International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN - 2395-1990
Online ISSN : 2394-4099
OPEN ACCESS
Available Online at :www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET24116174

Integrated Water Management Practices in Wainganga River Basin: A Case Study of Vidarbha Region, Maharashtra

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ARTICLEINFO

Article History:

Accepted: 15 Nov 2024
Published: 30 Nov 2024

Publication Issue :
Volume 11, Issue 6
November-December-2024

Page Number :
122-128

ABSTRACT

The present study is Integrated Water Management practices in Wainganga river basin: A case study of Vidarbha Region, Maharashtra, using by geographical information system (GIS) and remote sensing (RS) techniques. The study will be based on secondary data. Then all the collected data were scrutinized carefully and recorded in master sheets. Runoff is one of the most important hydrological variables used in most of the water resources applications. Watershed based planning and management requires thorough understanding hydrological processes and accurate estimation of runoff. The determination of runoff at micro level is essential to address water conservation practices in a watershed. The information pertaining to occurrence of run off further helps in integrated water management practices such as prioritizing watersheds, erosion control and selection of sites for conservation measures. The monsoon rains in district are concentrated in the four months from June to September and receive 90.81% rainfall, post-monsoon 1.86% pre-monsoon 4.83% and winter 2.48%. Sandy red soil has covered 31% area; median black soil has covered 47% and Lomi red soil 22% covered the area of district. There are 580 large and 13,758 small and medium sized lakes in the district. The percentage of total area under forest 12.25%, especially during 2001 to 2011 periods it was in Bhandara (12.33%), Mohadi (19.89%), Tumsar (13.27%), Lakhani (11.13%) and Lakhandur (16.24%) decreased on large scale. The aim of this present study was to evaluate integrated management system in the Wainganga River basin that have been delineated based on the geospatial environment parameters with appropriate weights in GIS and RS techniques.

Keywords – Water Management, catchment, rainfall runoff relationship etc

1. Introduction

Even though the water content of the earth is 71%, it is not drinkable. Sea water is about 96.5%. The Antarctic Glacier, which contains 61% of all freshwater on Earth, is not available for regular use. The amount of potable water on earth is only 3%. Therefore, water should be used as much as required. Water should not be wasted. Water is the most important gift given by nature. So water is a natural resource. Water is extremely useful for all living things and nature. This has made it an integral part of human life. Water is used in a variety of ways in our daily lives. Water is used not only for drinking but also for washing clothes, washing dishes, cleaning and other activities. Similarly water is also used in industrial areas. Not only this, energy is also generated from water. The biggest need for water seems to be for farming. Because human beings cannot grow any crop without water and if they grow crops, they cannot get food, so water has a very important place in human life. Not only has that, our nature and plants needed a lot of water. There are many factories running business around you. And with the financial help that comes from it, people are making a living. But some of these industries are in dire need of water. In the study, an attempt has been made to delineate distinct physiography, soil types, geology, slope, relief, climate and rainfall, water quality analysis, demographics; water resource management schemes constructed the areas through water management practices in Wainganga basin. An integrated and comprehensive watershed management is achieved through multiple objectives such as controlling damaging runoff thereby controlling erosion and reducing the sediment production as well as enhancing ground water storage and appropriate use of the land resources in the watershed. There must be a close co-ordination of vegetative and structural control measures.

2. Study Region

The area selected for present study is Wainganga River Basin. The Wainganga River rises at El 640.0 m in the Seoni District of Madhya Pradesh from the Western slopes of Maikala Ranges which is continuation of the Satpura Ranges in Central India. The Wainganga River receives numerous tributaries on either 8 bank and drains the western, central and eastern regions of the Chandrapur, Gadchiroli, Bhandara, Gondia and Nagpur districts of Maharashtra. (Kudnar N.S., 2012; Bisen D.K and Kudnar N.S.,2019).

(Latitude extension- $19^0$30'N to $22^0$30 N' & Longitude extension- $79^0$00'E to $80^0$30 E')

The river in its initial reaches flow westwards and thereafter southwards in M.P. State and continues to flow Southwards in Maharashtra State. It is joined by the Wardha River at a place called Gundapet flowing from the west, draining the major portion of the Maharashtra Plateau. Thereafter the river is known as Pranhita River. The climate of the sub-basin is characterized by hot summer from March to May with rainy season from June to September although the area has some rains in post monsoon season also. The upper catchment area lies in the high rainfall range of 2000-4000 mm. The Pranhita River joins the Godavari River on the left bank which drains the Eastern Coast in Andhra Pradesh and flows out to the Bay of Bengal (Kudnar N.S., 2016, Bhagat R.S. 2015).

3. Objectives

The following are the objectives of the present study.

