Peer Reviewed International Research Journal of Geography
Maharashtra Bhugolshastra Sanshodhan Patrika
ISSN : 0971-6785 {Impact Factor 4.567 Renew (IIFS)} Vol. 38, No.2, July-Dec 2021. pp 39-46

"GIS-Based Multi-criteria Approach towards Sustainability of Rainfall distribution and Flood hazard Areas in Wainganga River in Maharashtra, India"

Ravindra S. Bhagat[1] Nanabhau S. Kudnar[2] Hanumant D.Shinde [3]

Abstract

The present study on GIS-based multi-criteria approach towards sustainability of rainfall and flood areas in Wainganga River in Maharashtra, India.Effect of physical factor on Flood hazard of the Wainganga River in Maharashtra, India: A GIS & Remote sensing techniques. Flood is a one of the natural calamities. It's occurred in all rivers and drainage and its damages natural resources and the lives and also the loss of economy and human being. So we have attempt to how physical factor effect on occurring flood of Wainganga river based on GIS & Remote sensing techniques. So the considered that study we use rainfall distribution, land use and land cover, types of soil, drainage density, slope etc. are factor on flood hazard. The present study depicts the process of evaluating various physical and hydrological parameters of the Wainganga River by applying remote sensing, geographical information system and global positioning system techniques. The data can be used for basin management, hydrological, and utilized in restoration and conservation of natural resource studies in the future.

Keywords: *Wainganga river basin, Grid rainfall, Flood hazard map, GIS, remote sensing etc.*

Introduction

The occurrence of extreme flood events is among Earth's most common and most destructive natural hazards due to the devastating consequences on both individuals and communities, e.g., social, economic, and environmental consequences. Flood is natural disaste (Theochari, et al, 2021). Flood is local event and sometime short or long period events and it not give any warning to happening on earth surface(Ajin et al, 2013, Bhagat and Bisen, 2015, 2016; Bhagat, 2020;Hire, 2000).Flood frequency, magnitude and the cost of damage are on the rise all over the world. We know that man has constructed his settlement along the streams, rivers or coasts (Kale,2002; Horton, 1932;Rajasekhar et al, 2021).Now a day's small settlements are converted into big cities as population is fast increasing and at the same time constructions are also increasing which has reduced the percentage of available land(Thilagavathi, et al 2011; Salunke et al, 2021). Any region having high population density is more sensitive to floods because of lack of flood control, lack of emergency response infrastructure and early warning systems. The rivers bring heavy sediment load from the catchments. Inadequate carrying capacity of the rivers is responsible for causing floods, drainage congestion and erosion and deposition of river-banks.

Study area

The study areas lies between latitude extension 19030'N to 22030 N' and longitude extension of 79000'E to 80030 E'. The Wainganga River rises atEl 640.0 m in the Seoni District of Madhya Pradesh from the Western slopesof Maikala Ranges which is continuation of the Satpura Ranges in Central India (Kudnar, 2015, 2017, 2018). The Wainganga River (Salunke et al, 2021; Kudnar, 2020; Kudnar et al 2021) receives numerous tributaries on either bank and drains the western, central and eastern regions of the Chandrapur, Gadchiroli, Bhandara, Gondia and Nagpur districts of Maharashtra(Bisenand Kudnar2013). This river draining major portion of the Maharashtra plateau. The upper catchment area lies in the high rainfall range of 2000-4000 mm.

