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Methodology Article

Development of Village Level Geospatial Framework for "Digital India"

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Abstract The Digital India is a programme of the Government of India with a vision to transform India into a digitally empowered society and knowledge economy. Digital land record of villages is one of the important components of information system which plays a vital role in making this type of society Land record system is primarily managed manually in the country using registers and cadastral maps in the form of papers, clothes which are very rough, tempered, torn and in a bad condition. Thus, the record keeping and updation of the village level information is a big challenge. Preserving, updating and retrieving these records needs integration of the information in a single framework. This paper presents the development of village level geospatial framework which highlights the three growth areas among nine pillars of Digital India. It encapsulates the digitization, geodatabase preparation, topology, and geospatial framework development using revenue (Khasara) maps, Google earth imagery data and GIS technology.

Keywords *Cadastral map (Khasara map); Digitization; Geodatabase; Topology; GIS; Land record; Digital India*

1. Introduction

India is proceeding towards developing the digital empowered society with a vision to ensure the digital infrastructure as a core utility to every citizen, governance and services on demand and digital empowerment of citizens by launching the Digital India. The main concern of the program is to bring the rural and urban areas in the mainstream for the progress and development of the country with the support of nine beams as shown in Figure 1.

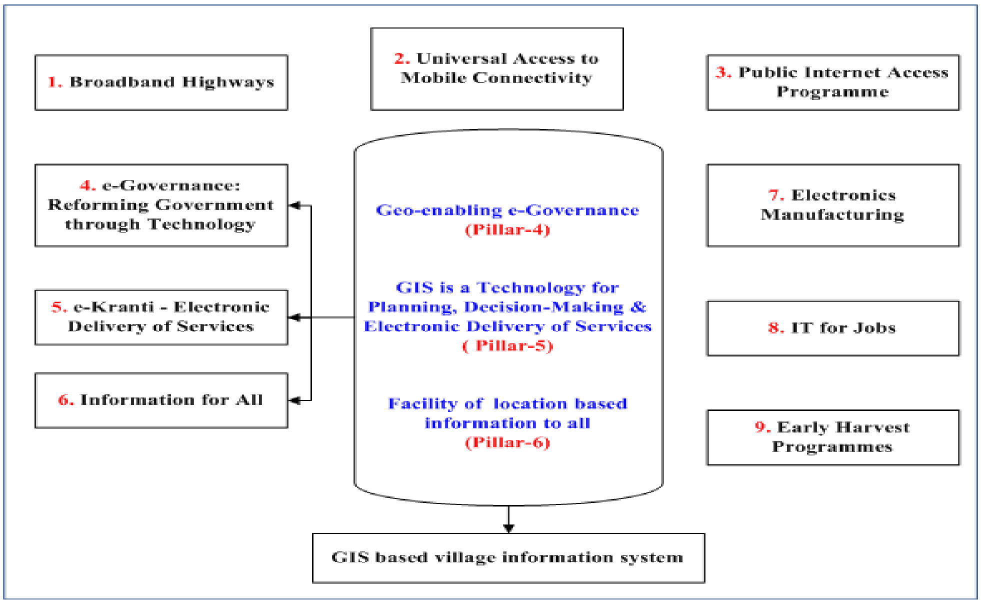


Figure 1: *Nine beams of Digital India*

Villages in the country need to be planned and developed as per the envisaged program of Digital India which will bring efficiency in to the system. Cadastral maps (Khasara map), provide the detail information about land property within a specific area which plays a significant role not only in decision making of rural level planning but also in property dealing, revenue administration and development and updation of village information system. The cadastral maps and other records in various independent departments in paper, clothes and different format, without any geographic reference, are, in most of the part, maintained and managed manually in day-to-day operation for providing the services and solution for village level problems. This caused them to be rugged, tempered, torn and delayed. Integration of all these records requires their updation, storage and fast retrieval to ensure the user-friendly availability and easy accessibility anytime and from anywhere. These are possible with the emergence of Geographic Information System (GIS) which facilitates, manipulates, stores, shares, analyzes information and displays it at the right location spatially.

A variety of approaches, GIS based land information system Mondal, S., et al., (2016), demarcation of administrative boundaries Rao, S.S., et al., (2014) along with error correction Sayin, S.B., et al., (2002) have been used. Web GIS Singh, P.S., Chutia, D. and Sudhakar (2012), Mobile Singh, K. and Agarwal, H. (2013) and Object oriented based, using Use case, UML Bình, T.Q. (2013) and Sequence diagram Balram, S. and Dragicevic, S. (2006) have been used to develop geospatial framework. This framework provides the village information system to support decision making for rural, rain harvesting Mbilinyi, B.P., et al., (2008) fisheries Munywoki, B. et al., (2008), power distribution and socio-economic data visualization planning.

