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Digitization of River Atlas of Bhima: Pandharpur Basin

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Abstract

The availability of the data that is currently present in the form of Topographical format. In the current era of digital data this data needs to be available to be in the form of digital data. This research provides a detailed view of the 1st to 5th order of streams. This further more helps to trace the total distance of streams present. This also helps the CGanga and Namami Ganga for keeping a track of streams and total amount of water reserves depending on the climate. This project helps to create a river atlas of this specific basin i.e Bhima to pandharpur basin. All the data generation and processing are done on ArcGIS a geodata processing software.

Keywords: GIS (Geographical Information System), Streams, Geo-Referencing, Digitization, DEM (Digital Elevation Model)

1. Introduction

The Advances in data collection and storage techniques have led to an enormous amount of data being stored in repositories, and this amount is expanding at an accelerated rate. Satellite images, also known as remote sensing images, are an essential part of the increasingly relevant data that is gathered and processed.[1] Because of the need for more economical and efficient ways to observe the world, humans have developed remote sensing satellites. The remote sensing image-based spatial information archives are growing at the fastest rate. The spatial and spectral resolutions of remote sensing photos range from 1-meter panchromatic images to the next generation of polar-metric radar imagery satellites. Basically, water is a part of survival of all living creatures. It is utterly essential for public wellbeing, food security, sanitation and a variety of other uses. It is in the interest of each nation to get a strong picture of the situation with forthcoming water pedigree as well as methods for successful water resource management. The issue is pressing as demands of the mankind, furthermore combat climate, forge unsustainable sources when stable. In fact, water projects are often massive and expensive, and it takes the several years implement, so future planning is necessary. Understanding relevant facts is essential to performing an effective and efficient earth analysis. Although image archives are rich in useful information, people find it difficult, if not impossible, to extract strategic data from them without specialized tools due to their size and complexity.[1] With the abundance of easily available large archives of Remote Sensing photos, data analysis requires the employment of appropriate technologies.

A collection of landscape images from a vast remote sensing database offers a rare opportunity to understand the where, when, and how of changes that have occurred around the world. The first operational satellite for remote sensing was launched in 1972 and named LANDSAT-1. The study of collecting information about the Earth's surface without physically being in contact with it is known as remote sensing, according to the Canada Centre for Remote Sensing.[1] Remote sensing, as utilized in the applied sciences, is the study of the Earth's surface using devices known as remote sensors that are carried by Earth observation satellites or aircraft.
The process of digitization involves the employment of a tool called Shapefile, whose polyline function is essential to our job. Subsequently, we must complete the coordinate system using the catalog that shows up beneath the name. The next step is to pick "WGS 1984 UTM Zone 44N." Following completion, select the editor's tab and begin editing. Before beginning, make sure the shapefile type was produced by checking the create features tab. We can begin digitizing the streams after that has been examined, and once we have completed the process, we must save our adjustments before continuing.
Utilities can extend the life of vital infrastructure with Asset Performance Management (APM) and which is to reduce maintenance costs and increase the efficiency. Primary continuous improvement objectives are achieved by the overall maintenance and operations strategy.
A great deal of geographic data is available in formats that are difficult to link with other GIS data, like historical maps, other paper maps, and image files (JPG, PNG, etc.).[2] For these types of data to be used in GIS ("pin it to Earth"), they need to be in line with previously collected geographically related data. This process is also known as georeferencing.
This project is administered under the Cganga organization the work to be done is given to the Gokhale Institute Of Politics And Economics with the department of Centre for Sustainable Development (CSD).

Fig 1.1 Organization working for.

2. Research Problem

1. Significance of Research work

This process helps to keep digital track of the rivers and its streams to advance the current scenario of information present in paper format to digital and manageable data for the good health of this streams of water. Knowing the full extent of water sources available and making creative decisions depending upon the weather, climatic condition and water quality depending on the Government of India how to use this data.

Objectives:

1. Digitizing each and every stream of order 1 to 5 in Bhima – Pandharpur Basin.
2. To get the complete understanding of the stream network in the Basin.
3. Submitting this created data to Cganga and Namami Ganga officials.
4. Complete Digitized Topographical Sheets nos. 48.
5. A Database of stream network of Upper Bhima to Pandharpur.
6. Experience to Work on Government Project and chances to get further scope.

2. Methodology:

In order to achieve above stated objectives, the following work plan is prepared:
Study and review literature about digitization, stream network and ArcGIS.

1. Collection and review of documents related to existing digitization, stream network and ArcGIS.
2. Acquisition of topographical maps, getting the tiles from the USGS 5m tiff files.
3. Getting the licensed copy of ArcGIS software necessary for digitization.

3. Geographical Information System (GIS)

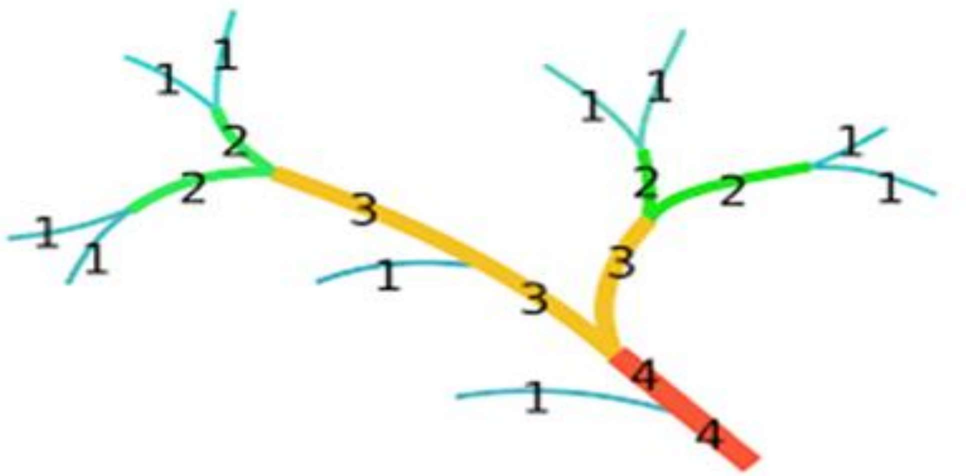
A Geographic Information System (GIS) is a collection of computer-based tools used for specialized objectives that include gathering, storing, accessing, processing, and displaying geographical data from a discipline-specific domain. While CAD software may accomplish comparable tasks, geographical analysis and display of data are where GIS really shines, rather than data processing and storing capabilities. [4] Examining geographic patterns in data and noting correlations between geographical features are aspects of spatial analysis. Spatial analysis techniques can range from straightforward mapping following an analysis to more intricate models that use multiple data layers to simulate the real world. Thus, complicated spatial analytic operations (such as proximity analysis and buffering [4] on geographic data that would be too time-consuming, costly, and inaccurate to do by hand can now be completed by GIS software. [4]
Geographic Information System (GIS) has proven to be a useful tool in resolving many transportation-related issues.[4] Geographic Information System for Transportation (GIS-T) is the name of this specialized field of GIS that is especially well-suited for transportation applications. According to Miller and Shaw,[4] GIS-T is the term for the concepts and uses of using geographic information technologies to address transportation-related issues. One of the most popular GIS application fields is GIS-T, which has been applied to a wide range of transportation-related fields, including environmental impact assessment, hazard mitigation, intelligent transportation systems, traffic monitoring and control, infrastructure planning, design, and management, transportation safety analysis, travel demand analysis, and planning and operations for public transportation.[4]

4. Streams

Headwater streams, which are here classified as first- and second-order channels,[5] make up the vast bulk of a river network's channel length when taken as a whole.[5] However, these relatively small streams are likely to be ignored by legal protections extended to rivers and to be aggressively altered in connection with diverse land uses. A substantial body of research on the physical, chemical, and biological functions of headwater streams clearly indicates their importance to the entire river network.

Headwater streams are diverse, making it challenging to make generalizations about them despite their relatively small size. Headwater streams can be steep, highly turbulent channels that are narrowly constricted between valley walls in high-relief situations.

Streams are the tributaries that are come from river and the ranking depends on the main stream and sub streams. River will be stream order 5 (O5) the tributary of that river is order 4 (O4) lets say this O4 has a split tributary it will be termed as order 3 (O3) and this O3 splits then it will be order 2 (O2) and this O2 splits then it will be order 1 (O1) the last order of the streams. The below given image will make a good understanding of stream orders.



5. Geo-Referencing

1. An The data that is received is in the format of '.tiff" file.
2. This data is received from the Survey Of India (SOI) website from the open series maps.

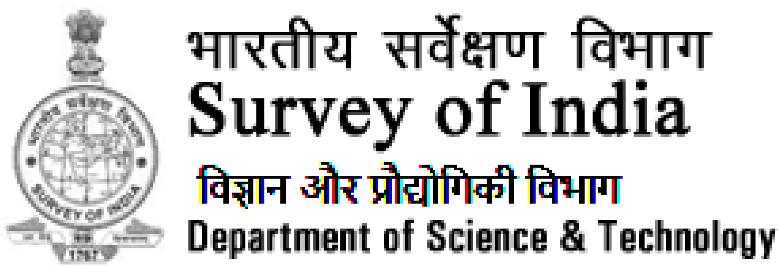


Fig 5.1 Survey Of India (SOI).

3. This data is not Geographically referenced i.e. there is no Co-ordinate provided to this topographical sheet.
4. Hence Geo-Referencing is a crucial task to assign this toposheets to respective position depending on the latitude and longitude of the area.
5. There is the option for Geo-Referencing in the tittle bar where in we have to enter the co-ordinates and the target the point to Geo-Reference.

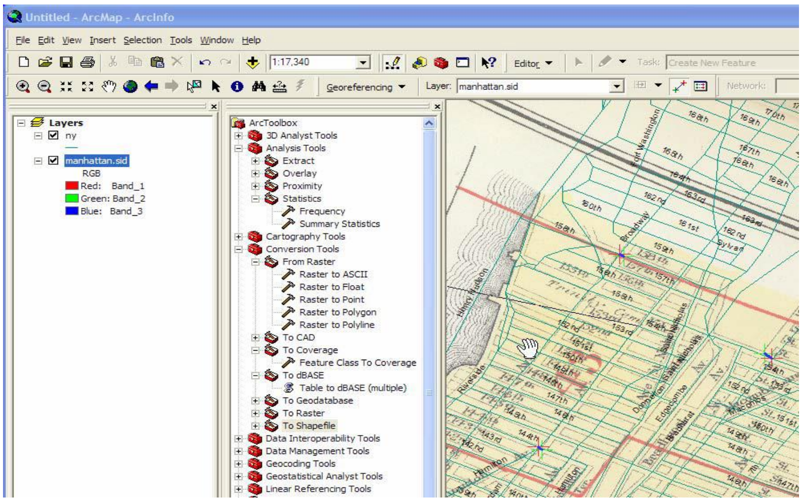


Fig 5.3 Interface of ArcGIS.

Fig 5.4 Geo-Referencing tool Box.

6. This process is carried out for the 48 topographical sheets.

The georeferencing tool is the main tool we'll be using in the first portion of today. To access the georeferencing toolbar, click Imagery in the ribbon. "Georeference" falls within the group of alignment. As you get more accustomed to using ArcGISPro,[2] you'll notice that selecting a tool from a menu item—like in this case, "Imagery"—can cause that tool—Georeference in this case—to appear in the ribbon tool categories.

7. Basin Boundary

1. The basin boundary is defined as the area of the respected study or the river path till the end of the river or any confluence.
2. In the respective case we will be studying the basin area of Bhima River.
3. The Boundary of Bhima River is termed as Bhima Basin Boundary.

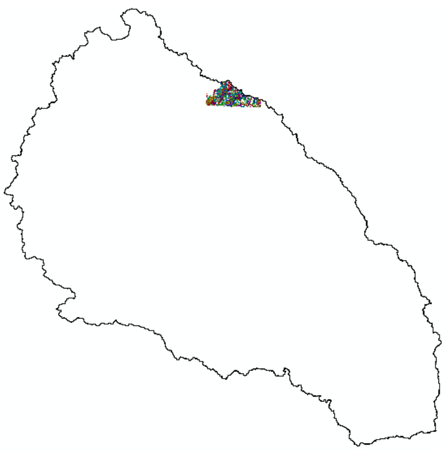


Fig 5.5 Bhima-Pandharpur Basin Boundary.

8. Shapefile

1. The shapefile is a type of file which can be used to generate digital data from maps or topographical sheets.
2. The shapefiles are of various different type depending on the work for example point, polyline, polygon, multipoint, multipitch. These types help us to do various types of work for rivers, plots, building, industrial sector and residential area or for reserved forests, etc. depending on the work.
3. The shapefiles can be created by, Folder is selected in which the shapefile is to be placed.

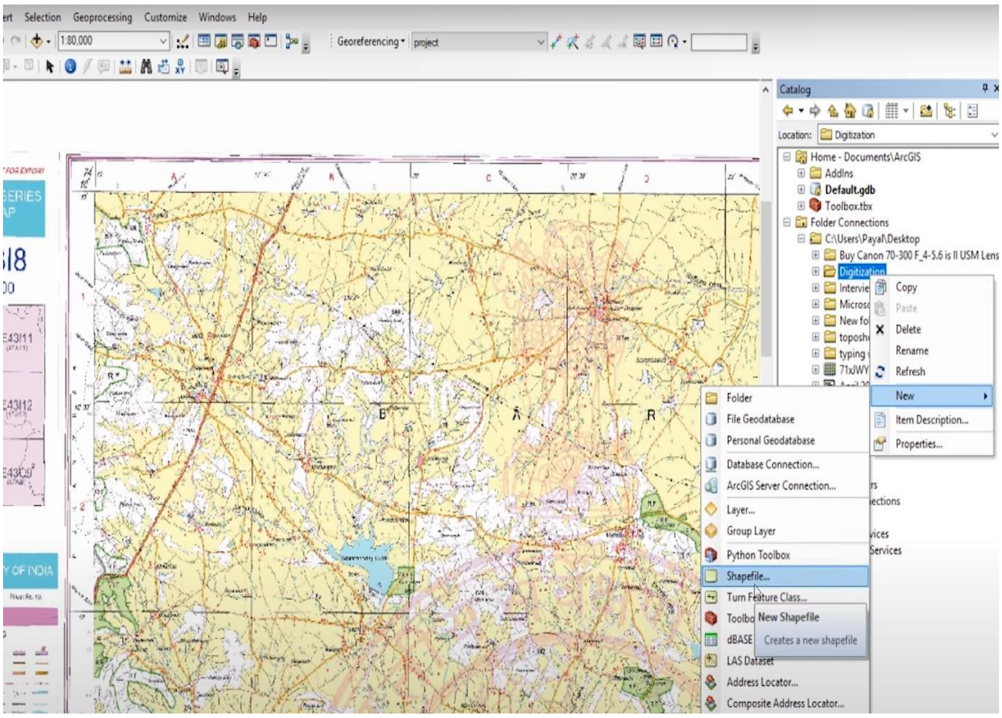


Fig 5.6 Shapefile Creating Process.

