Journal of Advanced Zoology

ISSN: 0253-7214

Volume 44 Issue S8 Year 2023 Page 335-342

"Integrated Geospatial Solutions for Enhanced Kukadi River Basin Delineation using Remote Sensing and GIS Techniques"

Ms. Shital Dhobale[1]*, Dr. Deepak Shaligram Narkhede[2]

**Research Student, University of Mumbai, Mob. 9890560353 (sdhobale96@gmail.com)*
[2]Associate Professor and Research Guide, Head, Department of Geography, Changu Kana Thakur Arts, Commerce and Science College, Panvel, (University of Mumbai), Mob. 9702365766 (deepaknarkhede176@gmail.com)

***Corresponding Author: -** Ms. Shital Dhobale*
**Research Student, University of Mumbai, Mob. 9890560353 (sdhobale96@gmail.com)*

Abstract:

This study offers an innovative approach to enhance the precision and accuracy of the delineation of the Kukadi River Basin by integrating cutting-edge geospatial technologies, particularly Remote Sensing (RS) and Geographic Information System (GIS) methods. Due to its varied topography and land cover, the Kukadi River Basin play a crucial hydrological entity in the area which presents difficulties for standard delineation techniques. High-resolution satellite imagery is used in the study to provide exact information on land cover in the Kukadi River Basin. The work aims to extract comprehensive land cover data by utilizing spectral analysis and image classification techniques, which are part of RS. In order to improve the delineation of the Basin borders, this data is seamlessly integrated with GIS spatial analytic tools, which also incorporate digital elevation models, slope, and other terrain metrics. The research findings demonstrate the possibility of combining RS and GIS technology to overcome the challenges associated with varying terrains, hence furthering the improvement of Basin delineation approaches. The results provide a useful and dependable paradigm for defining river Basin in a variety of geographical contexts, which is important for water resource management, Environmental Conservation, Land use planning, decision-makers, researchers, and practitioners working on hydrological studies.

Key Words: Kukadi Basin, Delineation, DEM, Slope -Aspect, GIS and Remote Sensing

Introduction:

There are multiple ways to define watersheds. One that is frequently employed is manual demarcation using topographic maps' contour information. Despite the development of GIS technology, this process is still frequently employed before a digital watershed dataset is created. Although accurate delineations can be obtained using this manual method, it is an expensive and time-consuming process. Watershed has emerged as the basic planning unit of all hydrologic analyses and designs. Each watershed shows distinct characteristics which are so much variable that no two watersheds are identical.(Bose et al., 2011). With the development of computer and information technology, distributed hydrologic models become research focus, in which watershed delineation based on DEM (Digital Elevation Model) is the key step and priority.(Luo et al., 2011). Delineation of a river basin refers to the process of establishing and mapping the geographical boundaries of the area that supplies water to a certain river or stream. A river basin is a naturally occurring hydrological unit that includes the portion of the land surface where all of the water flows into a certain river or its tributaries.

Study Region:

Geographical Extent: The study region encompasses the drainage area of the Kukadi River and its tributaries. The Kukadi river basin occupied 1422.49 sq.k.m area. Basically, Kukadi River Basin covered North part of Junnar Tehsil in Pune District. It is situated in Latitude: 18.4717° N to 19.5511° N Longitude: 73.2014° E to 74.5612° E.
Topography: The study region features diverse topography, including the Western Ghats where the Kukadi River originates in Kukdeshwar. The river flows through hills, plateaus, and plains as it makes its way towards the Ghod River. Major tributaries, such as the Pushpavati River and Mandvi River meets from left bank which contribute to the flow of the Kukadi River.

