the topographic classification of hydrological models. These methods operating on some form of overland flow estimation to define catchment areas and drainage courses and therefore have a difficulty dealing with flat areas and closed depressions on digital land surface models. Few fundamental probabilities about the nature of these problem regarding geomorphic features in DEM are solved in the several techniques and methods developed to deal with them in creation of automated drainage analysis (Martz and Garbrecht, 1998). Geo-hydrologic process and water resource issues are commonly investigated and analyzed by use of distributed watershed models. These watershed models require topographic data and information such as distribution of the channel network, location of water shades, channel slope and length, and sub-catchment geometric components. Commonly, these parameters are obtained from maps or from field analysis. During last few years, this information has been increasingly generated directly from digital representations of the physiography (Jenson and Domingue, 1988; Mark, 1984; Moore et al., 1991; Martz and Garbrecht, 1992). The digital presentation of the physiographic or relief features is called a Digital Elevation Model (DEM). It is seen that the automated derivation of geomorphic watershed data from DEMs is less subjective, provides more reproducible measurements and faster than conventional manual techniques applied to topographic maps (Tribe, 1992). The technological advancement provided by GIS, the increasing availability and quality of DEMs have greatly explored the application potential of DEMs to many water resources, environmental investigations, hydrologic and hydraulic (Moore et al., 1991). In this paper the resolution, quality, availability, production and capabilities of DEMs are cross checked and elaborated with respect to the derivation of geomorphic data in support of water resources investigations and hydrologic. In this paper pertains the subject matter which covered to DEMs of natural topographic features and does not extend to small and scale embankment and manmade structures such as street gutters, inlets, bridges, drainage ditches and culverts control surface drainage patterns.

II. STUDY AREA

The source Amodar Nod (River) is located at 87.47E, 23.04N in Joypur Block, Bankura (Fig.1a) . It is the significant tributary of river Darakeswar. The river is passing through 3 blocks, i.e. Joypur and Kotulpur Block of Bankura District and Goghat Block of Hooghly District. The length of this river is 76 km approx. This area has fertile low elevated alluvial soils. Thus agricultural activities are so dominant in that area. More over 91% of population are living in rural area, whereas less than 9% of people are living in urban areas. A large number of people are working as marginal agricultural labourers. Moreover 16000 hectares area under Net Shown Area (NSA) of this basin and near about 12000 hectares area under one crop. Agri-irrigation is being done basically in canal irrigation mode and some of through tank water irrigation, river lift irrigation, deep tube well and shallow tube well. The area is famous for Potato and Aman Paddy cultivation.



(a) **(b)**

Figure: 1. (a) Amodar River and (b) Amodar River Basin

So many minor gullies, rills and channels are the main supplier of water, sediments, minerals, pollutants (Agricultural, household, brick clines) etc. The upper segment of this river is passing through comparatively harder rocks and after towards confluence alluvium is present. The river course is much meandering in middle stage and the number of meandering is increasing at lower reaches. Sediment load is on peak at middle to lower portion. That is why, embankment is common phenomena in rainy season. River course is become significantly swallowing as well as enlarge. Unscientific culverts, bridges, bandh, reservoirs are now creating more vulnerable situation during rainy season. So flooding is now common event during last few decades. The river basin (Fig.1b) is so significant for agri-economics because of enriched flood plain.

III. MATERIALS AND METHODS

Digital elevation models (DEMs) are very useful source of data for the auto delineation of flow paths, sub watersheds mapping and stream flow networks for accurate hydrologic modeling. Digital or satellite based representation of the channel flow network is central to distributed hydro-geomorphic models because it enable to encodes the model element correlation through which flow is routed to the outlet portion.