4. Then a new shape file needs to be create named stream.
5. The shapefile of type Polyline needs to be created.
6. The Co-ordinates that are to be assigned are "WGS 1984 UTM Zone 44N".
7. Thus, the new shapefile is created for stream.

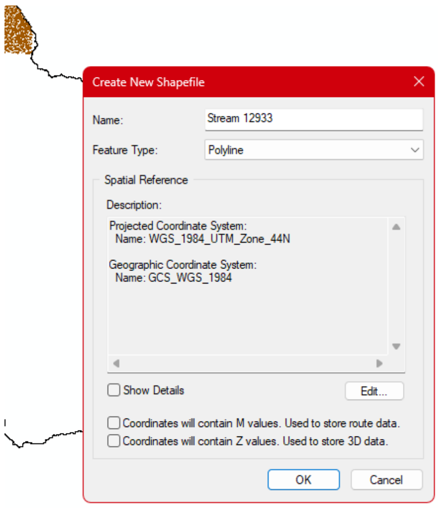


Fig 5.7 Shapefile type and Coordinate System.

9. Digitization

1. Digitization is a process of transforming the data from analog format to a digital format. This process was introduced by Alan Turing in the 20th century when all the data was in the hard paper or analog format. This system cause a revolution where the conversion of the data into digital format was started.
2. The process helps us to access the data from any place and at any time of need causing the progress and betterment of the nations.
3. There are various methods of digitization depending on the data weather it is documents, pictures or maps. This process has helped the river data to organize and produce a large-scale management procurement.
4. In our project there were lots of challenges during finalizing the process and also the software to be used we tried various softwares like QGIS, Google Earth Engine and ArcGIS. This finalization took use almost a month as this software has their perks and disadvantages.
5. To say if we see QGIS this software can be used on low processing devices but the major issue was that data management it can handle a data of 150 streams but after that we have to create a new folder for the next streams. But if we see 1 toposheet it contains more than 2500 streams. So, handling this amount of data QGIS is not good.
6. If we look at Google Earth Engine it is very good software as it can handle data over 4000 streams but the major problem is vegetation cover it makes hard for our objective here as we have to trace the 3rd, 4th and 5th order streams. This makes it impossible to work. Hence Google Earth Engine is not good.
7. Now if we look at ArcGIS it plays a good part in handling the data as well as vegetation cover is not a issue so ArcGIS plays a good part in completion of the project.
8. After finalization of ArcGIS the digitization work is started on ArcGIS.
9. The digitization is done by using the shapefiles that we have created previously.
10. The using an editor's tab for using this polyline shapefiles as streams and the small black lines on the toposheet representing the streams. After digitizing the streams, the save and stop edit is used.

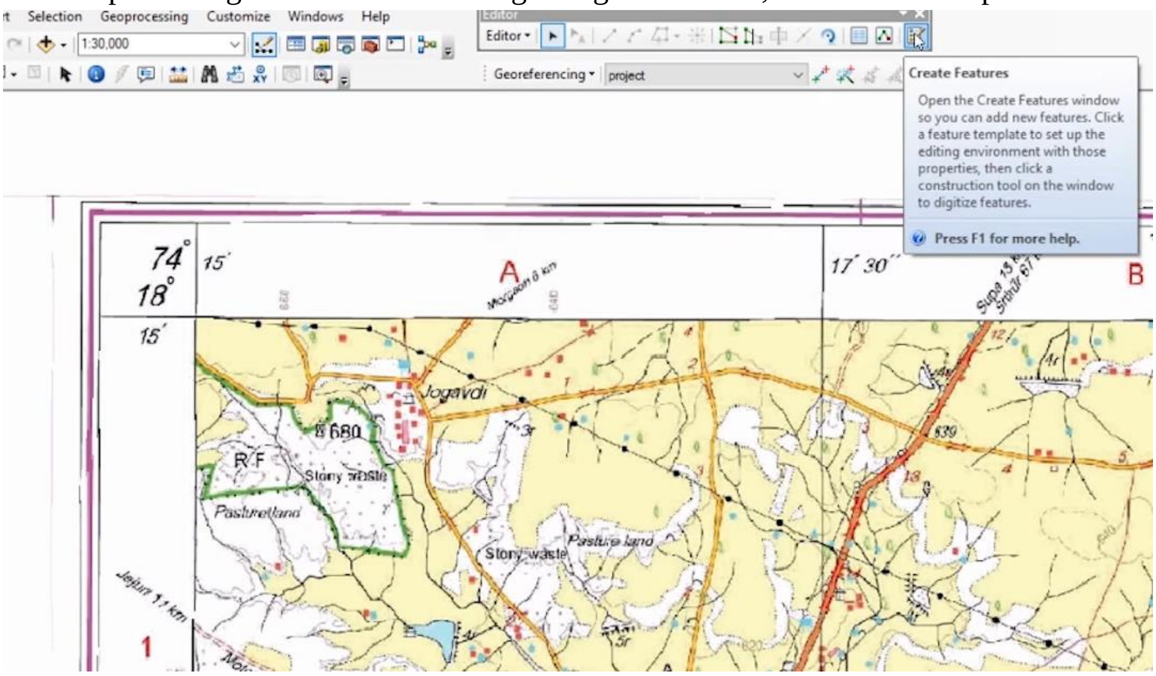


Fig 5.8 Reference Topographical Sheet.

11. This process is repeated multiple times until the toposheet is completed.

10. Digital Elevation Model (DEM)

Information about elevation produced from TM (Topographical Map) is a valuable source of data, particularly for GIS applications. One of the most widely used and traditional methods for representing elevations in TM is the use of contours.[6] TM could be incorporated into a GIS directly in raster format or through the vectorization process as digital data. Planimetric coordinates and elevations are the most common types of digital topographical information that customers require. Raster data therefore falls short of user expectations for real-time practical engineering and geoscience applications. Therefore, it is necessary to analyze the transition from the TM to the DEM in the spatial coordinate system. DEM, or digital elevation mapping, is a three-dimensional computer depiction of a portion of the earth's surface created using modeling algorithms and sampling reference points (SRPs) on a local or worldwide scale.[6] These days, DEM are widely utilized in a wide range of applications, including radio communications planning, aviation simulation, civil engineering, mining engineering, visibility analysis, hydrological modeling, urban planning, and regular mapping applications.

Different methods have been used to collect DEM data in the applications:

1. Terrestrial topographical surveying.
2. GPS supported observation.
3. Photogrammetric measurement techniques.[6]
4. Digitizing the existing topographical map.

In recent years, many techniques have become popular for elevation data collection such as:

1. Orthophoto maps.[6]
2. Remote sensing images.
3. Lidar “light detection and ranging” technology.
4. Interferometric SAR (syntactic aperture radar) data.
5. Digital elevation databases.

a. DEM Processing:

1. Acquisition of Contour Map in Raster Image Format via Scanning Process.
2. Raster to vector conversion by thresholding, gray scaling, filtering, thinning, edge detection.
3. Contour line digitization as polyline in raster coordinate system.
4. Updating their height information and transforming the polylines' points to a ground coordinate system.
5. Form of the surface fitting 3D DEM input data file various input data sets with 100%, 50%, 25%, and so on for the number of sampling points.
6. Utilizing interpolation techniques to determine the surface of the land thin Plate Spline Variable grid size with smoothing and search ellipses.
7. Demonstration of DEM.
8. The raw data looks like:

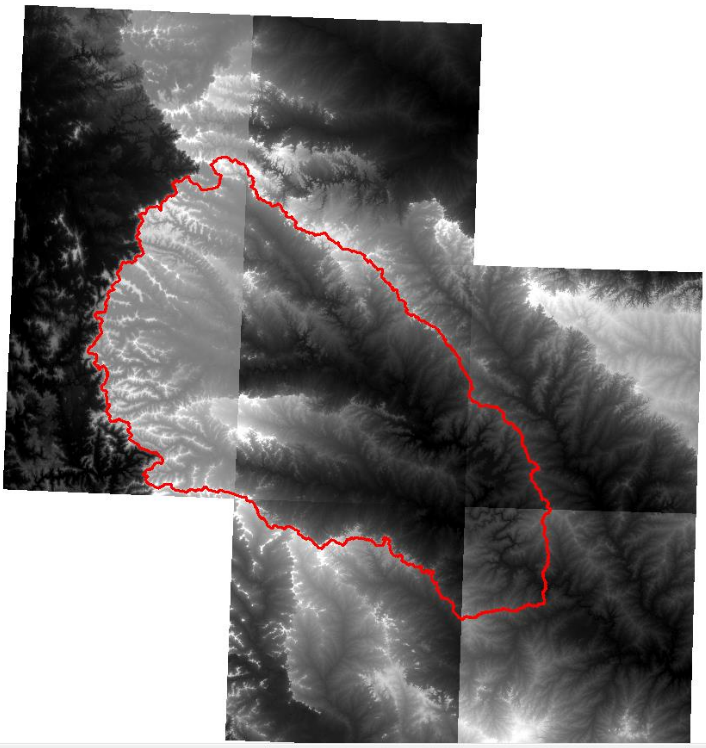


Fig 9.1 Raw data for Digital Elevation Model (Dem)

9. The data above is not refined, to process this data to our project there is arc tool box in ArcGIS.
10. This tool box is used to further the filtration where in Spatial Analysis Tool contains Hydrology tool.
11. This hydrology is used by in this Flow Direction is used to trac the geography.
12. Then Flow Accumulation is used to trace down the rivers and streams.
13. To extract this streams 'stream' tool is used on the Flow accumulation data resulting in a accurate stream network using DEM data.

11. Topographical Sheets

1. The topographical sheets are the geographical data converted to a map depending on the contours, rivers, vegetation and the cities.
2. This toposheets are the base resource for my project as they are certified and accurate according to the government of India on the Survey Of India (SOI) website.
3. The data we will be using is open series maps and for my basin it requires 48 toposheets.
4. All this data is digitized and then compiled into a merge file.
5. All the toposheets used are as followed:

1. E43B11_47E11:

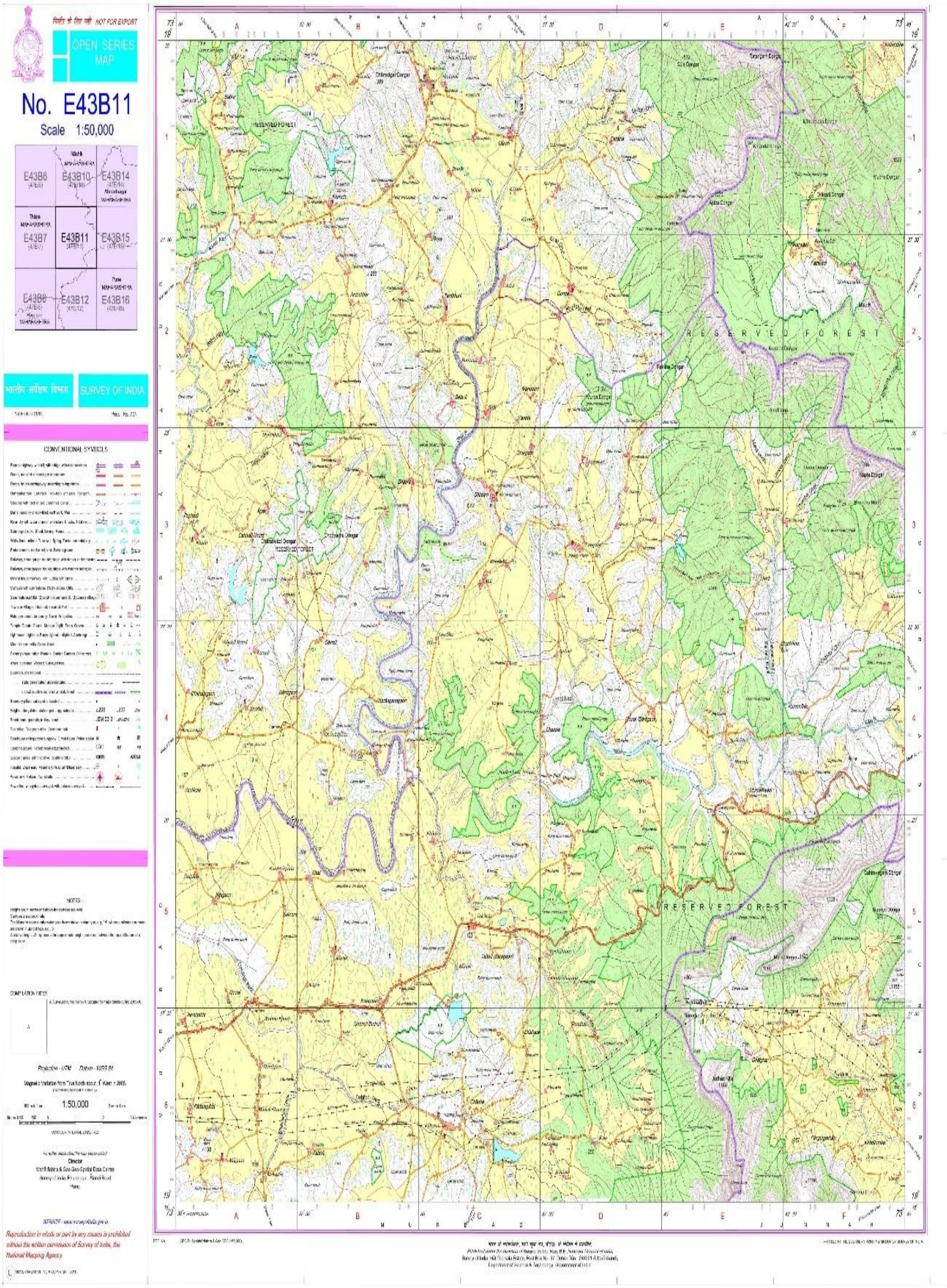


Fig 10.1 Toposheet E43B11_47E11.