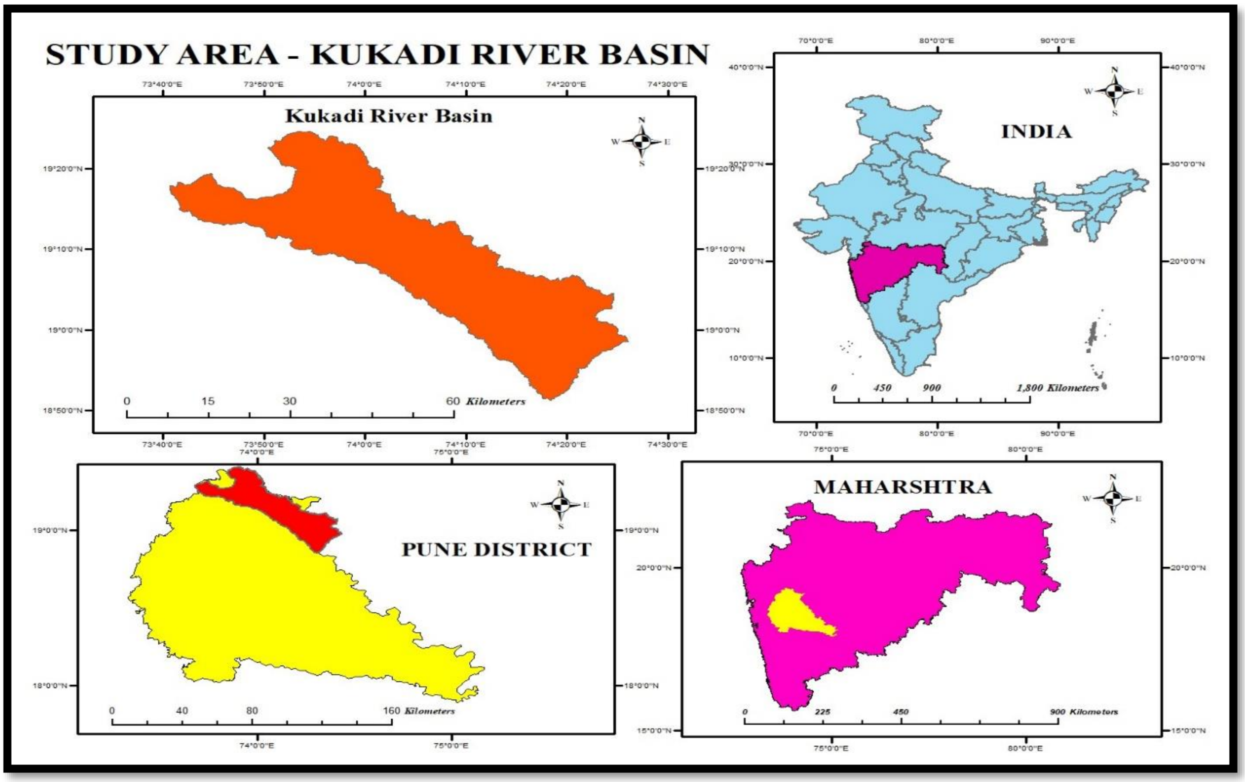

Fig. 1 Study Area- Kukadi River Basin

Objectives:

1. To Delineate the Kukadi River Basin.
2. To Develop the Digital Elevation Model (DEM) of Kukadi river using GIS and Remote Sensing.
3. To Create the slope and Aspect Map of the Kukadi River Basin.

Data Base and Methodology:

The toolbox for hydrological analysis, which includes the following functions: flow analysis, stream analysis, and watershed analysis, is provided by ARC 10.8 and QGIS software. By calculating the flow direction or flow accumulation and applying it to the Watershed function, watersheds were defined from a digital elevation model (DEM). Figure 2 illustrates the procedure of extracting hydrological data. Watershed boundaries were established using raster data with a flow direction. The processing of DEM to delineate watersheds is referred to as terrain pre-processing.(Requirements, 2012). The Strahler stream order method is a numerical system used to classify and analyze the hierarchy of a river or stream network based on the arrangement of its tributaries. Developed by Strahler in 1952, this method provides a systematic way to assign an order to each stream segment within a watershed, facilitating the understanding of river systems and their behavior.