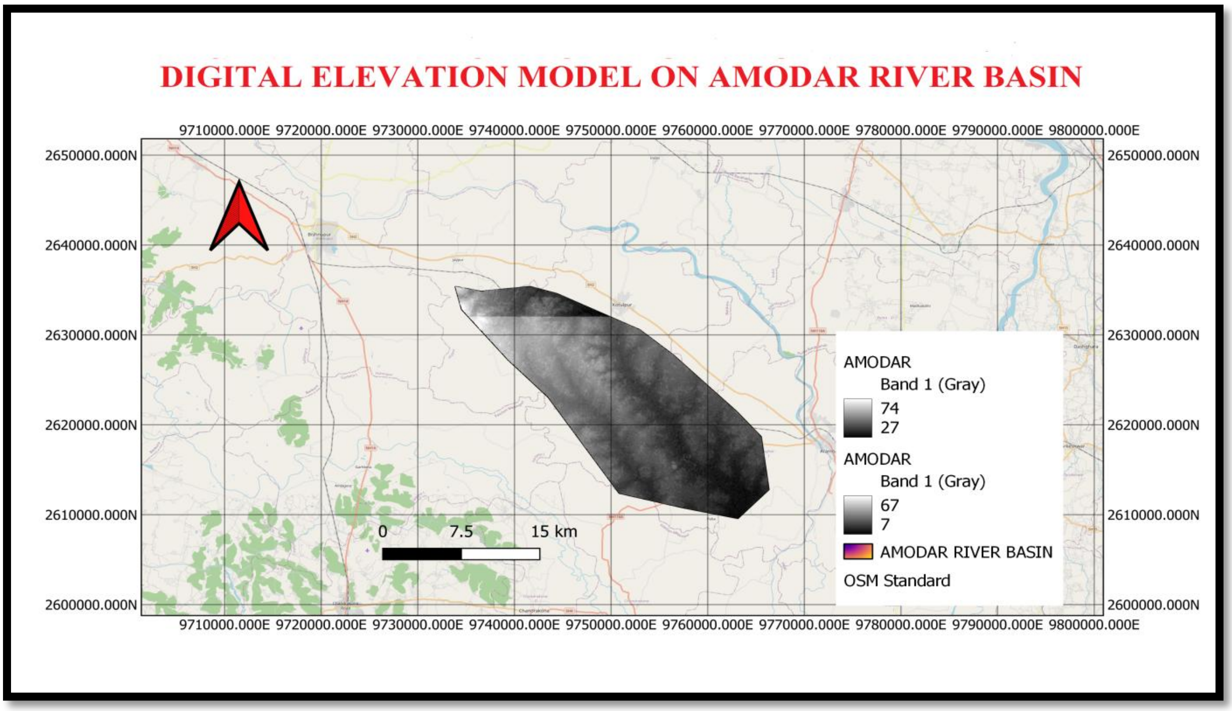


Fig: 2. Digital Elevation Model (DEM) of Amodar River Basin

In the flow network, the scale of drainage density is used to controls the scale of hill slope and channel flow model elements. Although field mapping is categorized as the most prominent way to calculate channel networks and drainage density, it is often significant, especially for large watersheds, and DEM derived flow networks then offer a useful substitute for channel or basin networks. There are a several of approaches or methodologies to delineating channel flow networks, using different algorithms or digital technologies such as single (channel drainage pattern to a single neighboring cell) and multiple (partitioning of channel flow between multiple neighboring cells) flow direction methods for the calculation of water contributing area and local identification or signature of upstream curvature. The scale of the delineated network is sometimes controlled by a support area threshold. Through this analysis, I am trying to examine the question of describes a method based on terrain curvature and objective estimation of drainage density, that variable drainage density can spatially accommodate. DEM horizontal resolution and its ratio to vertical resolution can have a significant bearing on computed land surface components that create differences in elevations. For instance, slope is computed as the difference in elevation between two adjacent pixels divided by the distance between them. The calculated slope can only take on a limited number of discreet values since DEM elevations are generally reported in full meters or feet. The study incorporates with the Hydrologic Engineering System models effective within the stipulated geographic information system to simulate and flood hazards map of Amodar Basin. Through the DEM of Amodar River Basin (Fig. 2), it is seen that south west part of the basin have maximum water and sediment feeding gullies and channels. The validity and accuracy of this model was verified using various statistical measures.

IV. RESULTS

One of the most destructive natural hazards is flooding that happen around world. It causes damage of property and infrastructure or even the loss of lives. As a result of combined issues like climate change and anthropogenic factors, the intensity and number of flooding events happened. So there is a need of real-time solutions for mapping flood hazards and its probable vulnerability. A methodological framework is proposed through this study which enables the assessment of flood hazard and consequences level dynamically by using satellite remote sensing (STRM data) and Q-GIS based data from the region of the Amodar Basin.