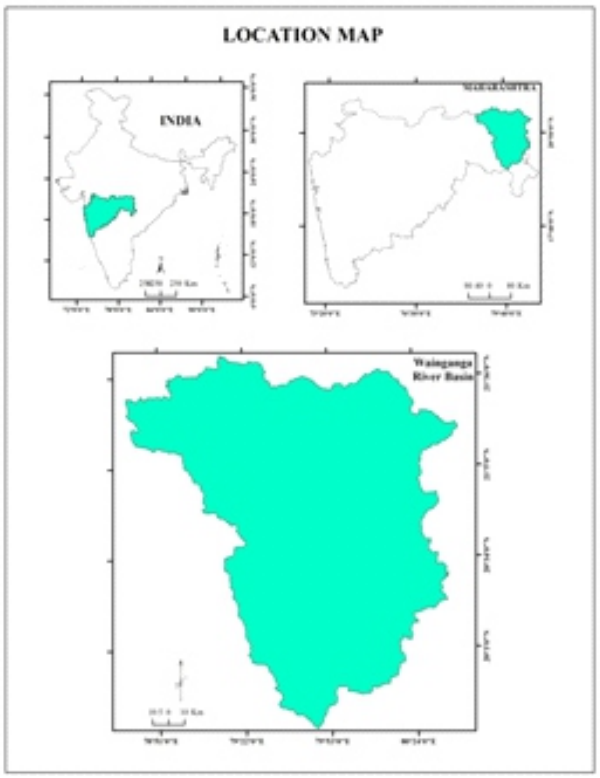

Fig 1. Location Map of Study Area

Objective

1) GIS-Based Multi-criteria Approach Towards Sustainability of Rainfall and Flood hazard Areas in Wainganga River in Maharashtra, India
2) To understand general land use and land cover of study area.
3) To understand the Physiographic profile of study area
4) Try to identify controlling factor on flood hazard.

Data Collection and Methodology

For the present studies the various maps were formed using ArcGIS. For the present studies of flood analysis data have obtained from one inch topographic map of Survey of India (1:63,360 or 1:2, 50,000). For the prepare a base map, drainage map, water bodies digitized from the toposheet No. 55K, 55O, 55P, 56M, 64C, 64D, 65A.

Result & Discussion

Soil type

Soil type is important factor as the amount of water flow through soil is depends on infiltration capacity for the flood hazard zone. The characteristics and distribution of soils in upper Wainganga region are influenced essentially by the nature and intensity of weathering and the mode and rapidity of fluvial transport on the plateau. For eg. Kali, Kanhar, Sihar, Morand, Khardi and Bardi are the main types of soils that are found in study region. Soil types was obtained from Survey of India toposheet and National Bureau of Soil Survey and Land use Planning. Wainganga sub-basin may broadly be divided into three main categories namely black soil, red soil and mixed black and red soil. So the

high infiltration rate is more than other soil. That means to chances of flood increase with decrease in infiltration capacity (Salunke, et al. 2020; Sneh, 2013).

Rainfall distribution

The rainfall data of these stations were collected from IMD and the rainfall maps was prepared using 49 Grid stations and prepare spatial and temporal rainfall map form collected IMD .Rainfall distribution is important factor for flood hazard zonation. High intensity rainfall is results into heavy floods. Floods occur when the volume of water exceeds the ability of a stream and river to hold the water within its normal banks. Gridded rainfall data of 0.250 * 0.250 resolutions was analyzed to annual and seasonal scales in Wainganga river basin located in Maharashtra during 1961 to 2014.

Distribution of Rainy Season Rainfall

Precepitation records are considered for a period of 54 years from 1961 to 2014 for 49 grid zone in the catchment. Another important aspect of the annual variability of rainfall is the variation in rainy season rainfall for Wainganga basin. The peak maximum of the annual rainfall of recorded 1434 mm to 1487 mm covers area about 129.12sq.km. But the lowest rainfall during monsoon season ranges between having 1052mm to 1106mm its cover area of 751.91 sq.km. Another way of explanation of maximum area is 9200.82 sq.km. area 1216 to 1269 mm of rainfall.

Table 1: Rainy Season Mean Rainfall With Area in mm (1901 - 2014)

Sr. No.	Annual Rainfall	Area km^2
1	1,216 - 1,269	9200.82
2	1,107 - 1,161	1006.58
3	1,162 - 1,215	2748.54
4	1,434 - 1,487	129.12
5	1,379 - 1,433	668.37
6	1,325 - 1,378	3670.93
7	1,270 - 1,324	8170.52
8	1,052 - 1,106	751.91
	Total	**26347.47**