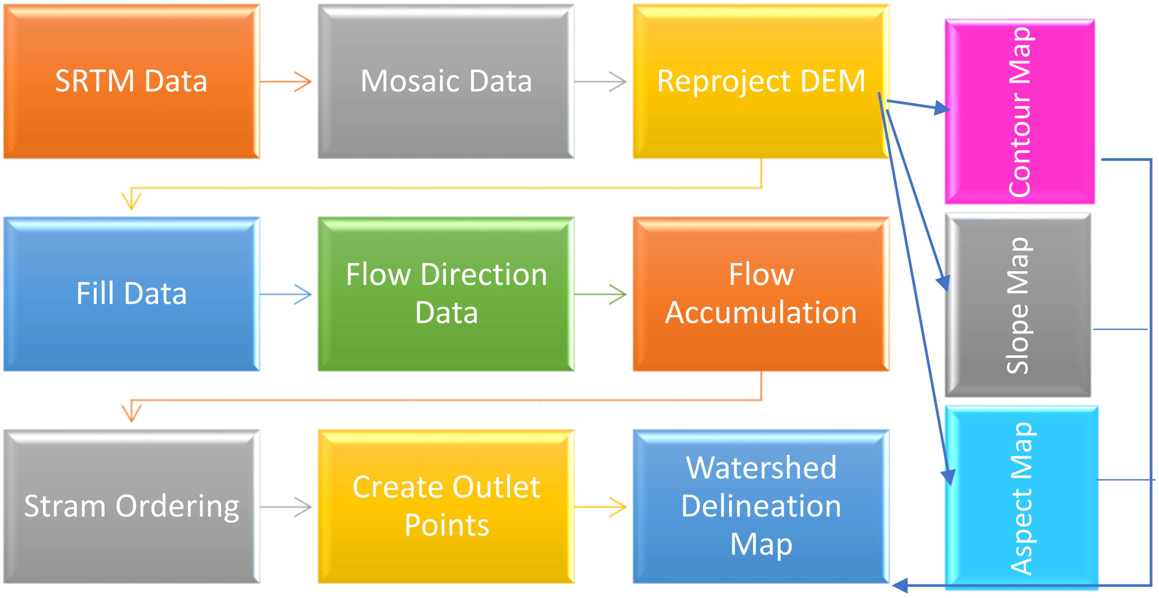

Fig. 2 Methodology and procedure of River delineation

Result and Discussion:

Combination of the satellite imagery data and hydrogeological spatial analysis in geospatial environment is made easy to recognize and differentiate the drainage region (Gautam et al., 2021). According to Kang (2008), a flow direction raster shows the direction water which is flow out from each cell of a filled elevation raster.

Digital Elevation Model:

Digital elevation model (DEM) can be defined as numeric or digital representation of terrain elevation specified as a function of geographic location. DEM is the fundamental data for the automatic delineation of catchment and drainage network for spatially distributed hydrological model(Akram et al., 2012). Digital Elevation Model is created to highliht the genenal topographical slope of the study region. It clearly observed that the high elevation located in the north and north western part of the study region.

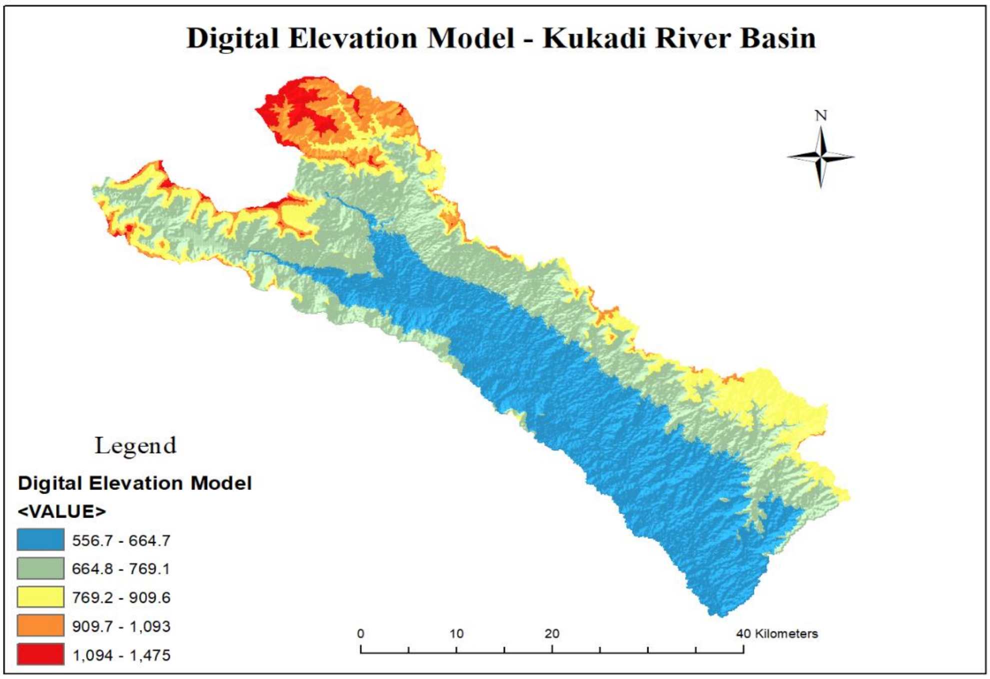

Fig. 3 Digital Elevation Model of Kukadi River Basin

Flow Direction:

The flow direction raster, as shown in Figure 3, has eight different values. The direction code that represents the flow out of each cell is indicated by each value. The eight direction (D8) flow model is used by ArcGIS. For example, in a small portion of the study region, the majority of the cells move in the direction of their eastward-facing neighbours. due to the terrain, geological strata and slope of the topography extended towards eastern and south-eastern part of the region. It is observed that the high elevation flow cell is decreasing towards eastern cell.