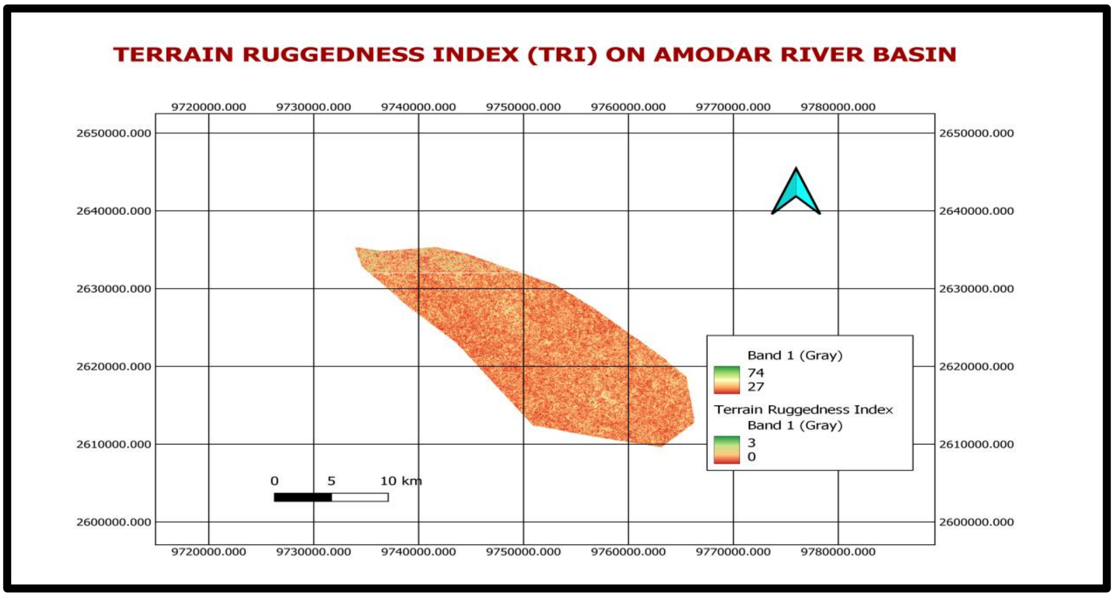


Fig: 3. Terrain Ruggedness Index (TRI) on Amodar River Basin

From the Fig.3, we can say that the majority of this basin area is flat and slope towards south east as the local base level of erosion is river Darakeswar. So, the average ruggedness index is near about 3, which is very low in terms of elevation.

Lastly, by a combination of a rule-based study to get the exposure and vulnerability with the continuous assessment of flood hazard, the estimation of the flood risk was achieved.

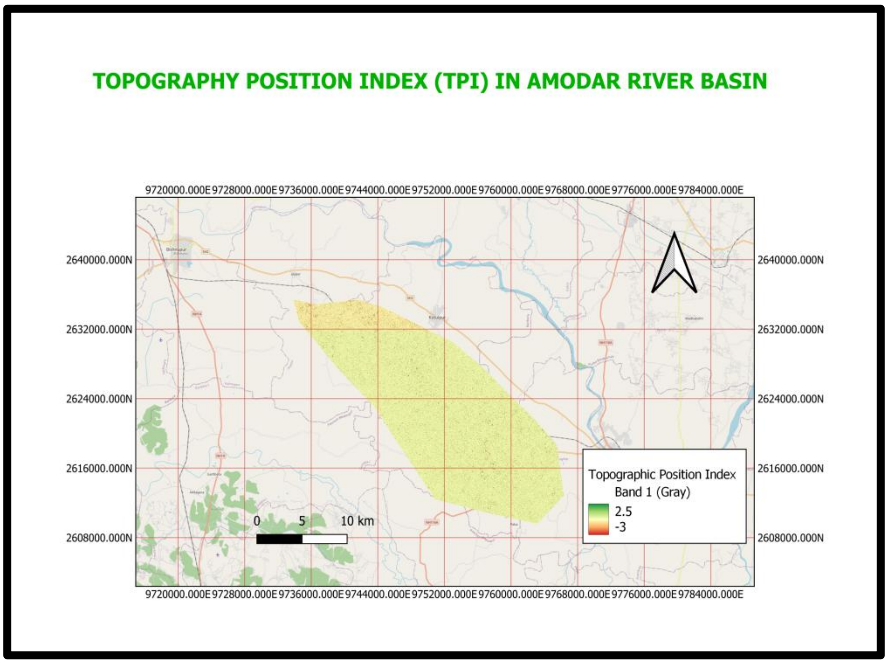


Fig: 4. Topography Position Index (TPI) on Amodar River Basin

Significant topographic features are not available here (Fig.4). Moreover, 80% of Total area is covered under alluvial pan. So, due to increasing rate of surface runoff towards east and high sediment load, number of river meandering is very high in lower riches.