2. E43B12_47E12:

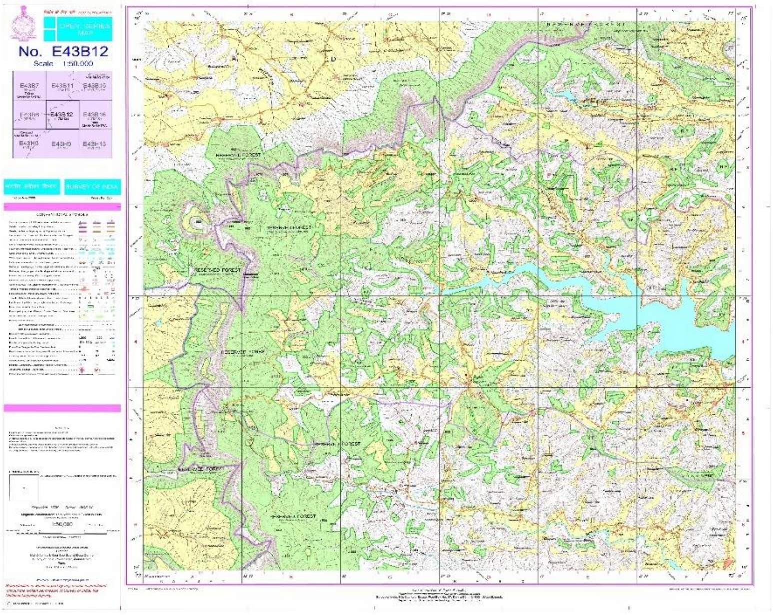


Fig 10.2 Toposheet E43B12_47E12.

3. E43B15_47E15:

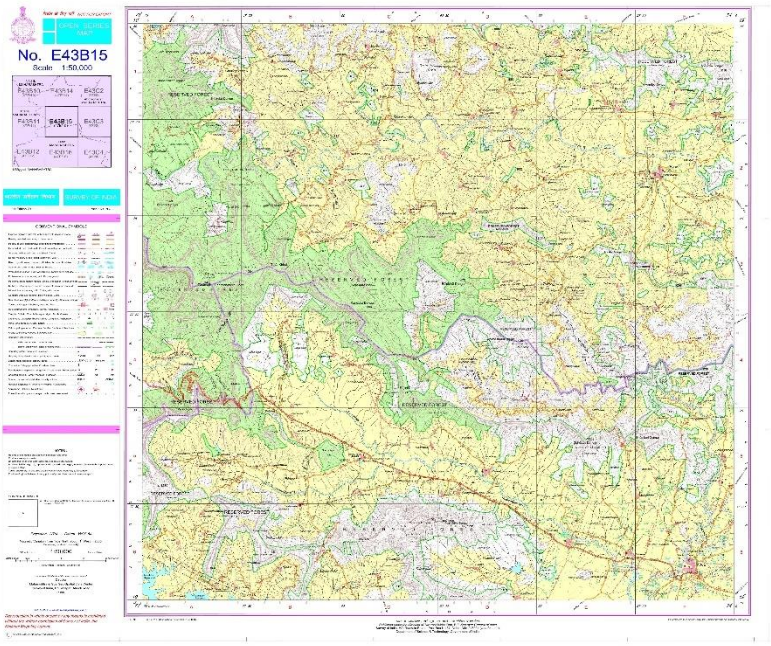


Fig 10.3 Toposheet E43B15_47E15.

4. E43B16_47E16:

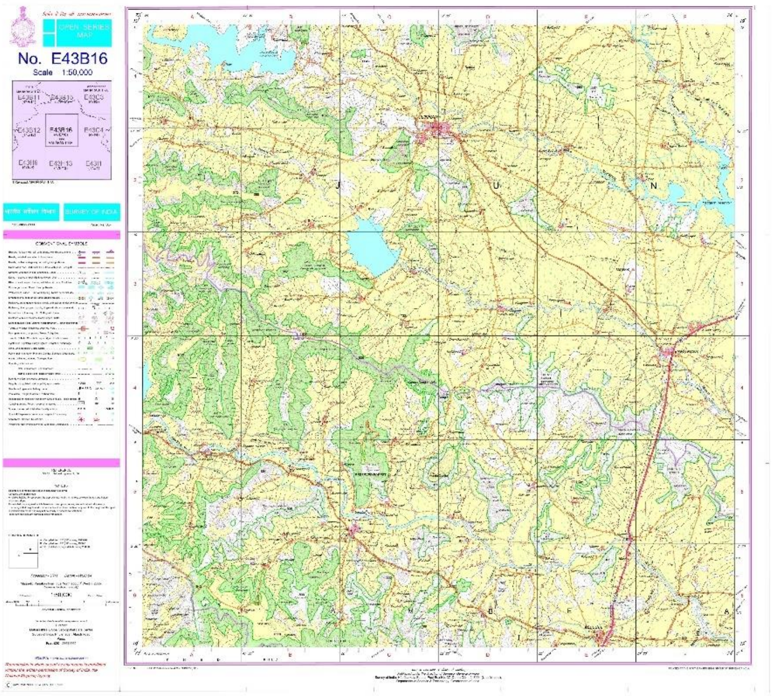


Fig 10.4 Toposheet E43B16_47E16.

5. E43C3_47I3:

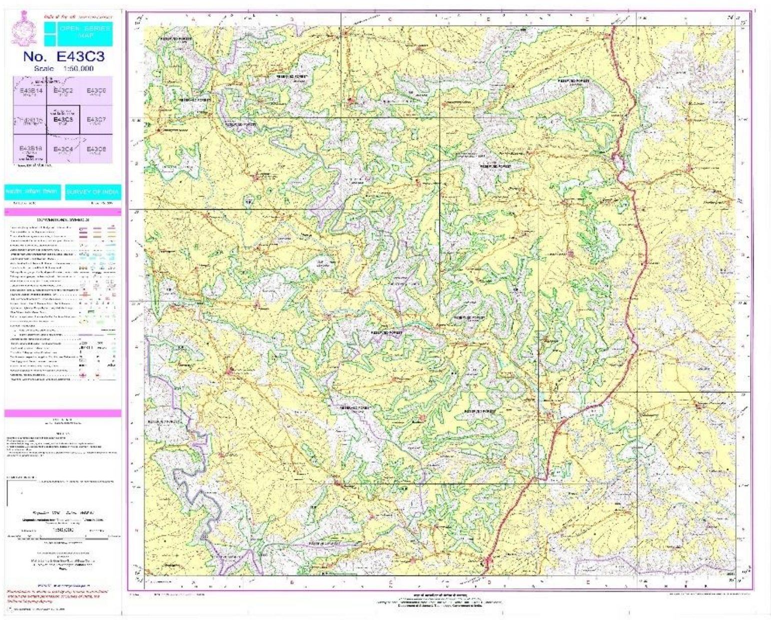


Fig 10.5 Toposheet E43C3_47I3.

6. E43C4_47I4:

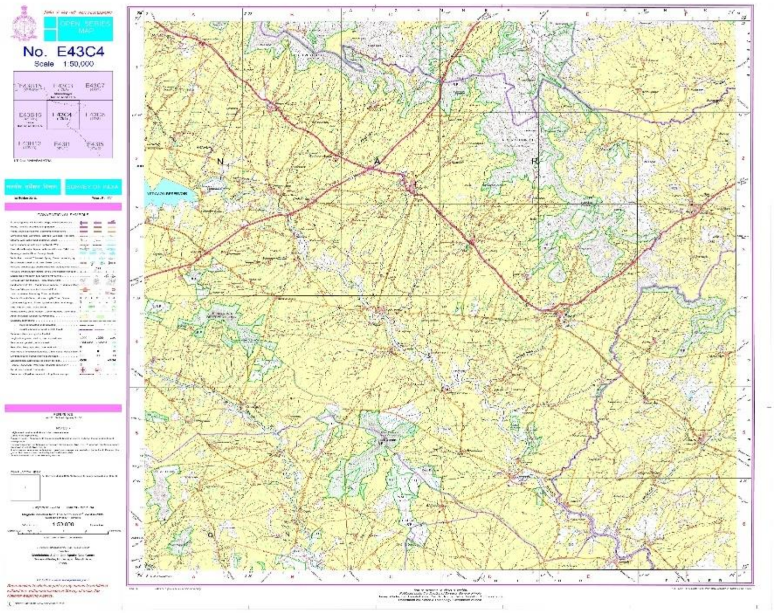


Fig 10.6 Toposheet E43C4_47I4.

7. E43C8_47I8:

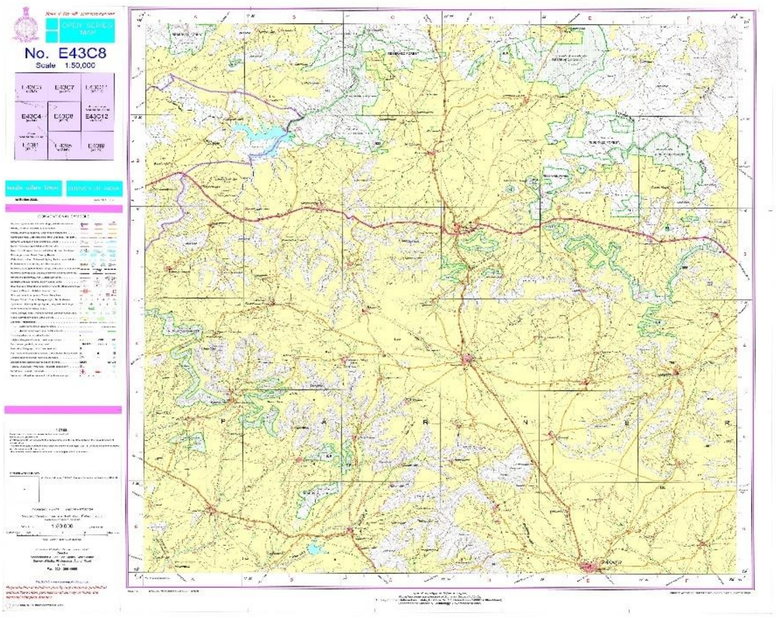


Fig 10.7 Toposheet E43C8_47I8.

8. E43C12_47I12:

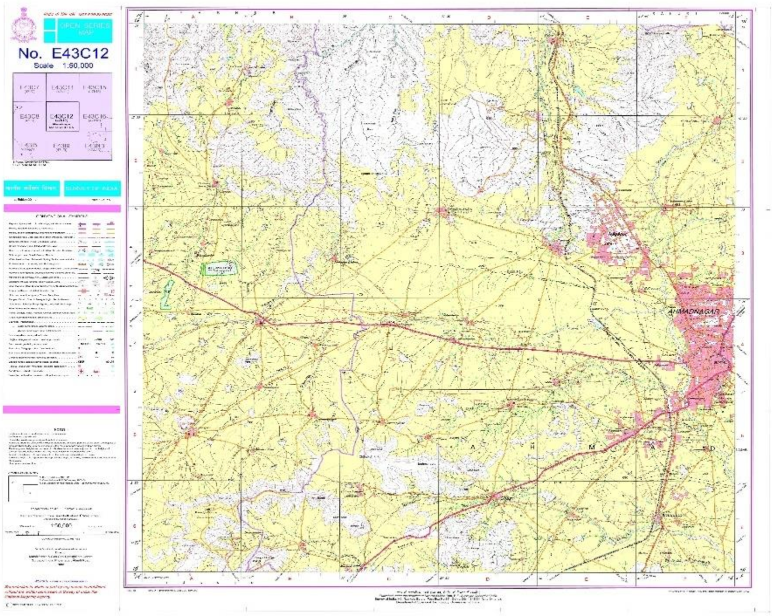


Fig 10.8 Toposheet E43C12_47I12.

9. E43H5_47F5:

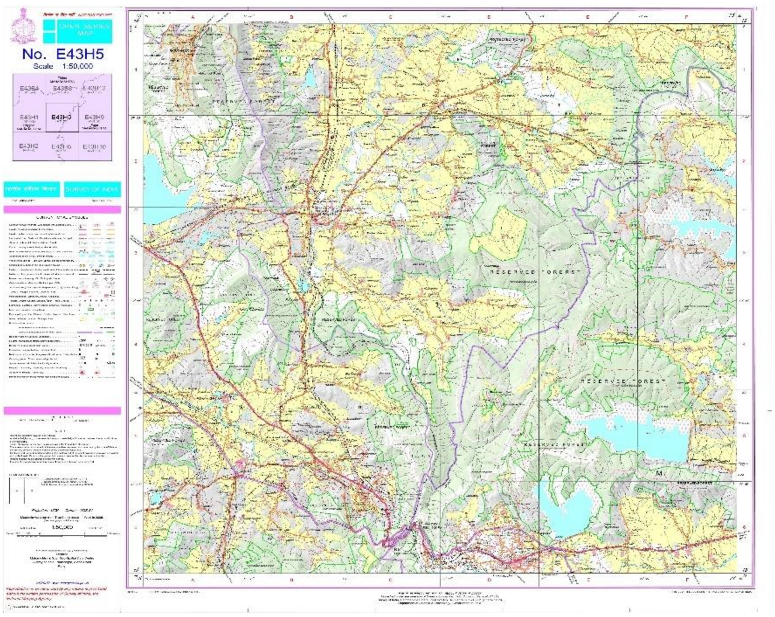


Fig 10.9 Toposheet E43H5_47F5.