1. To Promote water conservation to maintain the ecological balance of the basin.
2. To understand the relationship between rainfall patterns, land use, and runoff generation.

4. Database & Methodology

The analysis includes relief, forest, soil, drainage, rainfall and water analysis, Collection of rainfall and long term rainfall data for the entire Wainganga basin as well as small tributaries, particularly for district area have been collected from Indian Meteorological Department (IMD). Water management system of the Wainganga has been analyzed; Satellite data products Multispectral imageries have been acquired for time series analysis of various hydrological as well geomorphological features of in study area. Using SOI topographic maps, ArcGIS desktop 9.3 were used. After data collection the data were edited.

5. Result Analysis

Watershed characterization

The response of a particular watershed to different hydrological processes and its behavior depends upon various physiographic, hydrological and geomorophological parameters. Though these are watershed specific and thereby unique, the characterization of a watershed provides an idea about its behavior. Hydrologists attempted to relate the hydrologic response of watersheds to watershed morphologic characteristics. Computation of watershed morphological characteristics is a prerequisite to further detailed hydrological analysis of the watershed.

Important watershed morphometric characteristics included in the study are: Area of watershed, perimeter, Bifurcation ratio, Elongation ratio, Circulatory ratio, Form factor, Stream order, Drainage density, Average slope of watershed, Main stream channel slope etc. Geographical Information System when used in conjunction with conventional data could provide valuable inputs such as watershed area, size and shape, topography and drainage pattern for watershed characterization and analysis. The watershed has emerged as the basic planning unit of all hydrologic analyses and designs. Watersheds considered in engineering hydrology vary in size from a few hectares in urban areas to several thousand square kilometers for large river basins.

Land Use and Land cover classification

Land use/land cover inventories are essential for the optimal utilization and management of resources in a given sub basin. Land cover refers to different features covering the earth's surface including vegetation cover, water bodies, open scrub etc. It integrates the sum of human activities having an influence on the environment.

In such cases, remote sensing data are of great use for the estimation of relevant hydrological data. RS data can serve as a model input for the determination of river catchment characteristics such as land use /land cover, geomorphology, slope, drainage etc. GIS offers the potential to increase the degree of definition of spatial sub units, both in number and descriptive detail.

Surface Water

The Wainganga basin falls in the 'assured rainfall zone' however it was necessary to quantify and correctly estimate the rainfall in the region and its impact on the availability of surface water in the basin. Accurate estimations of surface water availability and its distribution within the basin also forms one of the parameters for determining the locations, the density and distribution of water storage project like dams, weirs and barrages. We observed that in Wainganga basin North, Northwest and Northeast side mostly found in water storage.

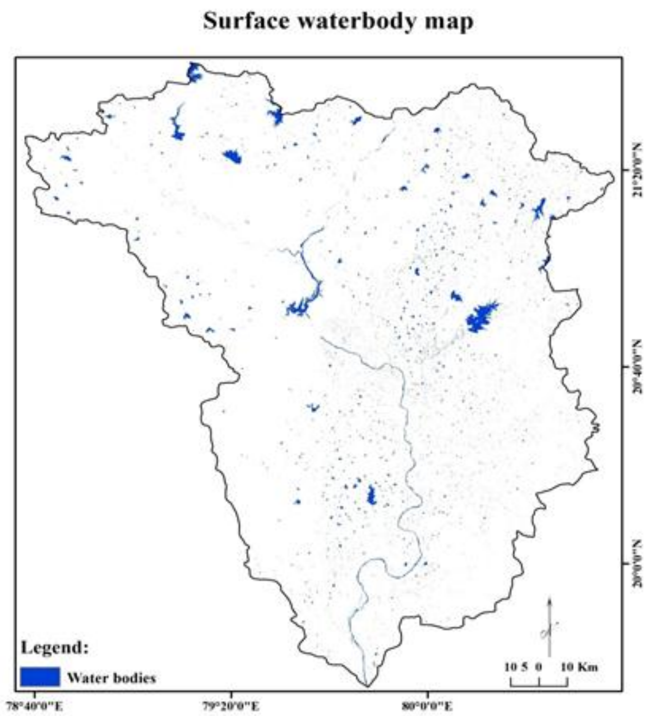

Fig.2 Surface Waterbody Map

Discharge Analysis

Discharge is the volume of flow moving through a given cross section of a river in a given unit of time. It is commonly given in cubic meters per seconds (cumec) (Strahler and Strahler, 1980). It is one of the important factors to govern the changes in alluvial rivers. The assessment of geomorphic effectiveness of a river requires an understanding of the characteristics of the discharge which is a product of volume and velocity. Distribution of rainfall of the river basin influenced on the discharge characteristics change from season to season and year to year. Hydrographs shows the useful information about the periods of high and low flows, seasonal distribution of high flow events, and duration of flow over a year and variability of flow. These characteristics are very important because of the pattern of geomorphic work in terms of erosion and transportation. Most of the river those are seasonal or perennial, small or big experiences short periods of high flow.