The GIS based applications as discussed above, in different disciplines, require integration of information into a single framework for its easy access and getting services on a click of a button. This requires development of village level geospatial framework as shown in Figure 2. This will produce spatially accurate and timely information and services at village level. It incorporates web server, map server and database server responsible to display result associated with map according to the request sent by the user. The framework focuses on establishing the three pillars of information system towards developing Digital India.

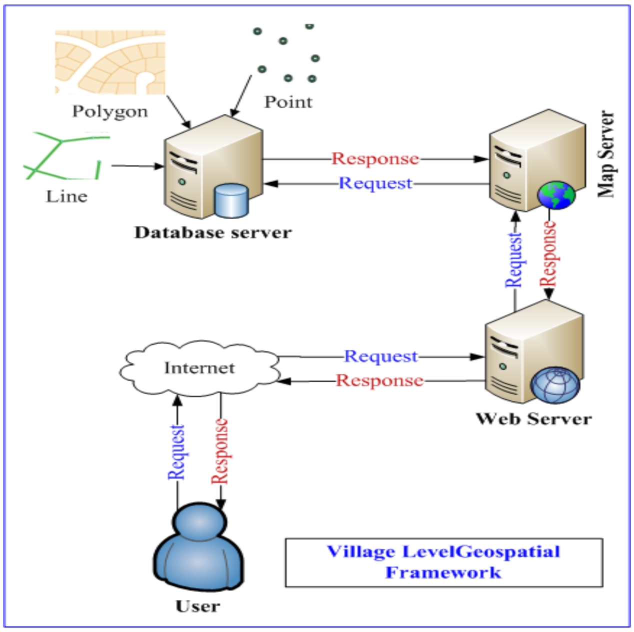


Figure 2: *Village level geospatial framework*

The main objectives of this research are, therefore, to develop GIS database for rural India at village level which consists of data collection, processing and geodatabase preparation using this geospatial framework. The data is collected from primary and secondary sources such as field surveys, GPS devices, satellite imageries, Survey of India maps, revenue maps, existing land records and drawings, census and economic data etc. Paper maps are scanned, georeferenced and digitized using various tools for the preparation of spatial data. Attribute data is prepared using land records, census, economic, metrological and data from other sources. Geospatial framework is developed using the developed geodatabase which consists of designing the relational database, use case, UML and sequence diagram design and development of interface.

Issues & challenges in developing village information system

Various problems are faced developing the information system at village level. Available land records have unclear text and boundary of land records, revenue maps such as cadastral maps are sometimes updated by free hand drafting on revenue that is not to up to scale which creates the confusion. There is mutual mismatch in adjoining boundaries of the villages. Various sources provide the village level detail but they differ in area and shapes. Positional mismatch is found in account of preparing the topographical map using data from these sources. These problems are clearly shown in the Figure 3.

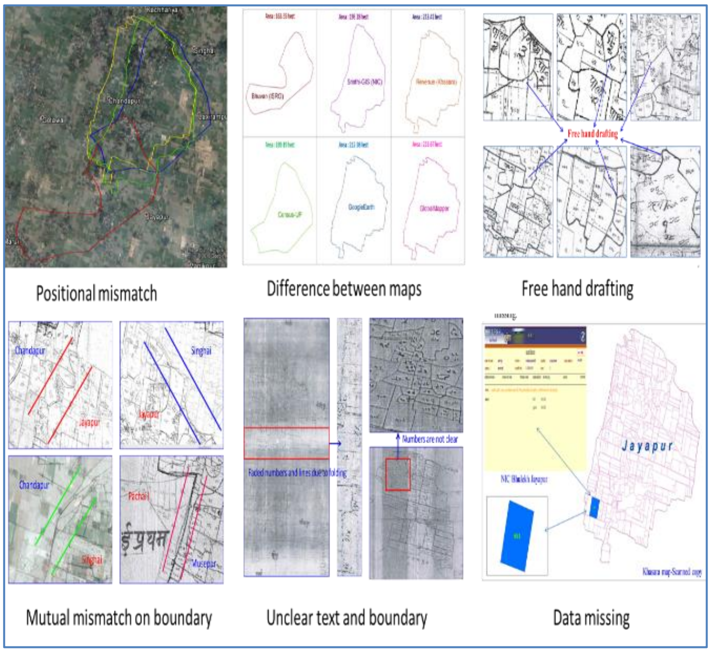


Figure 3: *Issues and challenges*

2. Study Area

The study area for the development of the proposed system is Jayapur village in Varanasi district of Uttar Pradesh state in India. It is a village under Sansad Adarsh Gram Yojana (SAGY), adopted by prime minister of India. It lies between 82.8198° E longitudes to 25.2116° N latitude covering an area of 171.851 hectares. It is situated in Aarajiline block of Varanasi district near NH-2 about 28 km from Varanasi city. The Jayapur village has a population of 2974 of which 1541 are males while 1433 are females as per Census of India, 2011.