10. E43H6_47F6:

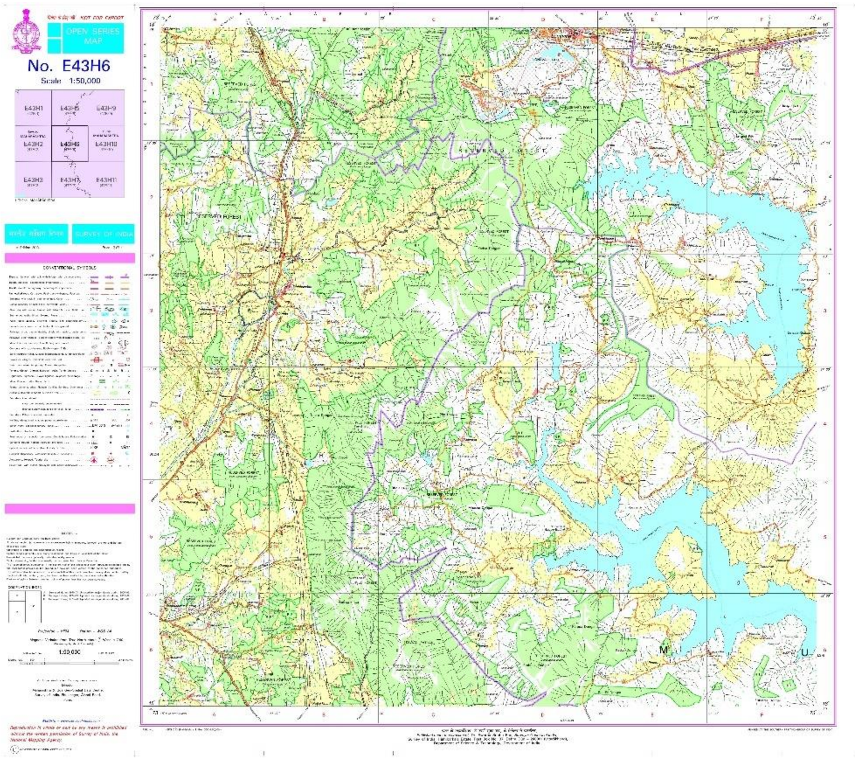


Fig 10.10 Toposheet E43H6_47F6.

11. E43H7_47F7:

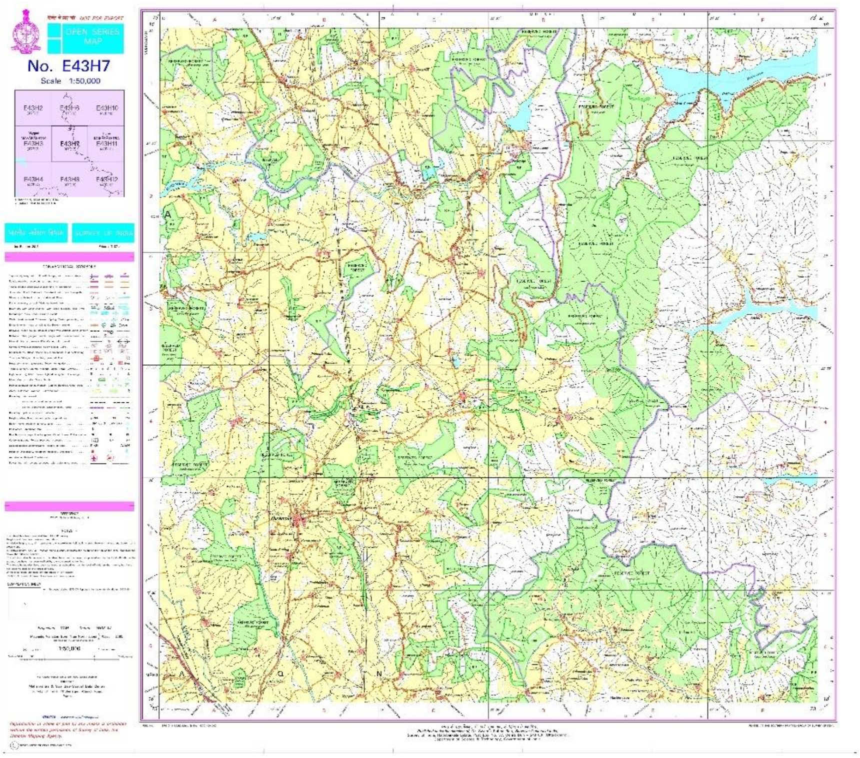


Fig 10.11 Toposheet E43H7_47F7.

12. E43H9_47F9:

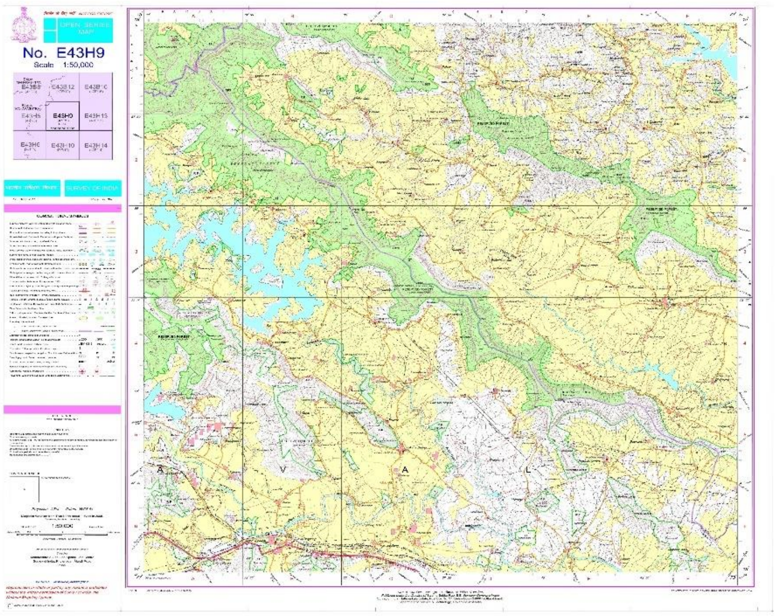


Fig 10.12 Toposheet E43H9_47F9.

13. E43H10_47F10:

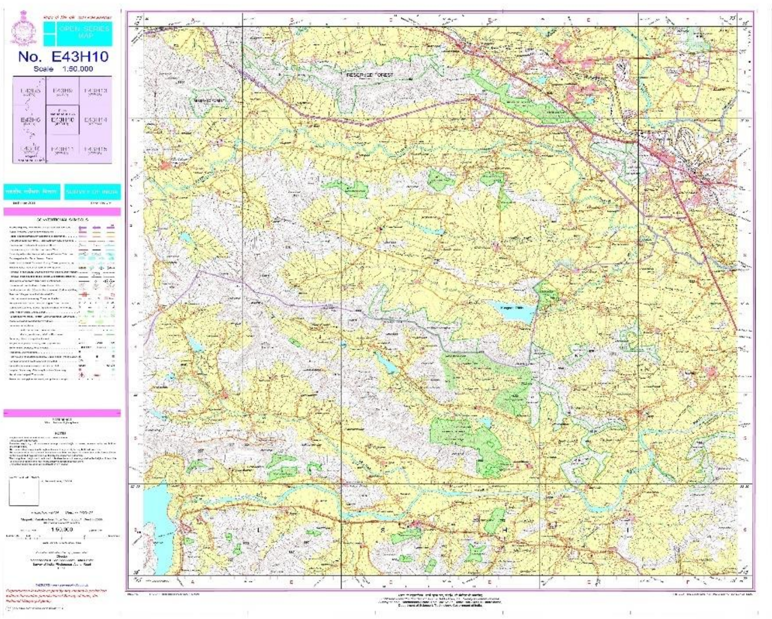


Fig 10.13 Toposheet E43H10_47F10.

14. E43H11_47F11:

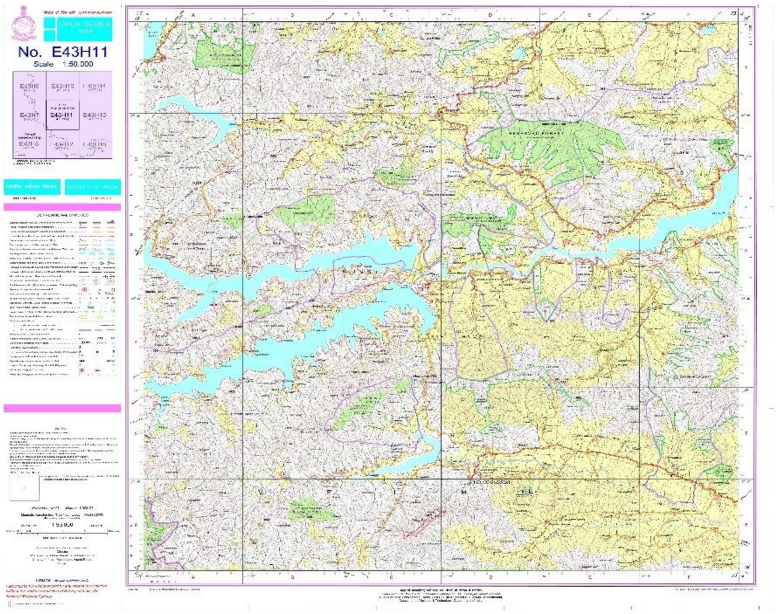


Fig 10.14 Toposheet E43H11_47F11.

15. E43H12_47F12:

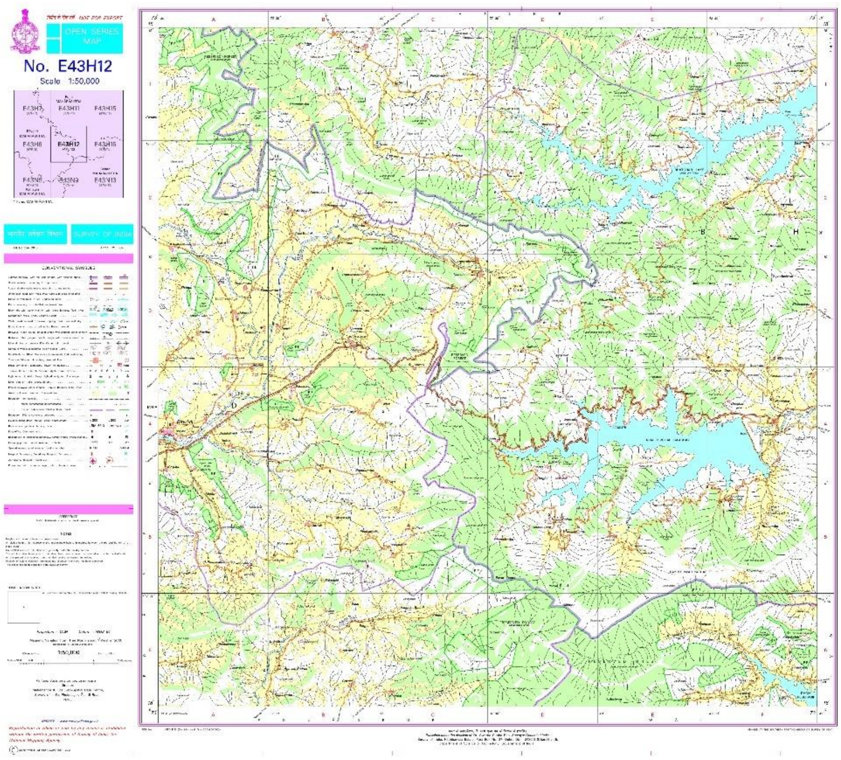


Fig 10.15 Toposheet E43H12_47F12.

16. E43H13_47F13:

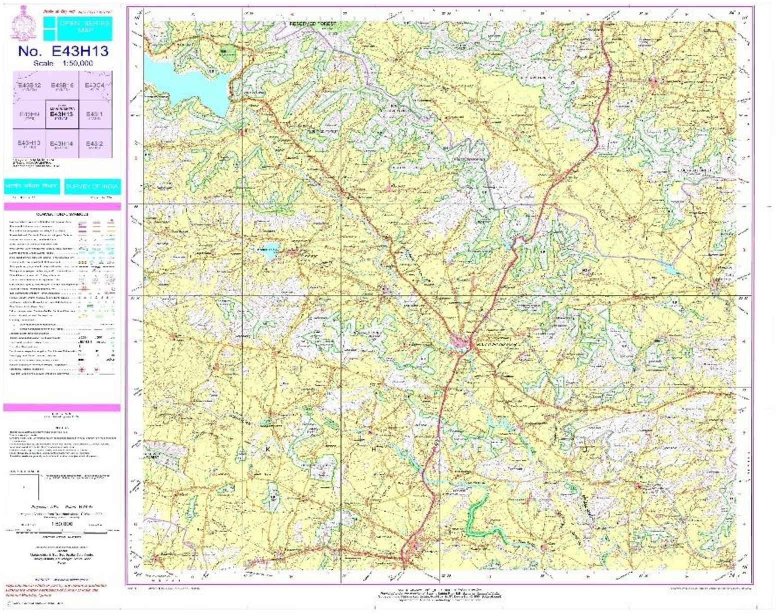


Fig 10.16 Toposheet E43H13_47F13.

17. E43H14_47F14:

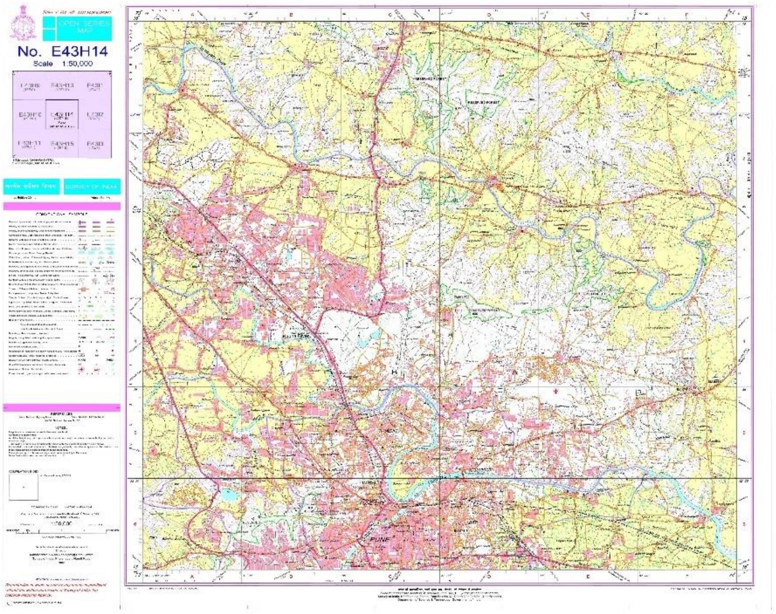


Fig 10.17 Toposheet E43H14_47F14.