Table: 1. Rainfall Distribution (Max, Min and Avg.) during Rainy Season from 2012 to 2021 on Amodar Basin Based on WRIS data.

Sl. No.	Period	Maximum Rainfall received (mm)	Minimum Rainfall received (mm)	Average Rainfall received (mm)	Source
1	June'2021-August'2021	200-400	200-400	200-400	Indiawris.gov.in
2	June'2020-August'2020	200-400	100-150	200-400	Indiawris.gov.in
3	June'2019-August'2019	200-400	50-100	150-200	Indiawris.gov.in
4	June'2018-August'2018	200-400	100-150	200-300	Indiawris.gov.in
5	June'2017-August'2017	>500	200-400	200-400	Indiawris.gov.in
6	June'2016-August'2016	>500	100-150	200-400	Indiawris.gov.in
7	June'2015-August'2015	>500	200-400	200-400	Indiawris.gov.in
8	June'2014-August'2014	200-400	150-200	200-400	Indiawris.gov.in
9	June'2013-August'2013	200-400	50-100	200-400	Indiawris.gov.in
10	June'2012-August'2012	150-200	100-150	150-200	Indiawris.gov.in

From the table 1, we can say that the basin area received maximum rainfall during rainy season from 2015 to 2017. So there is a flooding condition prevailing over there. On the other hand, when we see at 2021 (Fig.5), the rainfall volume is so high. Beside this, due to a newly constructed bridge on Chatra Khal, the river course partially affected. As a result of it, there is a flooding condition over the lower portion of this basin.

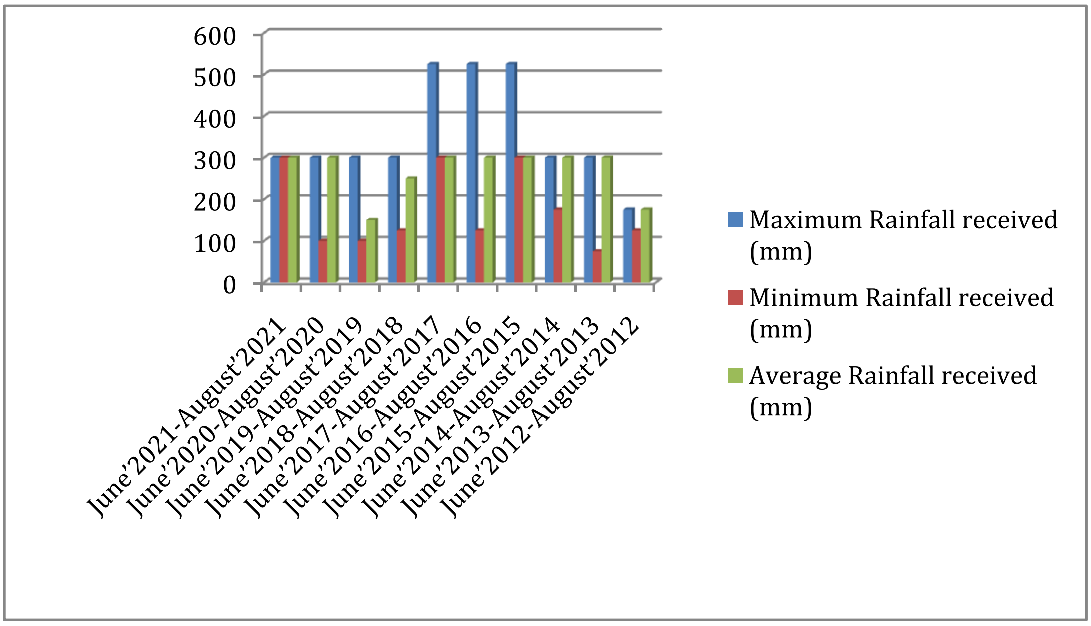


Fig: 5. Showing year wise rainfall (Max, min and Avg.) during rainy season from 2012-2021

Table: 2. Showing correlation among year wise rainfall pattern

Period	Maximum Rainfall received (mm)	Minimum Rainfall received (mm)	Average Rainfall received (mm)
Maximum Rainfall received (mm)	1	0.516753	0.521526
Minimum Rainfall received (mm)	0.516753	1	0.521526
Average Rainfall received (mm)	0.521526	0.40258	1

From table 2, we get a perfect correlation between rainfall data over the last 10 years. There is a positive correlation between rainfall data.