Source: Computed by Researcher

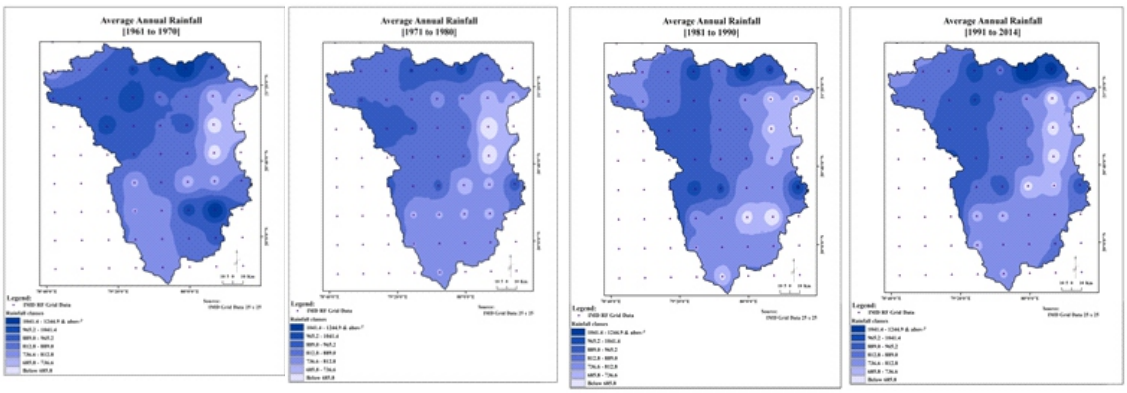

Fig 2.Rainfall Distribution

Land use land cover

The Wainganga distribution of land use land cover classes of image include rocky land /open space, dense Forest, water bodies, agriculture, sparse vegetation, fallow land, open Scrub, barren land,

settlement, gravel land. The major land use categories in the Wainganga River's basin includes build up land (1.89%) and agricultural land (14.17%) that comprises of generally kharif, rabi and double crop system in the region. For Agricultural land the presence of thick vegetation cover slows that's why the reduces amount of runoff. Forest cover (65.75%) comprises of dense forest (15.03%), sparse vegetation (23.01%), open Scrub (27.71%) and recent plantations. Deciduous or dense forest largely spreads out in the region in the east of the all Wainganga river basin area. Forest cover comprises of deciduous forests, degraded forests, forest blanks and recent plantations. Barren land consists of soil in which plants cannot grow results in increasing runoff on the other side fallow land causes destruction to free flow of runoff. Water Bodies (2.11%), barren Land (9.48%), fallow Land (4.19%), gravel Land (0.52%), rocky Land or open Space (1.88%) can also be found in the region. Waste land with or without scrub and barren rocky/stony waste can also be found in the region.

Table 2 - The Land use & Land Cover pattern of the Wainganga sub-basin

Sr. No	Land use/ Land Cover Category	Area in sq.km.	Total Geographical Area (%)
01	Rocky land/ Open space	495.49	1.88
02	Dense Forest	3960.89	15.03
03	Water bodies	558.21	2.11
04	Agriculture	3735.03	14.17
05	Sparse vegetation	6063.82	23.01
06	Fallow land	1101.28	4.19
07	Open Scrub	7299.50	27.71
08	Barren land	2497.43	9.48
09	Settlement	497.46	1.89
10	Gravel land	137.90	0.52
Total		**26347.01**	**100**

Slope

Slope of a land is one of the important physiographic aspects that influence the agricultural land use of an area. The direction of the slope of this study region is from north-west to south-east. The eastward slope and northwestern in the study area is gentle but the slope in the western and northern part is steep i.e. 1.50%.

Very Steep Slopes

The Balaghat Range has bare slopes and gullied topography. These are the limiting and controlling variables in terms of its land use pattern. It seems to be a severe soil erosion zone during monsoon. It is characterized by coarser texture of soil, thin soil cover and mere vegetation growth. The very strongly and steeply sloping zones are found in northern part of Wainganga basin. The steep slope area i.e. 5.66% is the limitation for the agricultural land use. Therefore, in such area the small patches of land between the two high elevated areas.

Table 3 : Slope in Study area

Sr. No.	Slope Class	Area in ha.	Area Sq.Km.	Area (%)
1	**Gentle**	1463008.80	14630.09	55.53%
2	**Moderate**	717292.50	7172.93	27.23%
3	**Stiff**	265055.62	2650.56	10.06%
4	**Steep**	149173.90	1491.74	5.66%
5	**Very Steep**	36758.14	367.58	1.40%
6	**Extra Steep**	2670.17	26.70	0.10%
7	**Precipitous**	722.07	7.22	0.03%
Total		**2634681**	**26346.8**	**100%**

Source: Computed by Researcher

Moderately Steep Slopes

Along the bank of Wainganga River, the eastern and northern part of the Bhandara, Gondia and some part of the Nagpur district has moderate slope. The central part has also moderate slope. The average slope of this region is about 300 to 400. Coarser texture soil is distributed due to surface wash and mass wasting process. The bare nature hill slopes support to high erodibility. The material is removed from upper slopes and deposited at the foothills. Large boulders are released and accumulated at the base of the hills. The unit appears to have maximum proportion of waste land, rocky barren and fallow land.