18. E43H15_47F15:

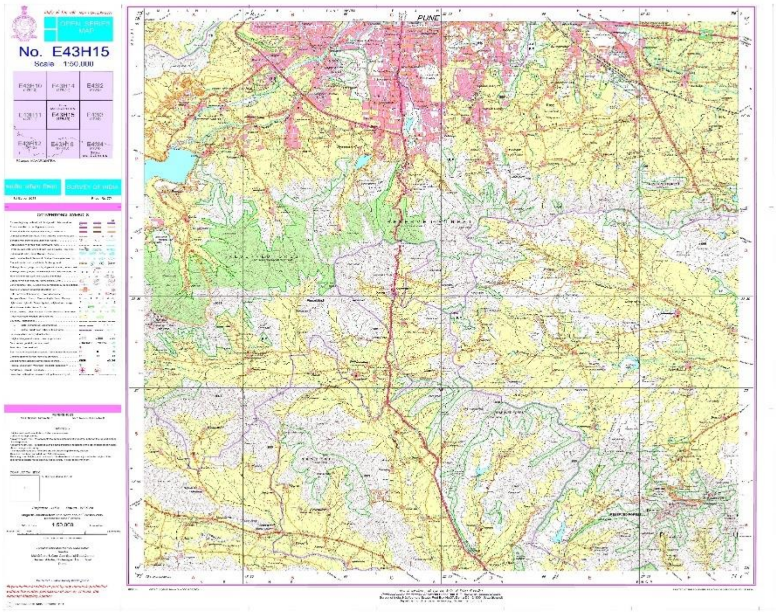


Fig 10.18 Toposheet E43H15_47F15.

19. E43H16_47F16:

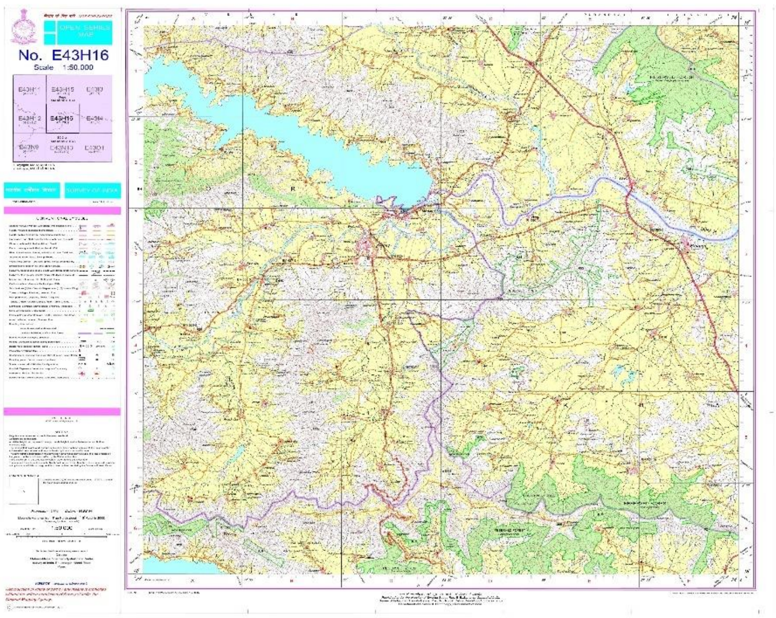


Fig 10.19 Toposheet E43H16_47F16.

20. E43I1_47J1:

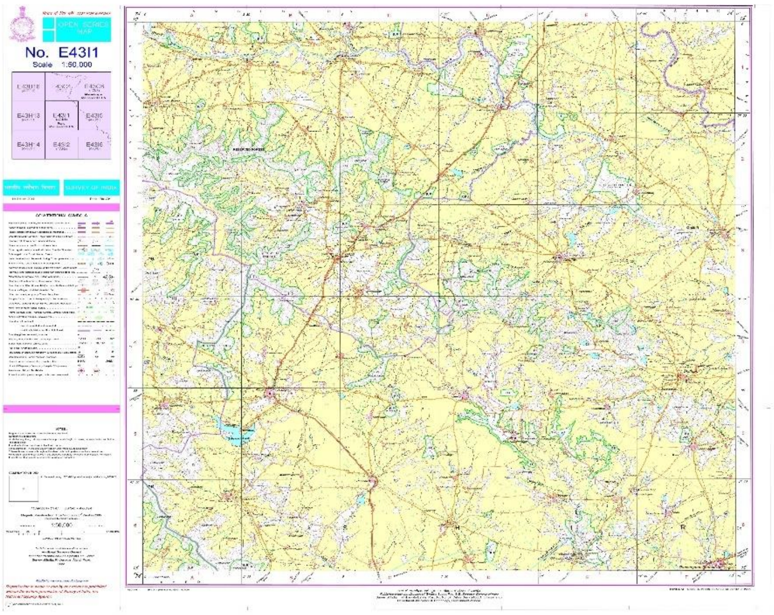


Fig 10.20 Toposheet E43I1_47J1.

21. E43I2_47J2:

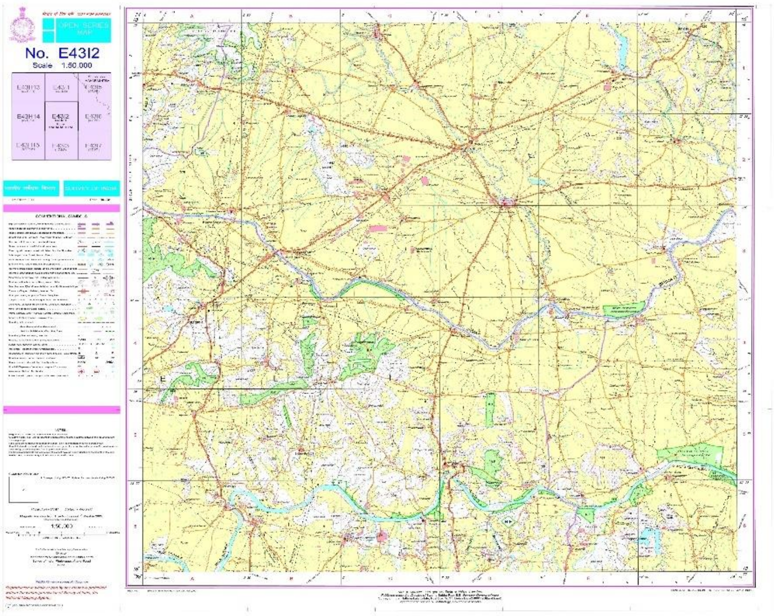


Fig 10.21 Toposheet E43I2_47J2.

22. E43I3_47J3:

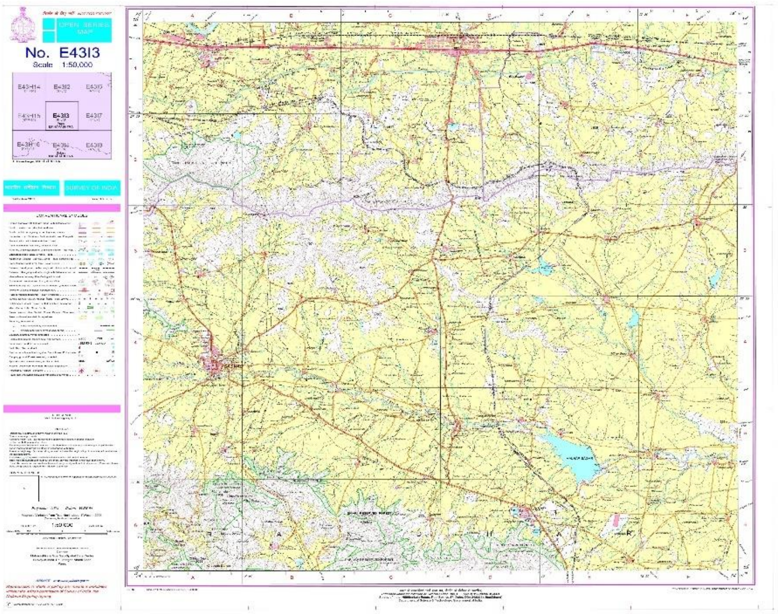


Fig 10.22 Toposheet E43I3_47J3.

23. E43I4_47J4:

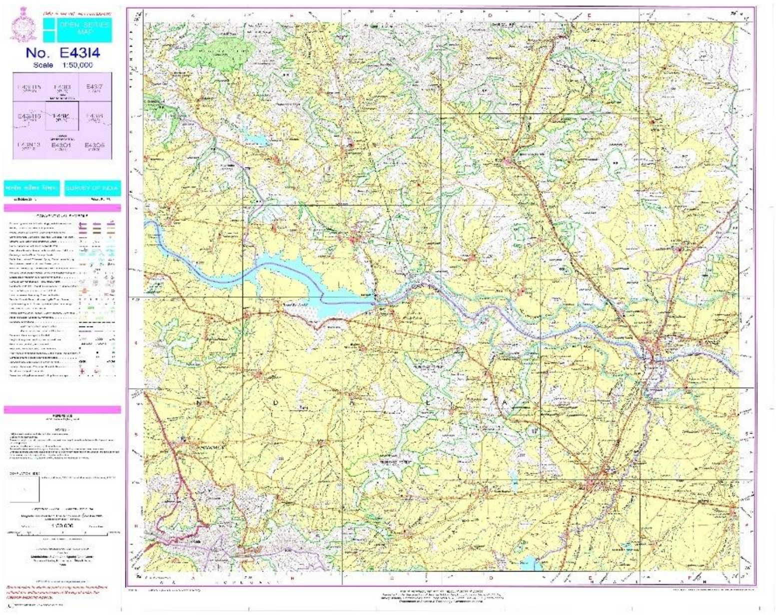


Fig 10.23 Toposheet E43I4_47J4.

24. E43I5_47J5:

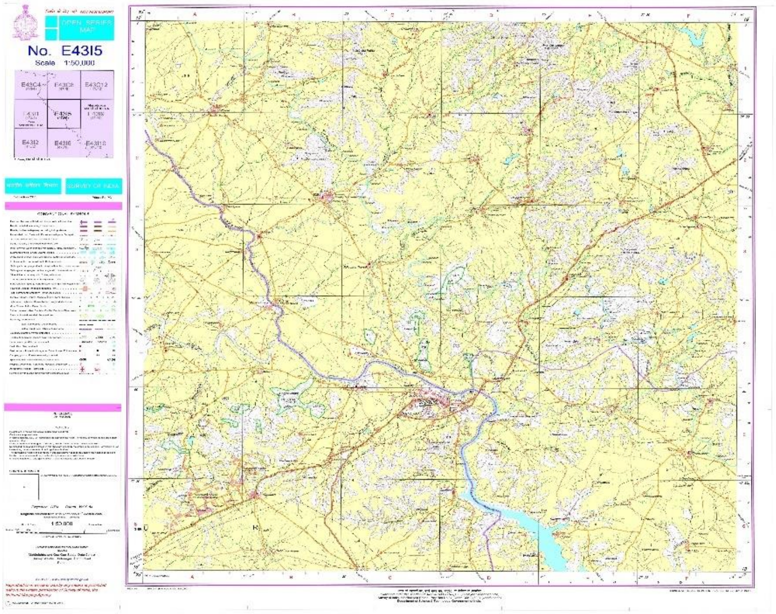


Fig 10.24 Toposheet E43I5_47J5.

25. E43I6_47J6:

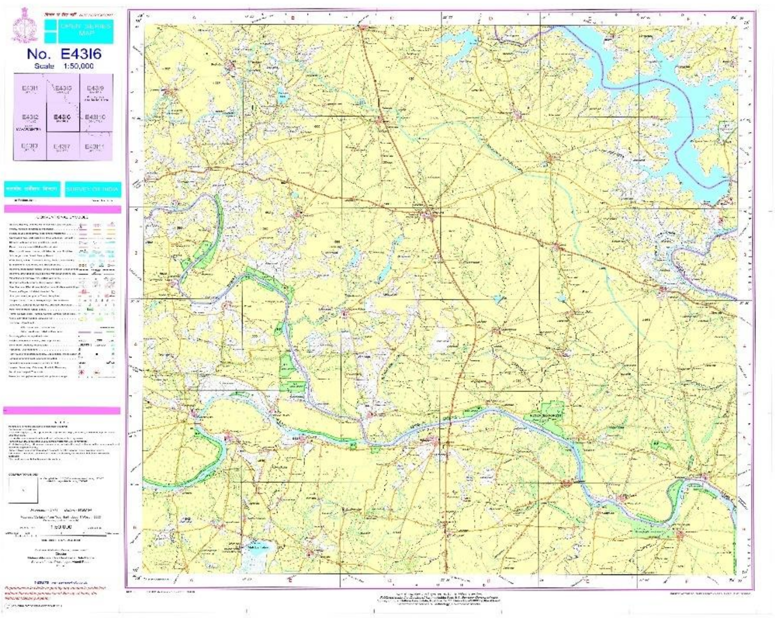


Fig 10.25 Toposheet E43I6_47J6.