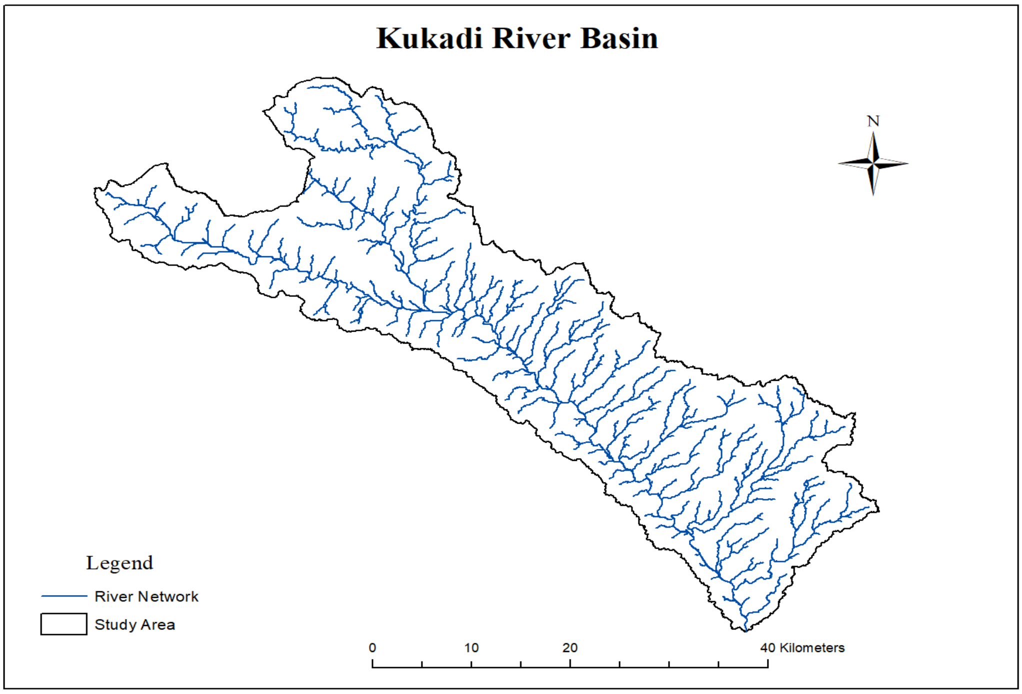

Fig. 4 Kukadi River Basin

Flow accumulation

The DEM is used to determine flow accumulation, which shows where water converges. By identifying the separation between several drainage basins, it helps in the delineation of the watershed boundary. A flow accumulation raster tabulates for each cell of the number of cells that will flow to it. A flow accumulation raster can be interpreted in two ways:

1. Cells having high accumulation values generally correspond to stream channels, whereas cells having an accumulation value of zero generally correspond to ridge lines.
2. If multiplied by the cell size, the accumulation value equals the drainage area. (Sukaesih Sitanggang & Hasmadi Ismail, 2011)

According to the ArcGIS 10.8 Desktop Help, the Flow Accumulation function computes cumulative flow as the total weight of all cells flowing into each downslope cell in the output raster. The value of cells in the output raster represents the number of cells that flow into each cell if no weight raster is supplied. A weight of one is applied to each cell.

The longitudinal shape of the River Basin in Figure 4 illustrates the accumulation of flow in a specific portion of the study region. Each blue cell indicates a lower height of the basin, whereas each dark red region cell has a high value, indicating a higher elevation.