Table: 3. Showing ANOVA on year wise occurrence of rainfall during rainy season

Source of Variation	SS	df	MS	F_{obs}	P-value	F crit
Year	151166.7	9	16796.3	3.296683	0.014962	2.456281
Rainfall in mm	166625	2	83312.5	16.35211	8.95E-05	3.554557
Error	91708.33	18	5094.907			

From the ANOVA (table. 3) we can say that there is a significant difference or variation between the years and rainfall parameters. F observe value is greater that F critical value in terms of both years and rainfall.

V. DISCUSSIONS

As a key input parameter for a detailed flood simulation and mapping, the topographic information plays a vital role. This study aimed to compute the accuracy statistics of the flood models developed using the digital elevation data with different spectral resolution resolutions from the ranging and light detection and through inter-ferometric synthetic aperture radar systems.The detailed physiographic data contained in light detection and ranging (LiDAR) through digital elevation models (DEMs) can face significant challenges for modelling fluvial drainage patterns. This information frequently represent anthropogenic infrastructure like drainage ditches and road embankments.

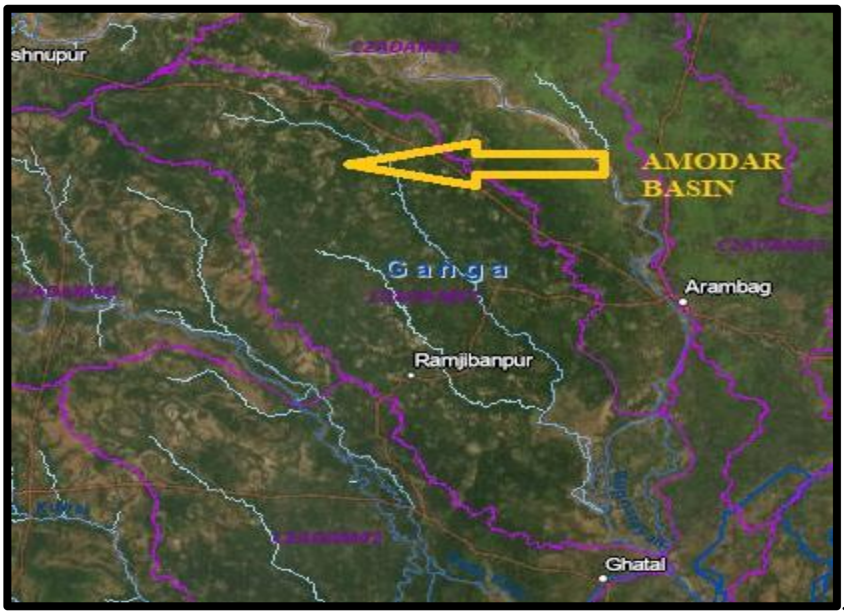


Fig: 6. Satellite View of Drainage Basin Area of Amodar River (From INDIA_WRIS)

With the help of depression filling raises, the average elevations of grid cells contained within topographic depressions to the elevation of the outer cell. Though number of algorithms have been evolved to fill depressions within DEMs, they differ only in their approach or methodology and computational proficiency. The solution resulting from any depression filling algorithm is identical. Depression breaching by comparison lowers the grid cells along a breach channel, or trench, through an artifact dam or drainage blockage (Rieger 1998). Depression filling yields a solution that is always contained within the DEM, whereas the trench channel of a breaching operation is external to the depression feature.

VI. CONCLUSIONS

Flooding phenomena is very common in Amodar Basin area. During the study it is seen that, presence of many small scale rill and gullies, lack of large water bodies besides the bank of this river, high soil erosion due to minimum vegetation cover beside the river, huge amount of surface run off due to presence of hard pan below the basin surface, adequate amount of rainfall during rainy season, unscientific construction of bridges, culverts, bandh etc are the main causing factors of flooding situation in middle to lower portion of the basin. So, our observations and recommendations are that if tree plantation may be done to minimise soil erosion, construction of bridges and culverts using scientific methods to help the free oscillation and passing of water through the channel during rainy season, construction of check dams may be done to create water pocket etc., then the situation may be regulated and on the other hand, water resources may be utilised for irrigation purpose or ground water recharge.

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