Gentle Slopes

This unit comprises of very high area of the study area (55.53%). These slopes are observed in the western, southern part of the Wainganga basin, the piedmont plain is formed by alluvium transported from the upslope region on the confluence of Wainganga and Wardha River near Ashthi village. Such plains are favourable for the agriculture activities. The left bank of Kanhan River has also the plain area.

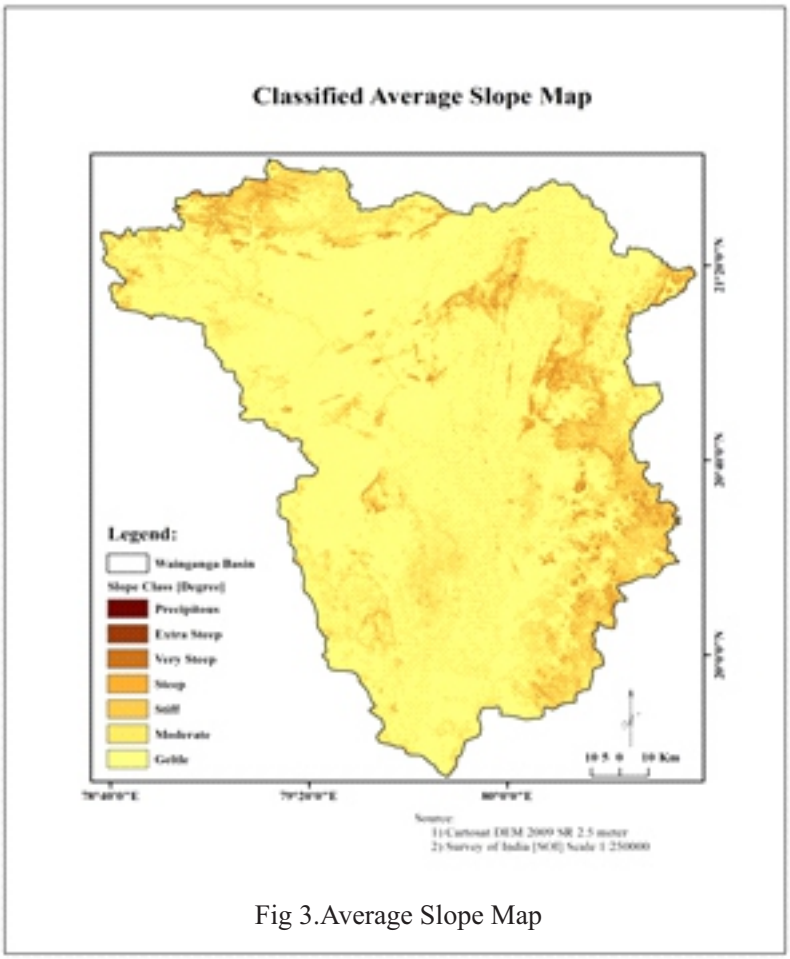

Fig 3.Average Slope Map

Drainage Density

Drainage density refers to total stream lengths per unit areaIt is a measure of how the watershed is drained by streams. A low drainage density value is not favourable for runoff or less runoff and hence indicates of high chance of flood.

$$\text{Drainage density} = Dd = \Sigma L/A$$
$$= 16634.51\ \text{km}/26347.47\ \text{km}^2$$
$$= 0.63$$

The Wainganga River sub-basin drainage density is Coarse (drainage density 0.63) on account of such as basalt, hilly relief, hard rock which tends to give low drainage density. Map 4.4 shows that North and south part have been the high drainage density but in the middle part of the basin very low dense. It is affected by the factors which control the characteristic length like resistance of weathering, permeability of rock formation, climate, vegetation etc. High drainage density is noticed in the regions of weak and impermeable surface material and sparse vegetation and mountain relief. The mean value of Dd in Wainganga river basin is 0.63 km. /sq.km. This indicates the resistance permeable material with fairly vegetative cover and low relief. But as the spatial variation is concerned, the upper Wainganga basin indicates very high Dd value (5 to 8 km. per sq. km.). Therefore, the basin is weak and impermeable surface material and relatively greater topographical relief.