The Wainganga River has marked significant changes in its flow regime. There is also fluctuation in sediment as well as runoff regime. So some of the factors that affect the annual discharge are climate and area.

Catchment Factors

In addition to the water balance of the catchment area physiography of the catchment area. If the other factors remain equal, the area of the catchment determines the total amount of rainfall caught. The effect of area may depend upon the prevailing climatic regime. Thus, in a region, where potential evapotranspiration (PE) exceeds rainfall, a larger catchment is just as likely as a smaller one to have a zero or very low annual discharge. Whereas, in a region in which rainfall exceeds the PE and the catchment area is large as a result the annual discharge will be high (Ward, 1978). The average altitude of the catchment area may affect the annual discharge indirectly through its direct orographic influence on rainfall. Thus, Altitude of the catchment area affects annual discharge due to direct orographic influence upon the rainfall which increases from south to north.

Factors Controlling River Regimes

Seasonal variation in the discharge of a catchment area depends primarily on the relationships between climate, vegetation, soils, rock structure, basin morphometry and hydraulic geometry. Of these, only rock structure and, to a lesser extent, basin size can be strictly independent of the climate. It should be stressed that the features of the basin morphometry and hydraulic geometry are only of direct relevance to the seasonal regimes of the large river basin (Beckinsale, 1969). The river regime of the Wainganga River comes under monsoon type of climate with monsoon maximum and winter minimum amount of discharge. The seasonal distribution of the annual discharge is given in table 5.7. About 87 per cent of the annual discharge is received in the monsoon season.

Runoff

In this model, surface runoff, as infiltration excess, is calculated using a modification of the SCS curve number method (USDA Soil Conservation Service, 1972) or the Green & Ampt infiltration method (Green and Ampt, 1911). Return flow is the fraction of total water precipitation and irrigation application that returns to the stream as a delayed contribution following a tortuous, essentially subsurface, travel and makes up the overall volume of stream flow. SWAT partitions sub-surface water into two distinct systems: a shallow, but essentially unconfined, zone which contributes return flow to streams within the basin and a deep, confined aquifer which also has the potential to contribute return flow to streams outside the basin (Arnold et al., 1993). Water percolating past the bottom of the root zone is partitioned into two fractions each fraction becomes recharge for one of the aquifers. In addition to return flow, water stored in the shallow aquifer may replenish moisture in the soil profile in very dry conditions or be directly removed by plant. Water in the shallow or deep aquifer may also be removed by pumping.

Rainfall Runoff Relationship

The total rainfall generated the main stream of the watershed is the function of total precipitation received on the watershed. However all the precipitation received is not converted into surface runoff. Some of the precipitation is lost temporally or permanently as the precipitation reaches the surface. This term as hydrological losses. Run-off from the sub-basin of Wainganga varied due to factors like distribution of rainfall, slope, forest cover or land use, number of reservoirs / tanks etc. The annual average run-off of found that the 1225.73 and the annual average of the Wainganga river is 0.45 MCM / sq.km. The annual water availability is estimated to be 6227.71 MCM. Interception by vegetation, temporary storages in ponds and lakes, infiltrations and evapo-transpiration are principle losses. Therefore the relationship between rainfall and runoff can be given as:

RO = P-L#Cs

Where, RO is the runoff generated

P is precipitation

S is Storage

The rainfall runoff process is described as:

Runoff = Rainfall – Interception – Evaporation – Infiltration - Transpiration

However it is generally expressed in a simple regression equation as;

R = m* P-C

Where, R = Inflow from catchment in mm

P = Rainfall over the catchment on as average in mm

M = Slope of line

C = Losses in mm

Table 1 - Average Observed (Monsoon) Run off At CWC Sites in the Wainganga Rivers sub-basin. (1996 - 2001)

Sr. No.	Name of the Site	Name of the River	Catchment Area sq. km.	Run Off (Cu. Km.) June-Nov
1	Satrapur	Kanhan	11100	1.98
2	Rajagaon	Bagh	5380	2.30
3	Keolari	Wainganga	29600.97	0.87
4	Rajoli	Mul	1900	0.40
5	Wairagarh	Khobragarthi	2600	0.55
6	Ramkona	Kanhan	2500	1.02
7	Kumhari	Wainganga	8070	3.18
8	Salebardi	Chulband	1800	0.54
9	Pauni	Wainganga	35520	9.53

Source: Central Water Commission (CWC), Information System Organization

(ISO – Hydrology Data Directorate)

The inflow of a body of water is the source of the water in the body of water. It can also refer to the average volume of incoming water in unit time. It is contrasted with outflow. Outflow is the amount of water that leaves the country. Inflow is mostly used when referring to rivers, and the amount of water in units that enters the country. In Keolari site in Wainganga River area is more but comparatively run-off is very less (0.87) but in the same river at Pauni site area is 35520 and outflow is 9.53 than the other river.