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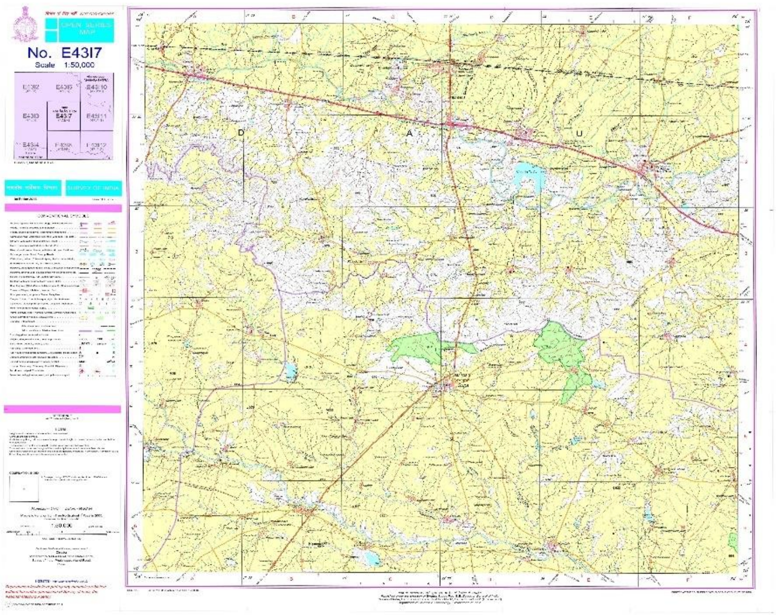

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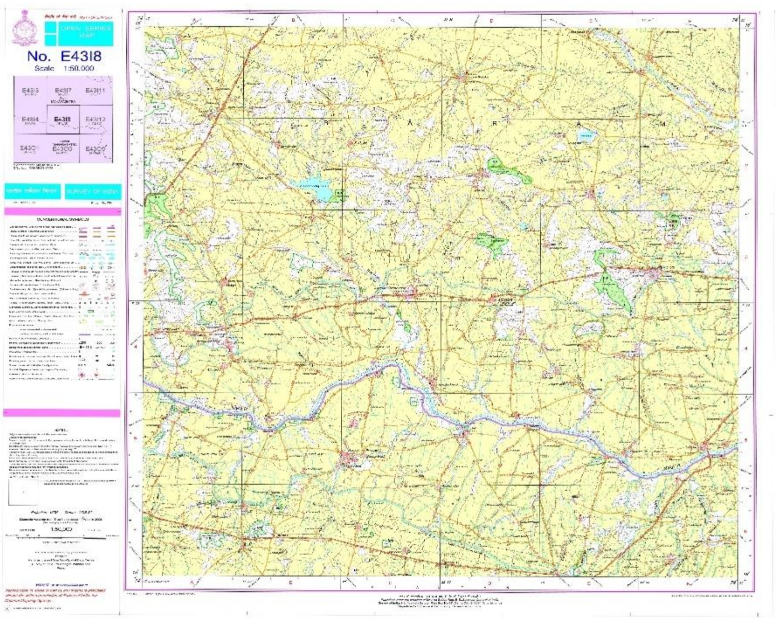

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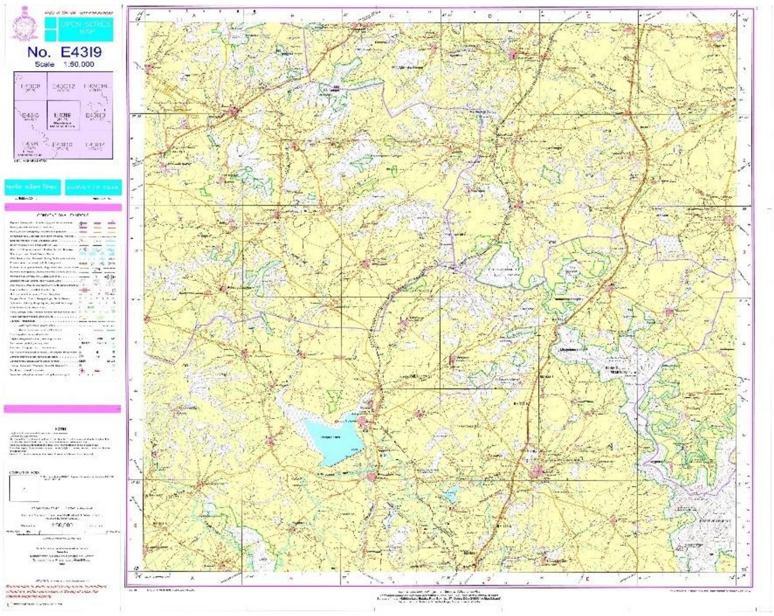
28. E43I9_47J9:



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29. E43I10_47J10:

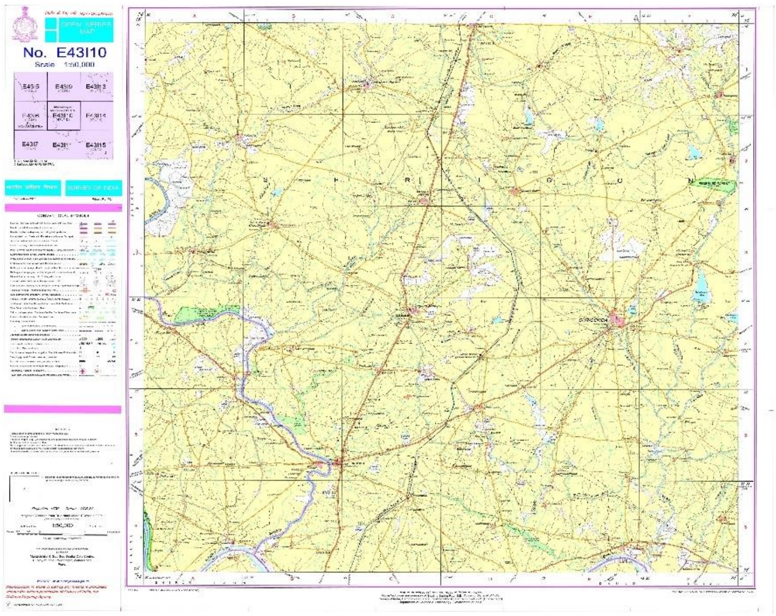

Fig 10.29 Toposheet E43I10_47J10.

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30. E43I11_47J11:

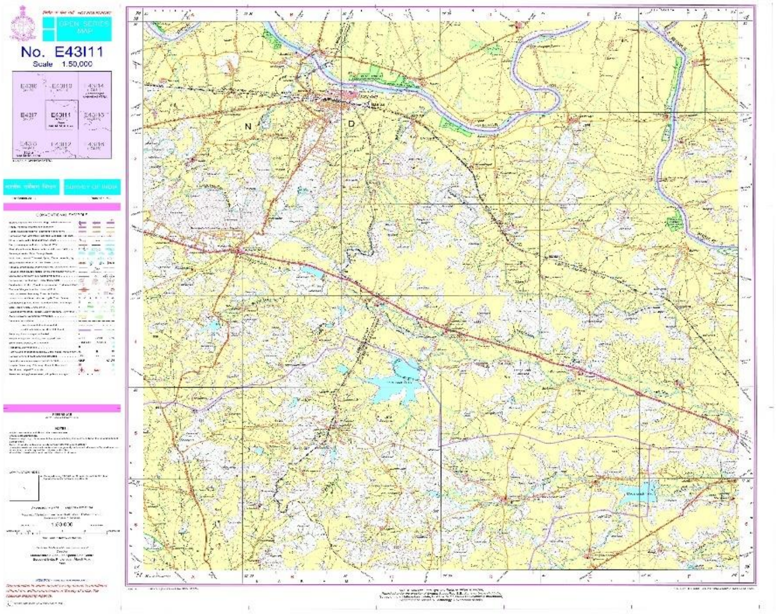


Fig 10.30 Toposheet E43I11_47J11.

31. E43I12_47J12:

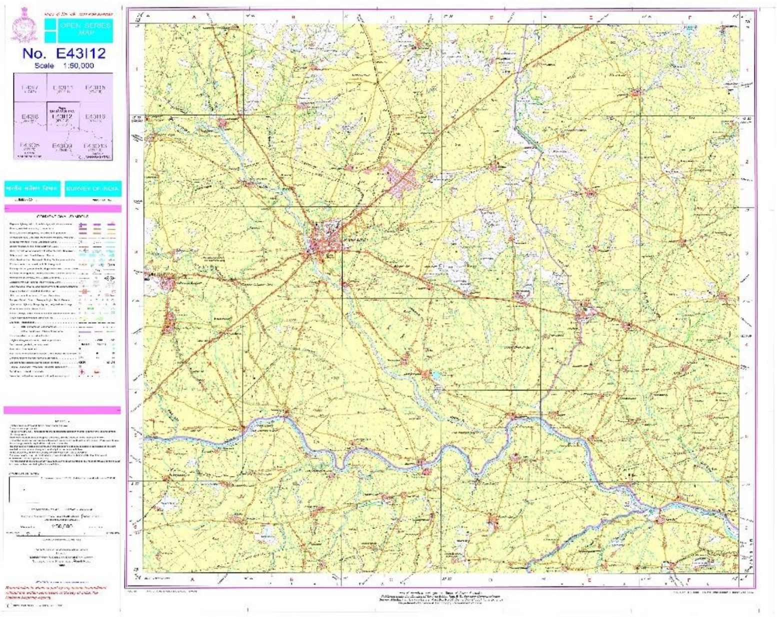


Fig 10.31 Toposheet E43I12_47J12.

32. E43I13_47J13:

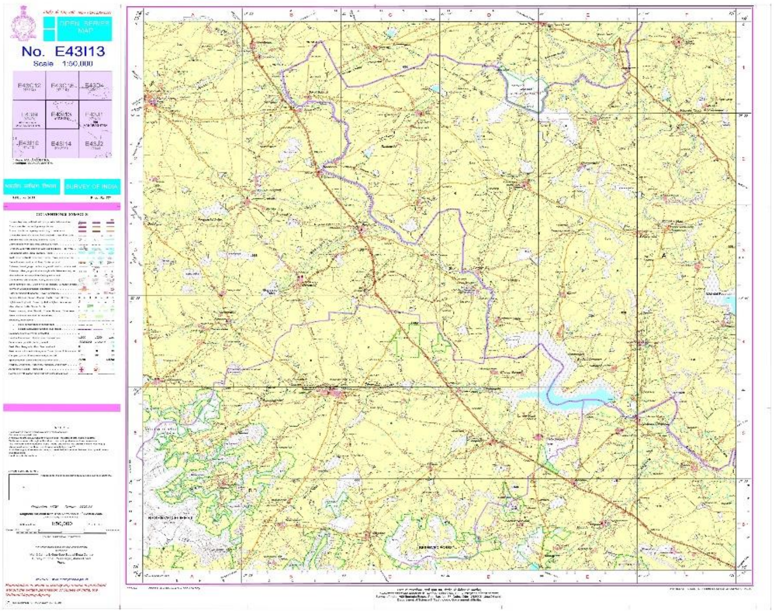


Fig 10.32 Toposheet E43I13_47J13.

33. E43I14_47J14:

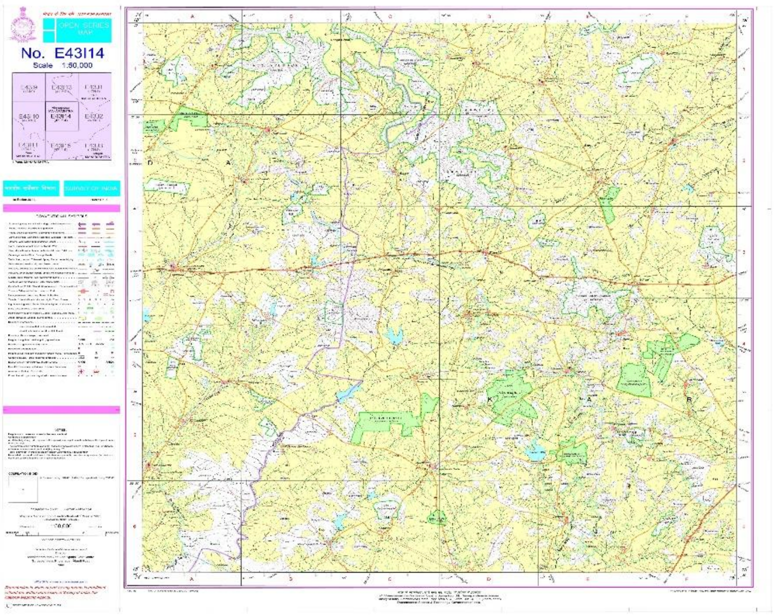


Fig 10.33 Toposheet E43I14_47J14.

34. E43I15_47J15:

Fig 10.34 Toposheet E43I15_47J15.

35. E43I16_47J16:

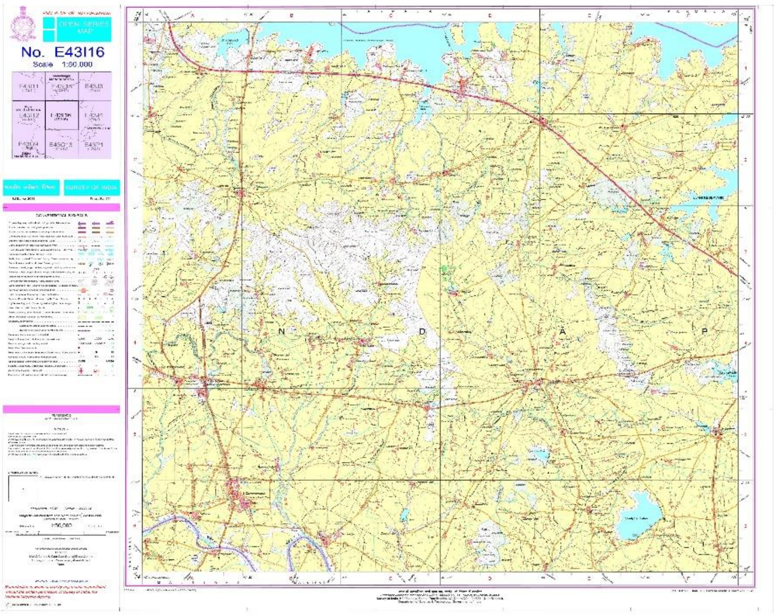


Fig 10.35 Toposheet E43I16_47J16.

36. E43J2_47N2:

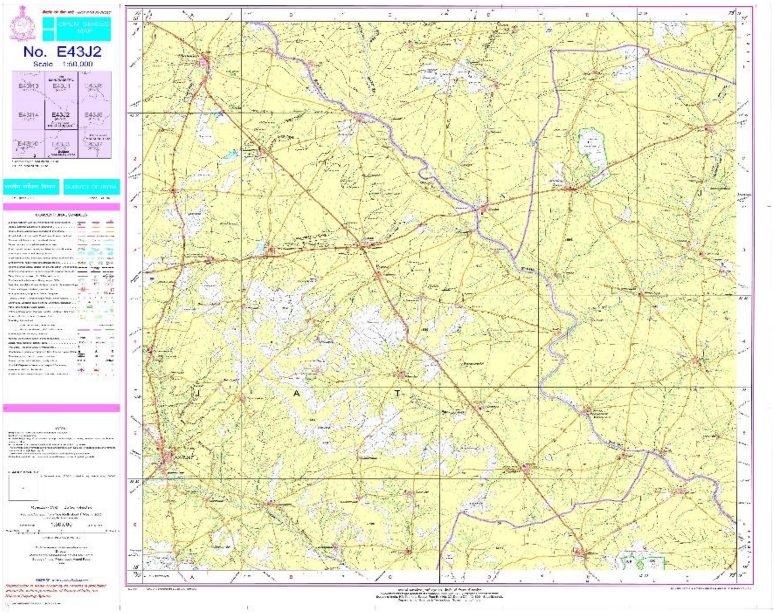


Fig 10.36 Toposheet E43J2_47N2.