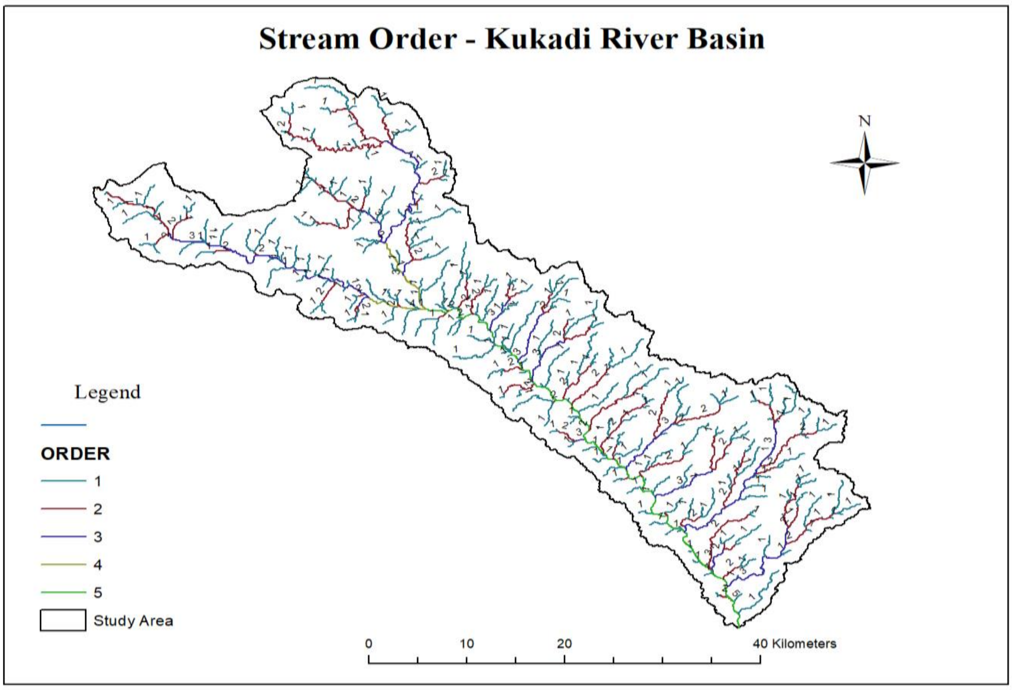

Fig. 5 Stream Order- Kukadi River Basin

Prior to establishing streams in stream networks, the threshold size should be established. This can be done by number of cells or area, measured in different units like square kilometers or hectares. The horizontal and vertical units of the DEM file should be expressed in meters in the attributes of the digital elevation model. The most common method of extracting channel networks from DEM is to specify a critical support area that defines the minimum drainage area required to initiate a channel using a threshold value (Akram et al., 2012). Strahler stream ordering method is used to understand the systematic flow and stream orders of the Kukadi river basin. It is observed that according to slope the highest 1 order streams located in the hilly region which covered north, north-west, south and south west part of the basin. Lower order i.e. 5 order streams flow towards downslope and occupied less cells compare to first order streams. Fig. 6 represents the Contour map of the study region which depicts the high elevation and low laying area. On the basis of contourization Slope map (Fig.7) and Aspect map (Fig.8) were prepared. This will help to understand proper slope and aspect of the river basin.

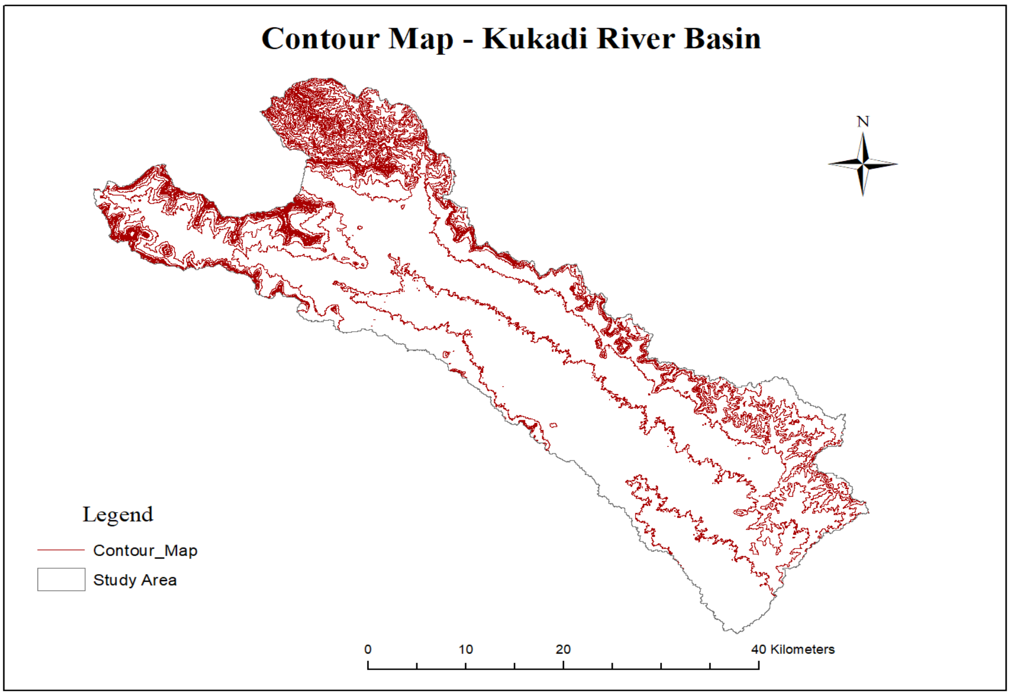

Fig. 6 Contour Map of Kukadi River Basin

Slope and Aspect: A geographical representation that offers important details about the topography of a certain area is called a slope and aspect map. In many disciplines, such as geography, environmental science, forestry, agriculture, and urban planning, these maps are valuable resources.