Table 2 - Distribution of Runoff Classes in Study Region

Sr. No.	Runoff Class	Area km^2
1	Low Runoff	1548.396
2	Marginal Runoff	21167.48
3	Moderate Runoff	3202.358
4	Maximum Runoff	428.69
Total		**26346.93**

Source: Computed by Researcher

Above table shows that Marginal runoff area having 21167.48km^2 and it's found all over the study region. Maximum runoff are found sub basin of Khobragadi, Gadhavi, Satti, Kathani and Tipagsrhi as an area about coverd with 428.69 km^2. Moderate runoffs are mostly found in West part and North side on the study region because of entire area has been very low rainfall.

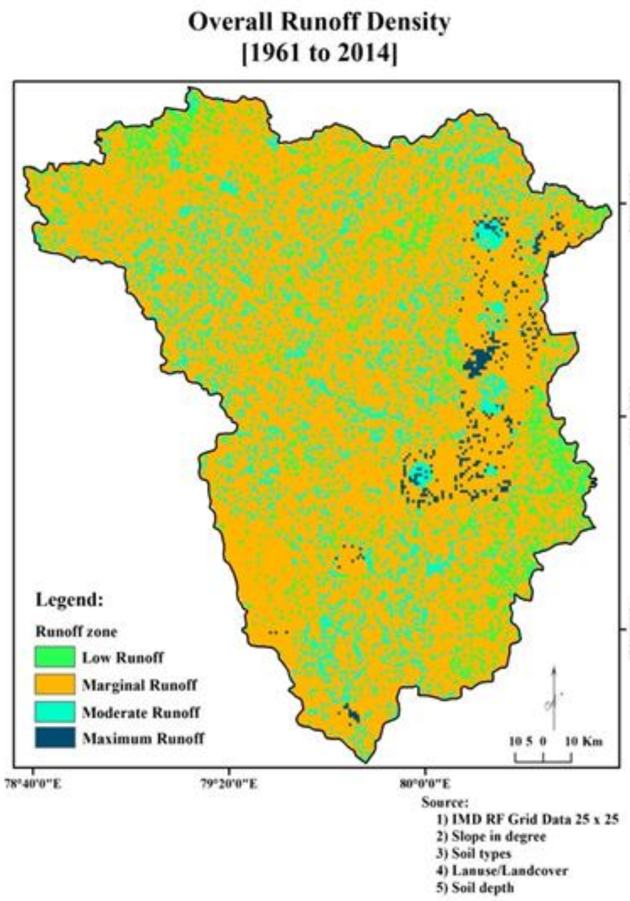

Fig.3 Rainfall Runoff Density Map

6. Conclusion

Watershed parameters evaluated through GIS environment, Watershed Drainage network, Rainfall and observed runoff for the study area has been and discussed. Analysis between rainfall and runoff estimated with fully distributed approach has been discussed. The daily runoff data was collected for a period from 1961 to 2014. Comparison and analysis of observed runoff has been carried out and presented. The observed daily runoff data was processed and converted to monthly and yearly runoff for further analysis. The annual average run-off of found that the 1225.73 and the annual average of the Wainganga river is 0.45 MCM / sq.km. The maximum runoff was recorded in the month of August. Yearly inflow values were calculated from the daily runoff and deviation was obtained from the average discharge for each year.

I. REFERENCES

[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 Bisen Devendra (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 Bisen Devendra (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 (2022) Geospatial Modeling in the Assessment of Environmental Resources for Sustainable Water Resource Management in a Gondia District, India. In: Rai P.K., Mishra V.N., Singh P. (eds) Geospatial Technology for Landscape and Environmental Management. Advances in Geographical and Environmental Sciences. Springer, Singapore. https://doi.org/10.1007/978-981-16-7373-3_4

[15]. Kudnar NS (2020b) GIS-Based Investigation of Topography, Watershed, and Hydrological Parameters of Wainganga River Basin, Central India, Sustainable Development Practices Using Geoinformatics, Scrivener Publishing LLC, pp 301-318.https://doi.org/10.1002/9781119687160.ch19.

[16]. 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

[17]. 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.

[18]. 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

[19]. 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

[20]. 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.

[21]. 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.

[22]. Salunke, V. S., Bhagat, R. S. et al. (2020) “Geography of Maharashtra”, Prashant Publication, Jalgaon, Pp- 1-229.

[23]. 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.