37. E43J3_47N3:

Fig 10.37 Toposheet E43J3_47N3.

38. E43J4_47N4:

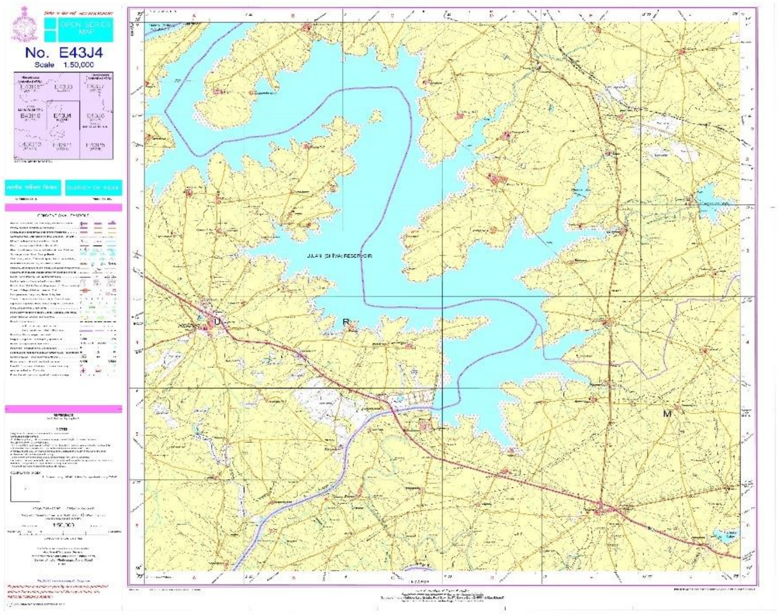
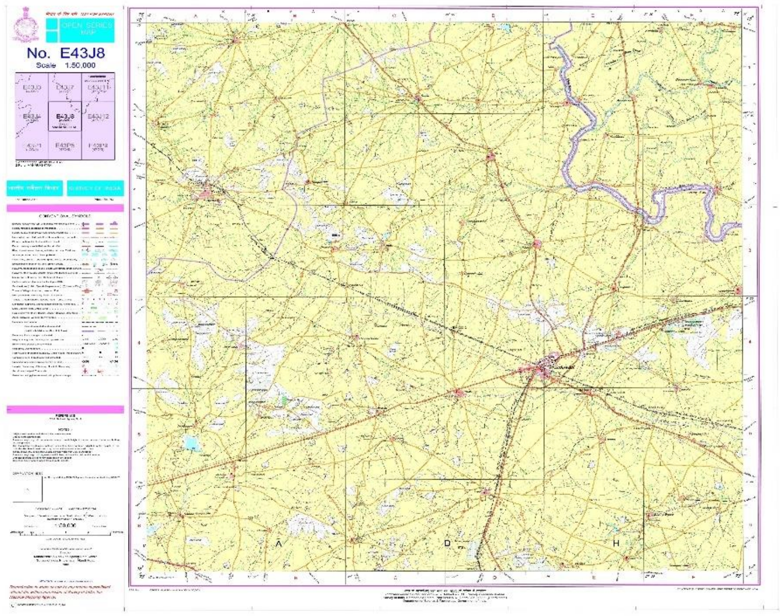


Fig 10.38 Toposheet E43J4_47N4.

39. E43J8_47N8:



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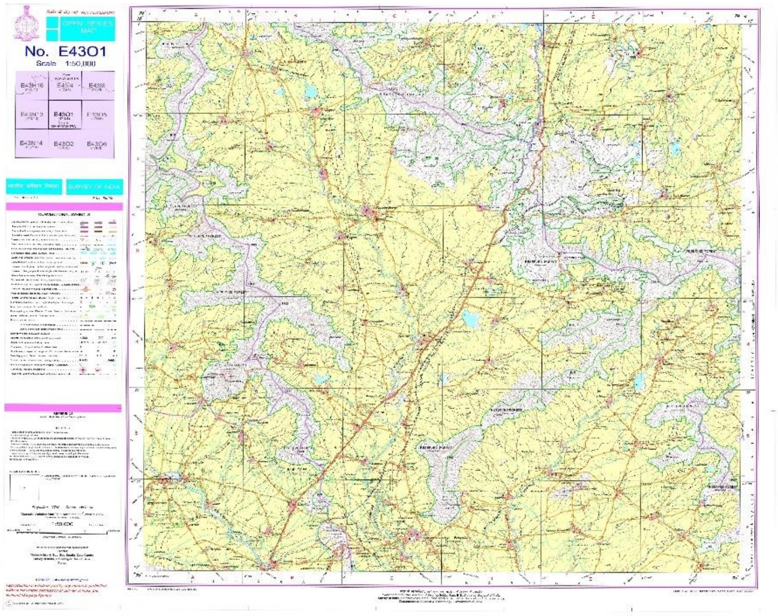

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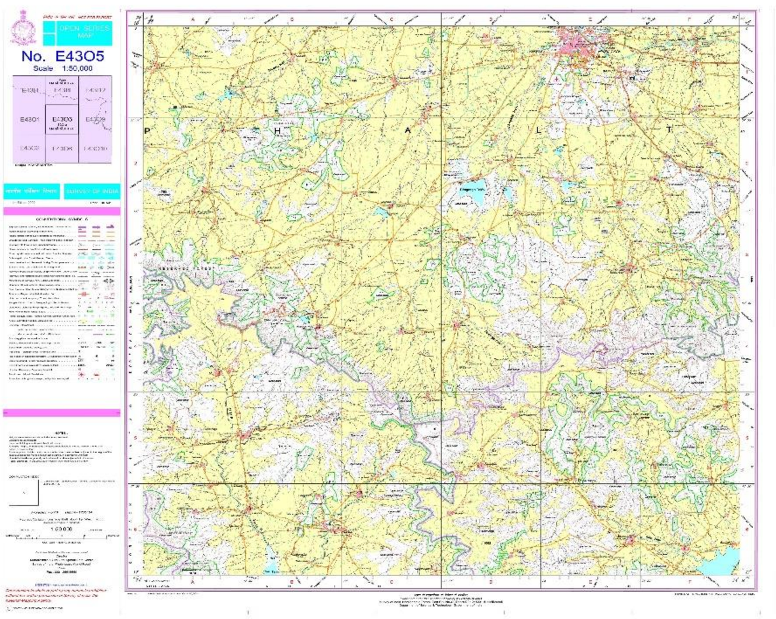

Fig 10.41 Toposheet E43O5_47K5.

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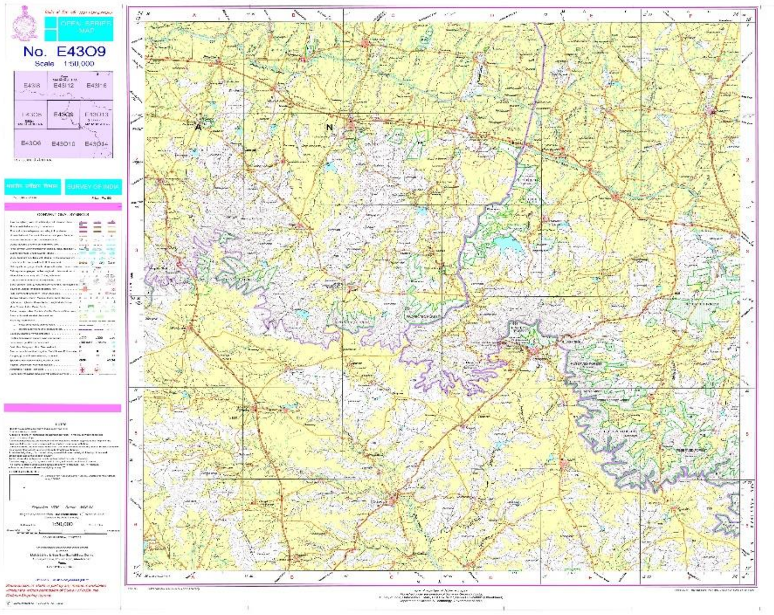
42. E43O9_47K9:



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43. E43O13_47K13:

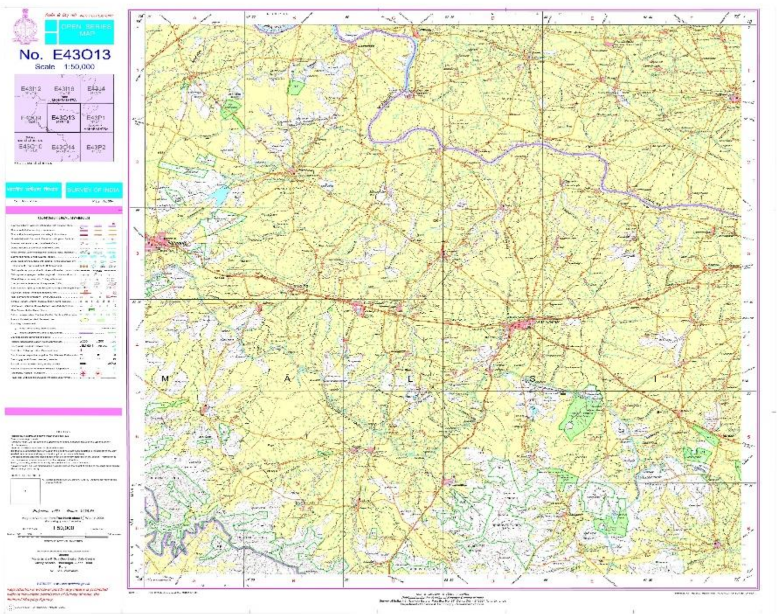

Fig 10.43 Toposheet E43O13_47K13.

44. E43O14_47K14:

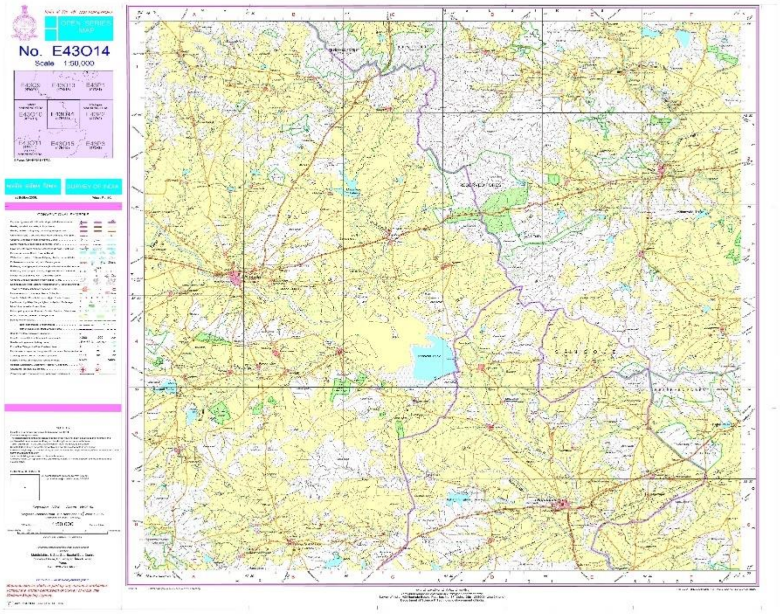

Fig 10.44 Toposheet E43O14_47K14.

45. E43P1_47O1:

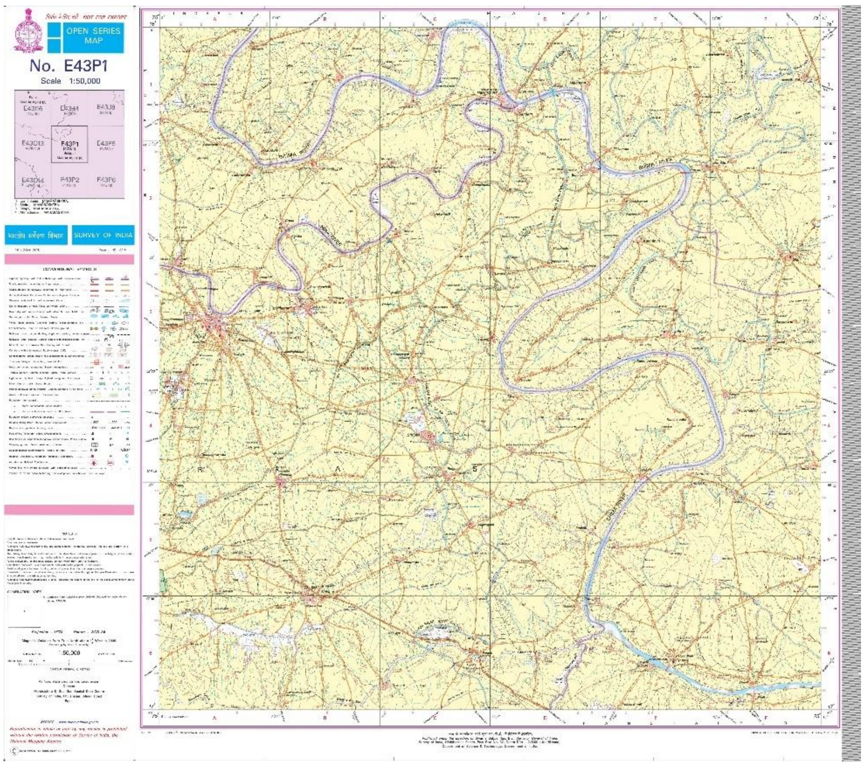

Fig 10.45 Toposheet E43P1_47O1.