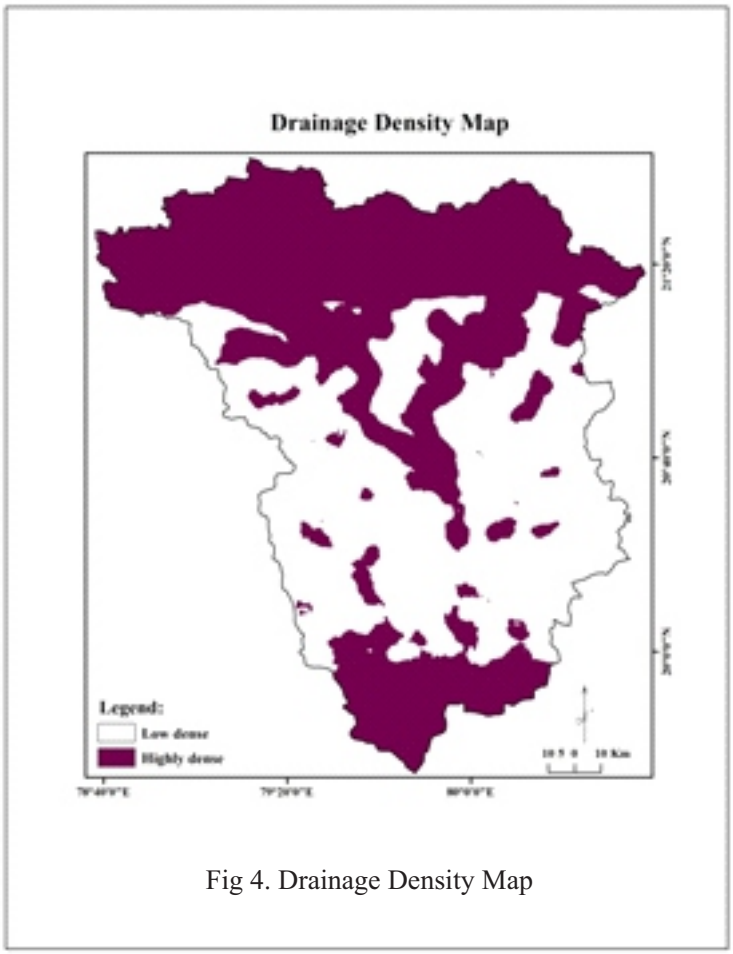

Fig 4. Drainage Density Map

Flood Hazard of study region -

Flood hazard give us an idea of highest flood levels in the flood prone areas which help to understand channel changes and socio-economic losses in the study region.

Conclusion

This paper presents a GIS-based MCDA approach for the identification of potential flood-prone area and flood hazard map assessment through hydrological analysis and hydraulic simulation at an ungauged river basin.The study was carried out with how physical factors are impact on flood on Wainganga basin. GIS tool is usefual for preparing of flood map which is useful for public awarenss. So planner take decision to response measure. Like as Flood booths are the major unit to provide relief and rescue operation. These booths provide real-time information on the flood stage of river to flood control. Flood forecasting stations should also be increased so that a proper coverage of entire area is done and a forecast should be done much before actual occurrence, so that evacuation can be carried out in time. This will save human and cattle lives and also the damage to moveable property.