An area's land surface inclination or steepness is depicted on a slope map. Usually, slope is given as a gradient, degree, or percentage. Users can distinguish between flat areas, moderate inclines, steep hills, and moderate slopes using the color-coding or contour lines on the map. Slope maps are essential for determining the land's stability and appropriateness for different uses. For instance, steep slopes could be difficult to build on or more prone to erosion, making agriculture more suitable for flatter terrain. Fig. 7 the highest slope value ranging between 71.09-258.9 and the lowest slope value ranging between 0-9.139.

The direction a slope faces can be found on an aspect map. It gives information on the direction that a specific site is facing—north, south, east, or west. Aspect has a degree range of 0 to 360. Understanding microclimates is made easier by aspect maps, since different slopes receive different amounts of sunshine during the day. This knowledge is essential for pursuits like forestry and agriculture, where exposure to sunlight affects the growth and development of plants. (Fig.7)

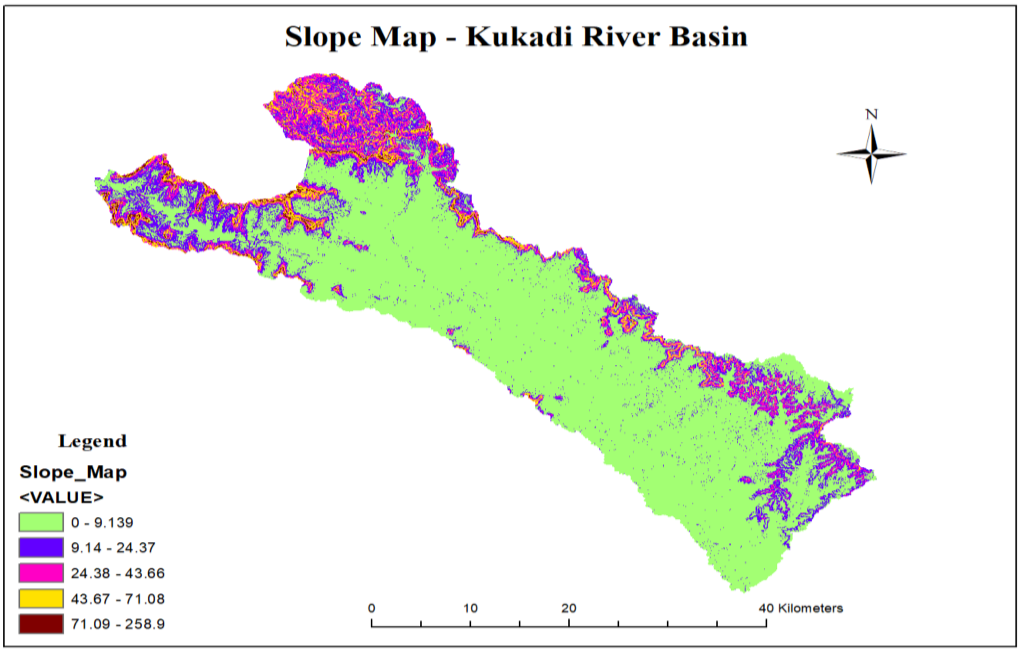

Fig. 7 Slope Map of Kukadi River Basin

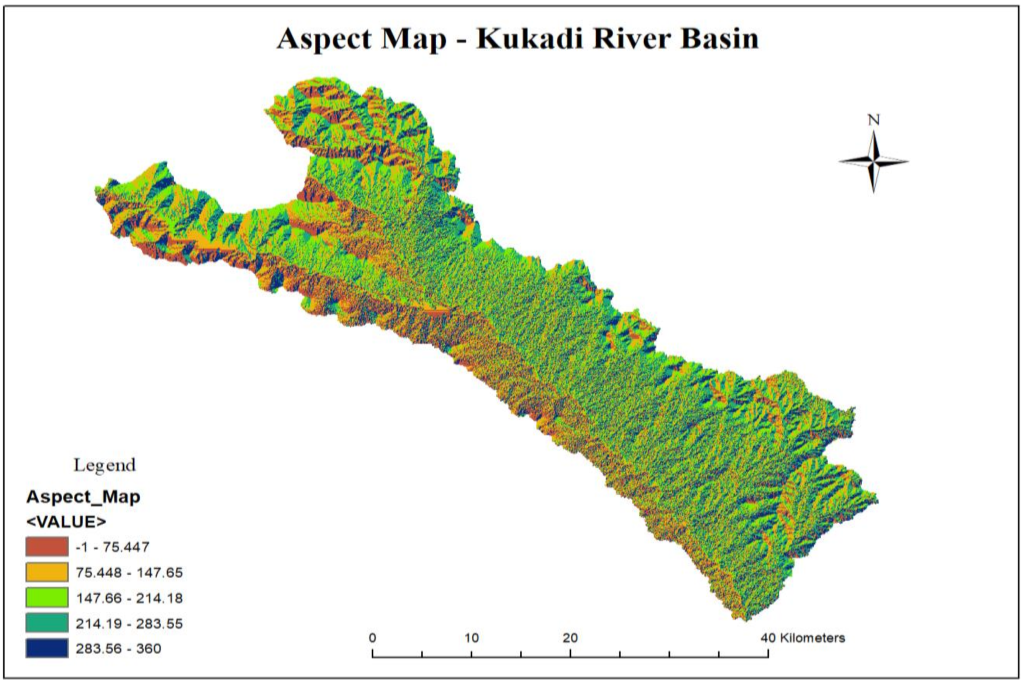

Fig. 8 Aspect map of Kukadi River Basin

Delineation of Kukadi River Basin:

A key step in hydrology is the delineation of a watershed, which entails locating and quantifying the borders of a region that contributes to a shared outlet, like a lake or river. Delineation and parameterization of landscape drainage features is an important study area in geomorphology and hydrology. Delineation of drainage networks involves their representation by a set of measurable physical properties. These properties are then used in various models to extract other characteristics, and also to ascertain the response of the drainage system to other variables (Gökgöz et al., 2006). Fig.9 shows the final output of the Delineation of the Kukadi River Basin.

To depict the three-dimensional surface of the ground, elevation data is used to produce digital elevation models. DEMs are useful for determining the boundaries, drainage patterns, and elevation changes of a basin. Determining the limits of watersheds involves examining the topography and pinpointing locations where water bodies meet. The boundaries of the Kukadi River Basin and its sub-basins are drawn using this approach. The terrain's slope dictates the direction the flow. Understanding how water spreads across the terrain and joins streams and rivers requires knowledge of this information.

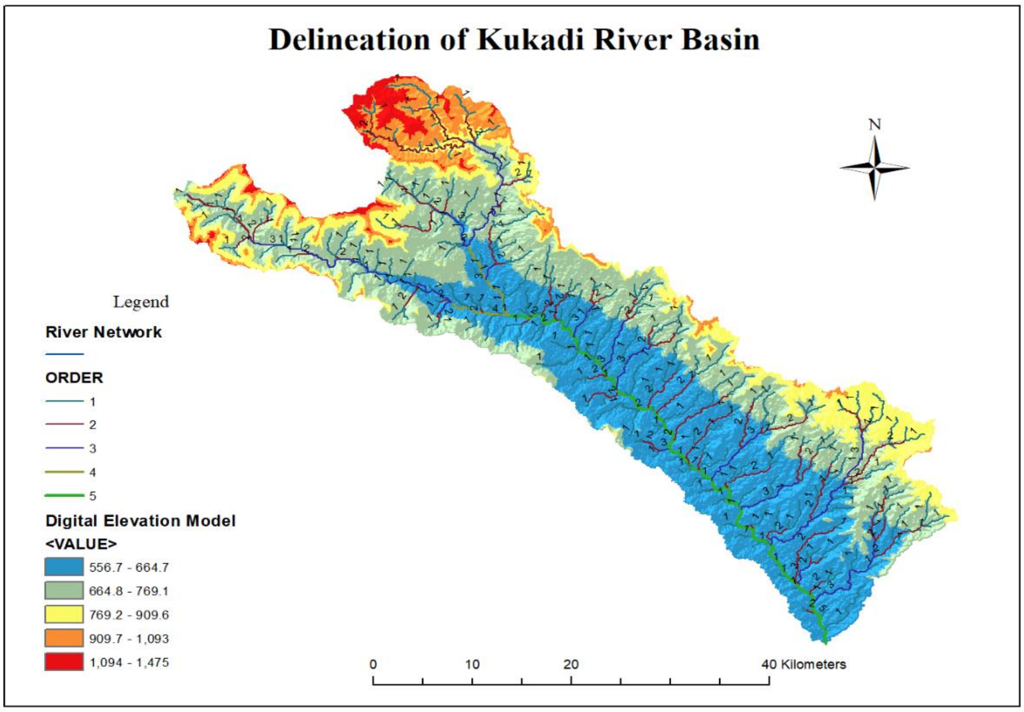

Fig.9 Delineation of Kukadi River Basin

Conclusion:

One of the most important steps in comprehending and controlling the hydrological features of this region is defining the boundaries of the Kukadi River Basin. By using advanced technologies and techniques like remote sensing and GIS (Geographic Information System), hydrologists and researchers can get important insights about the spatial distribution of landforms, drainage patterns, and land cover in the basin. Sub-basins, drainage networks, and the hierarchical order of streams utilizing techniques like the Strahler stream order system can all be identified according to the delineation process. Effective management of the Kukadi River Basin's water resources, evaluation of flood risk, and ecological preservation depend on this knowledge. DEM represents the 3D shape of terrain and also used as input to extract stream network.(Imran et al., 2019). The speed of delineation can be controlled by the user during the preprocessing stages (Giridhar et al., 2015)

To maintain the accuracy and dependability of the data, the Kukadi River Basin delineation will need to be updated and improved over time as technology develops. To preserve the integrity of this important data, cooperation between scientific groups, governmental organizations, and local stakeholders will be essential.

In ultimately, the Kukadi River Basin's boundary provides a cornerstone for comprehensive watershed management, supporting the biological balance of the basin and the sustainable use of water resources. Communities are better equipped to improve water security, mitigate the possible effects of natural disasters, and promote the Kukadi River Basin's long-term resilience thanks to the knowledge acquired from this approach.

References:

1. Akram, F., Rasul, M. G., Khan, M. M. K., & Amir, M. S. I. I. (2012). Automatic delineation of drainage networks and catchments using DEM data and GIS capabilities: A case study. *Proceedings of the 18th Australasian Fluid Mechanics Conference, AFMC 2012*, *1*(December), 3–6.
2. Bose, a S. C., Sridhar, P., Giridhar, M. V. S. S., & Viswanadh, G. K. (2011). *Watershed delineation and stream network analysis uisng gis*. *October 2012*, 1–13.
3. Gautam, V. K., Kothari, M., Singh, P. K., Bhakar, S. R., & Yadav, K. K. (2021). Determination of geomorphological characteristics of Jakham River Basin using GIS technique. *Indian Journal of Ecology*, *48*(6), 1627–1634.
4. Giridhar, M. V. S. S., Anirudh, R., Rao, G. S., & Sowmya, P. (2015). DEM Processing for Watershed Delineation using QSWAT. *International Journal of Scientific & Engineering Research*, *6*(8), 1670–1674.
5. Gökgöz, T., Ulugtekin, N., Basaraner, M., Gulgen, F., Dogru, A. O., Bilgi, S., Yucel, M. A., Cetinkaya, S., Selcuk, M., & Ucar, D. (2006). Watershed delineation from grid DEMs in GIS: effects of drainage lines and resolution. *Proceedings of the 10th International Specialised Conference on Diffuse Pollution and Sustainable Basin Management, Istanbul, Turkey*, *September*, 18–22.
6. Imran, R. M., Rehman, A., Khan, M. M., Jamil, M. R., Abbas, U., Mahmood, R. S., Mahmood, S. A., & Ehsan, R. M. (2019). Delineation of Drainage Network and Estimation of Total Discharge using Digital Elevation Model (DEM). *International Journal of Innovations in Science and Technology*, *1*(2), 50–61. https://doi.org/10.33411/ijist/20190102011
7. Luo, Y., Su, B., Yuan, J., Li, H., & Zhang, Q. (2011). GIS techniques for watershed delineation of SWAT model in plain polders. *Procedia Environmental Sciences*, *10*(PART C), 2050–2057. https://doi.org/10.1016/j.proenv.2011.09.321
8. Requirements, C. (2012). *Watershed and Stream Network Delineation using ArcHydro Tools*. 1–22.
9. Sukaesih Sitanggang, I., & Hasmadi Ismail, M. (2011). A Simple Method for Watershed Delineation in Ayer Hitam Forest Reserve using GIS. *Bulletin Geospatial Sektor Awam*, *1*, 14–19. https://www.researchgate.net/publication/267385418