46. E43P2_47O2:

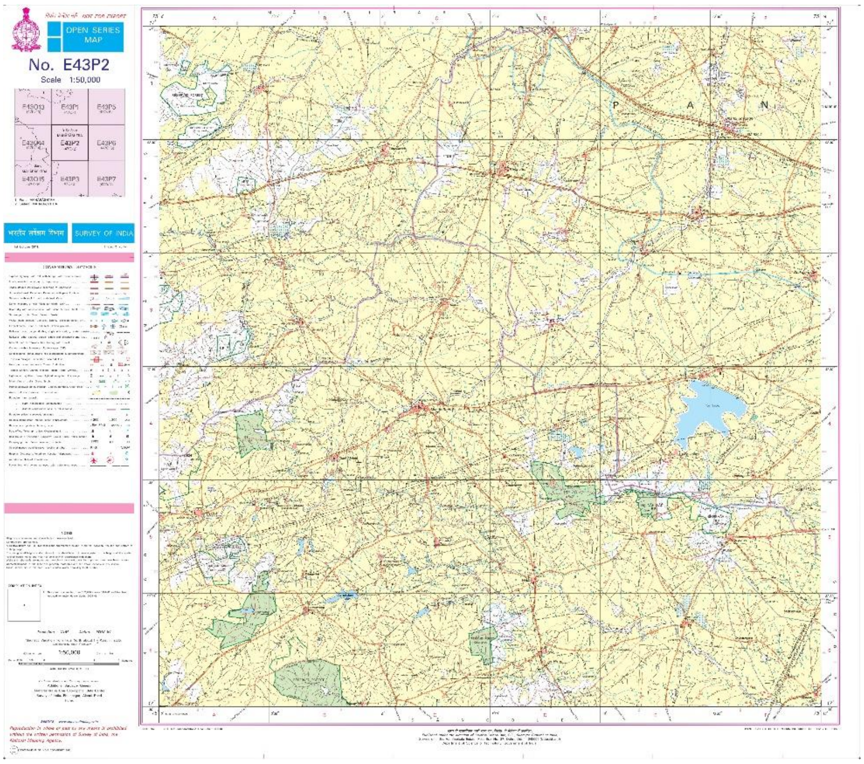

Fig 10.46 Toposheet E43P2_47O2.

47. E43P5_47O5:

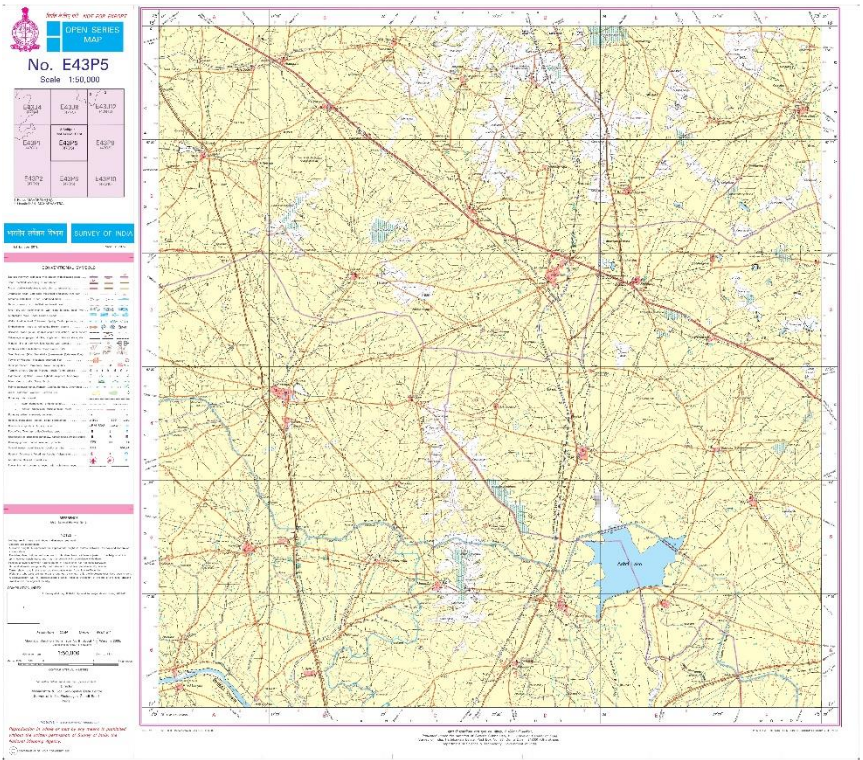

Fig 10.47 Toposheet E43P5_47O5.

48. E43P6_47O6:

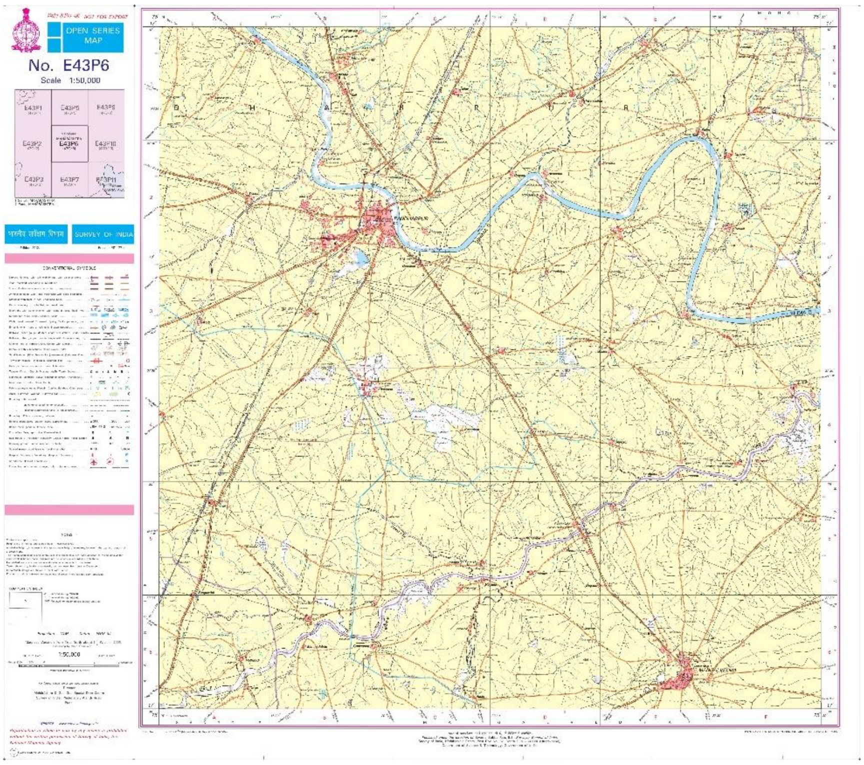

Fig 10.48 Toposheet E43P6_47O6.

12. Results and discussion

The toposheets above shown were completely digitized and also the merging of file was done to display the data. The process took with the given time frame:

1st Week of Project (01/12/2023):

Day 1 : I started with Geo-Referencing the Topographical sheet's to the designated co-ordinates according to the longitude and latitude of the area. The data that was acquired from Survey Of India website were not Geo – Referenced.

Day 2 : The work continued with the same procedure to Geo-Referencing.

Day 3-7 : During this time 24 Toposheets were Geo - Referenced.

2nd Week of Project (08/12/2023):

Day 8-14 : During this time various meeting with the seniors were taking regarding the training and the doubts that are arising further more I was assigned to understand the basic of the GIS systems and how does it work. To understand the basic principals of GIS I was asked to watch various videos by providing me with a YouTube playlist. I was asked to understand this videos and also to try the examples that will help me learn the working of GIS.

3rd Week of Project (15/12/2023):

Day 15-21 : During this time I was assigned to under stand the ArcGIS and its functioning. The process was further more indulged with a demo work and the problem solving process where in the technical and practical problems were summarized leaving the final part of this training to the last week of the month.

4th Week of Project (22/12/2023):

Day 22-28 : During this time I was assigned to under stand the Digitization work by watching various video and also by doing some trial tests. Due to the test and basic training I was ready to work on the project of Digitization of River Atlas of Bhima – Pandharpur Basin. The work was seen by various higher ups and Dr. Gurudas Nulkar and after this brief discussion I was assigned to work on this project.

5th Week of Project (02/01/2024):

Day 33-39 : During this time I was assigned to do the Digitization work on the toposheet assigned to me by Mr. Joy Chakroborthy as he was assigned to me for monitoring of the Digitization work. During this time I was assigned with the timeline to complete the toposheets during this time I have to complete the toposheet assigned.

6th Week of Project (10/01/2024):

Day 40-46 : During this time I started to work on my 1st toposheet I did my first 15 grids which was more than assigned so the higher up was happy with the progress.

7th Week of Project (17/01/2024):

Day 47-53 : During this time I started to work on my 1st toposheet I did 36 grids due to which they saw that the work can be done with a grate pace. Which cause a major change in the timeline and my scrutiny was setup with the higher ups leading to the error identification and resolving the problems. I made a total of 10 error in the whole toposheet which were corrected and the toposheet was submitted.

8th Week of Project (24/01/2024):

Day 54-60 : During this time I started to work on my 2nd toposheet I did my 18 grids during this time and submitted. After the scrutiny my errors were spotted and resolved.

16th Week of Project (20/03/2024):

Day 116-122 : During this time I completed the work on my 5th toposheet. Bye his time we the monitor Mr. Joy Charoborthy left and the part of project was handed over to me as to complete all the digitization.

9th May 2024 Final Day:

Day 172 : During this time I completed the work and the 25 interns that worked along got their certificates and the whole digitization was done and the final completion of my part for Dissertation. This whole project provided me with the enhanced knowledge of the GIS their uses and also, the project gave me a broad aspect of the field and the importance in the environmental field as it helps in multiple ways to identify the problem and also to solve it. Finally, this provided me with the vastness and the importance of our stream.

The generated data is as follows:

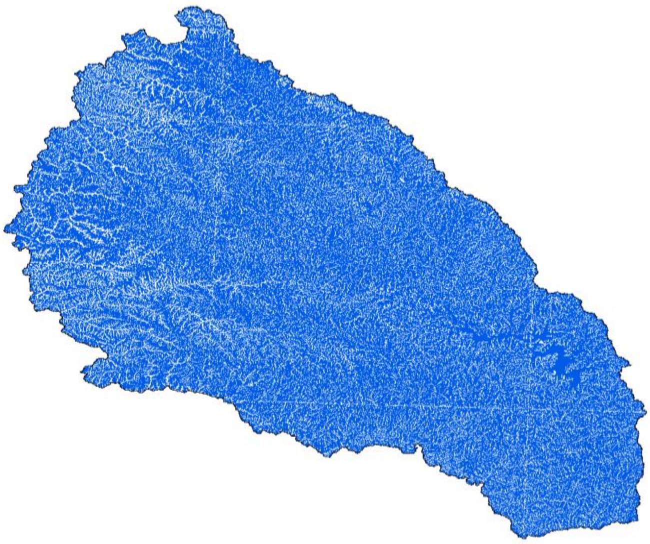

Fig 6.1 Stream Network of Bhima-Pandharpur Basin

The data for flow of water through the valley using a Digital Elevation Model (DEM) to find out the rainfall accumulation and major river streams and network. The data generated from DEM is shown below:

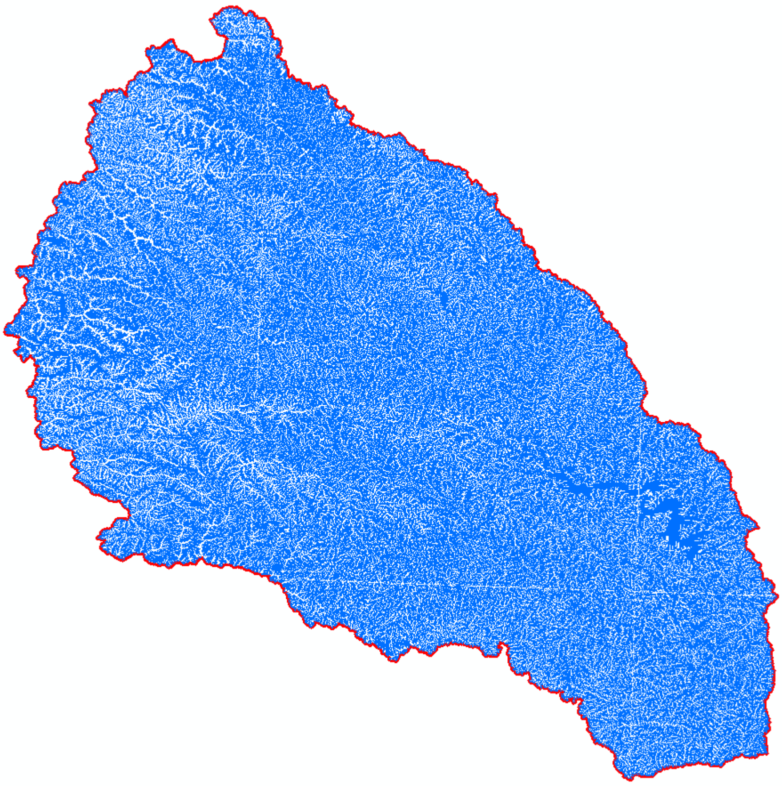

Fig 6.2 Digital Elevation Model (DEM) Stream Network of Bhima-Pandharpur Basin.

13. Conclusion

This paper provides a complete Digitization and DEM generated of Bhima-Pandharpur Basin and a decent idea of ArcGIS software and DEM generation. The digitization of streams has been greatly improved by the combination of ArcGIS and Digital Elevation Models (DEMs). ArcGIS offers strong capabilities for visualization and spatial analysis, while DEMs give precise topographical data that is essential for mapping stream networks. Using techniques like stream burning, which adds mapped stream networks into DEMs for more accurate flow accumulation and drainage patterns, ArcGIS makes it possible to precisely delineate stream channels. ArcGIS-prepared DEMs are vital because they offer elevation data required to produce precise topographic maps, which are critical for the investigation of stream networks. Applications requiring the most recent stream information benefit from ArcGIS Server's stream services, which also facilitate real-time data distribution.

1. During this project I personally visited various place to identify the availability of the streams in the respected vicinity and as they are poorly marked on the topographical sheets.
2. Due to this improper marking we have to check through Google Earth Engine whether or not the stream is divided into parts or is it complete.
3. We found out that the Bhagirathi Nadi had various parts of it that were not properly managed and waste was directly let into it.
4. Also most of the 5th order streams that are present on the topographical sheets are not accounted for and illegal practices are carried out.
5. Where in some of the streams were active for Rainy season only and most of the villages residing

nearby had to get water from the tankers. Hence all this will be accounted when there is a audit to work on the rejuvenation this are my personal remarks.

6. The Digitization is done to convert the visual data to a digital data. This data will be further used to rejuvenate the river and the tributaries. This project will be base of decision making for the CGanga and NamamiGanga organization for future scopes.
7. A database of stream networks is created for the Upper Bhima Basin up to Pandharpur by digitization.
8. The rainfall accumulation and the stream data is received from Digital Elevation Model (DEM).

14. Abbreviations and Acronyms

DEM : Digital Elevation Model.
GIS : Geographic Information System.
TM : Topographical Map.
GE : Google Earth.

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