Reference

1. Ajin, R. S., Krishnamurthy, R. R., Jayaprakash, M. and Vinod, P. G., (2013), Flood hazard assessment of Vamanapuram River Basin, Kerala, India: An approach using Remote Sensing and GIS techniques, Advances in Applied Science Research, 4(3), pp 263-274.
2. Bhagat, Ravindra and BisenDevendra (2015) Flood Study of Wainganga River in Maharashtra Using GIS & Remote Sensing Techniques, International Journal of Science and Research, 782-785.
3. Bhagat, Ravindra and BisenDevendra (2016) Land use and Land cover of Wainganga River in Maharashtra using GIS and Remote sensing technique, Golden Research Thoughts, International Recognition Multidisciplinary Research Journal ISSN: 2231-5063, Volume - 5 | Issue – 9, Page No. 1-7
4. Bhagat, R. S. (2020) Longitudinal Dispersion Characteristics of Wainganga River and Natural Streams, India, Our Heritage, ISSN: 0474-9030 Vol-68-Issue-1- Pp. 884 to 892
5. Bisen, D.K., and Kudnar, N.S. (2013) A Sustainable Use and Management of Water Resource of The Wainganga River Basin: - A Traditional Management Systems. figshare. Journal contribution. https://doi.org/10.6084/m9.figshare.663573.v1
6. Hire P.S. (2000) "Geomorphic and Hydraulic studies of floods in Tapi Basin published Ph.D.
7. Horton, R.E., (1932) Drainage basin characteristics, Trans. Amer. Geophysics. U. Vol. 14. pp. 350-361. https://doi.org/10.1029/TR013i001p00350
8. Horton, R.E., (1945) Erosional development of streams and their drainage basins; Hydro-physical approach to quantitative morphology. Bull Geological Social America 56:275–370 https://doi.org/10.1130/0016-7606(1945)56[275:EDOSAT]2.0.CO;2
9. Kale V S, (2002) Fluvial geomorphology of Indian Rivers-an Overview Progress. Physical Geography 26(3):400-433. DOI: https://doi.org/10.1191/0309133302pp343ra
10. Kudnar, N. S., (2015): Morphometric Analysis and Planning for Water Resource Development of the Wainganga River Basin Using Traditional & GIS Techniques" University Grants Commission (Delhli), pp-11-110.
11. Kudnar, N. S., (2017) Morphometric Analysis of the Wainganga River Basin Using Traditional & GIS Techniques, Ph.D. Thesis R.T.M. University, Nagpur pp-22-230.
12. Kudnar, N. S., (2018) Water Pollution a Major Issue in Urban Areas: A Case Study of the Wainganga River Basin, Vidyawarta International Multidisciplinary Research Journal, pp 78-84.
13. Kudnar, N.S. (2020)GIS-based assessment of morphological and hydrological parameters of Wainganga River Basin, Central India. Model. Earth Syst. Environ. 6, 1933–1950. https://doi.org/10.1007/s40808-020-00804-y
14. Kudnar NS., Padole MS, et al (2021) "Traditional crop diversity and its conservation on-farm for sustainable agricultural production in Bhandara District, India", International Journal of Scientific Research in Science, Engineering and Technology, Vol. 8 Iss. 1, pp. 35-43, https://doi.org/10.32628/IJSRSET207650

15. Pramojanee, P., Tanavud, C., Yongchalermchai, C., Navanugraha, C., (1997), An application of GIS for mapping of flood hazard and risk area in Nakorn Sri Thammarat province, south of Thailand, Report by Walailak University, Department of land development.
16. Rajasekhar M, Sudarsana Raju G, et al (2021) Multi-criteria Land Suitability Analysis for Agriculture in Semi-Arid Region of Kadapa District, Southern India: Geospatial Approaches, Remote Sensing of Land, 5(2), 59-72. https://doi.org/10.21523/gcj1.2021050201
17. Theochari, AP., Develekou, M. &Baltas, E. (2021) GIS-Based Multi-criteria Approach Towards Sustainability of Flood-Susceptible Areas in Giofiros River Basin, Greece. Circ.Econ.Sust. (2021). https://doi.org/10.1007/s43615-021-00096-z
18. Thilagavathi, G., Tamilenthi, S., Ramu, C. and Baskaran, R., (2011), Application of GIS in flood hazard zonation studies in papanasam taluk, thanjavur district, tamilnadu, Advances in Applied Science Research, 2 (3), pp 574-585.
19. Salunke, V. S., Lagad, S. J. et al (2021)"A Geospatial Approach to Enhance Point of the Interest and Tourism Potential Centers in Parner Tehsil in Maharashtra, India", International Journal of Scientific Research in Science, Engineering and Technology Volume 8 Issue 1, Pp. 186-196.
20. Salunke, V. S., Bhagat, R. S. et al. (2020) "Geography of Maharashtra", Prashant Publication, Jalgaon, Pp- 1-229.
21. Salunke, V. S., Bhagat, R. S. et al. (2021) "Geography of India", Prashant Publication, Jalgaon, Pp- 1-284.
22. Sneh.,Gangwar., (2013)"Flood Vulnerability in India: A Remote Sensing and GIS Approach for Warning, Mitigation and Management"., International Journal of Environmental Science: Development and Monitoring (IJESDM) ISSN No. 2231-1289, Volume 4 No. 2., pp.,77-79.

*** Nanabhau S. Kudnar**
Assistant Professor in Geography,
C. J. Patel College Tirora, Dist- Gondia,
Maharashtra, India

**** Ravindra S. Bhagat**
Assistant Professor in Geography,
S.S.Dhamdhere Arts & Commerce College,
Talegaon Dhamdhere, Tal-Shirur, Pune,
Maharashtra, India

***** Hanumant D. Shinde**
Assistant Professor in Geography,
Shri Padmmani Jain College,
Pabal, Tal-Shirur, Pune,
Maharashtra, India