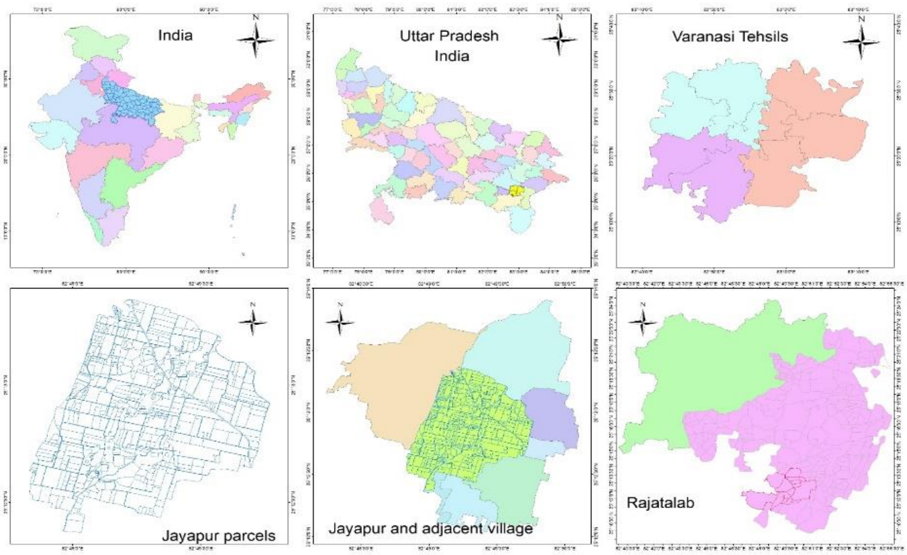


Figure 4*: Study Area*

3. Methodology

The methodology for the proposed framework was conceptualized in three phases as shown in Figure 5. Phase 1 consists of collecting and processing of primary as well as secondary data, Phase 2 covers the geodatabase preparation, digitization, validation, analysis, etc. and phase 3 highlights the development of village level geospatial framework. These are discussed in subsequent sections.

3.1. Data collection and processing

Data Collection: Primary Data were collected by GPS device through field survey and exported as ESRI shape file using GPS pathfinder software. Maps (Census, Survey of India, Ward, Cadastral maps) and attribute (Food and Civil Supply, road, socio-economic, cadastral i.e., revenue records, agriculture, demography, soil health card, etc.) data, considered as secondary data, were acquired from the concern departments.

Data Processing: The scanned maps were georeferenced, mosaicked, projected and transformed using ArcMap (ESRI's software) to register and overlay on each other with respect to the earth. Attribute data were posted into Microsoft excel. Functions, Countif (returns duplicate value), Left, Mid, and Right (selects no of character from the stings), Vlookup (matches the value in similar cell from different column) and Proper (changes the first letter to capital in a string), were implemented to make the data compatible in ArcMap.

3.2. Geodatabase Preparation and Analysis

Geodatabase: Feature dataset, Raster dataset and GIS service were created within the Geodatabase using the ArcCatalog. Feature classes (point, line and polygon) were further created in feature dataset, registered (raster) maps were imported to raster dataset and satellite imagery was incorporated with GIS server, as GIS service. Feature (road, parcel, drainage, electric pole, solar lamp, hospital etc.) extraction (digitization) was performed in using create feature, trace, snapping, cut polygon, merge, auto complete polygon and short key assignment tools. Attribute data (processed in phase 1) was joined with features (layer).

Topology and error correction: Data cleaning (using delete duplicate, erase short object, break crossing object, extend undershoot, dissolve pseudo node and zero length object cleanup actions) was performed to remove the geometrical error of digitized layer. Topology was built using the cleaned data for managing the relationship among them and exported to shapefile. The data was compared and analyzed with the real data and found the solution for the discrepancy.

Network analyst, Geometric network and Utility network analyst: Network analyst is used to analyze shortest route, service within a time interval, closes facility and OD (origin to destination) cost matrix for planning the route system. Geometric network analyzes the geometry, connectivity of networks and fixing errors for water supply and waste planning. The utility network analyst is implemented to analyze the flow direction, dysconnectivity, connectivity, disabled and enabled features for power distribution planning.

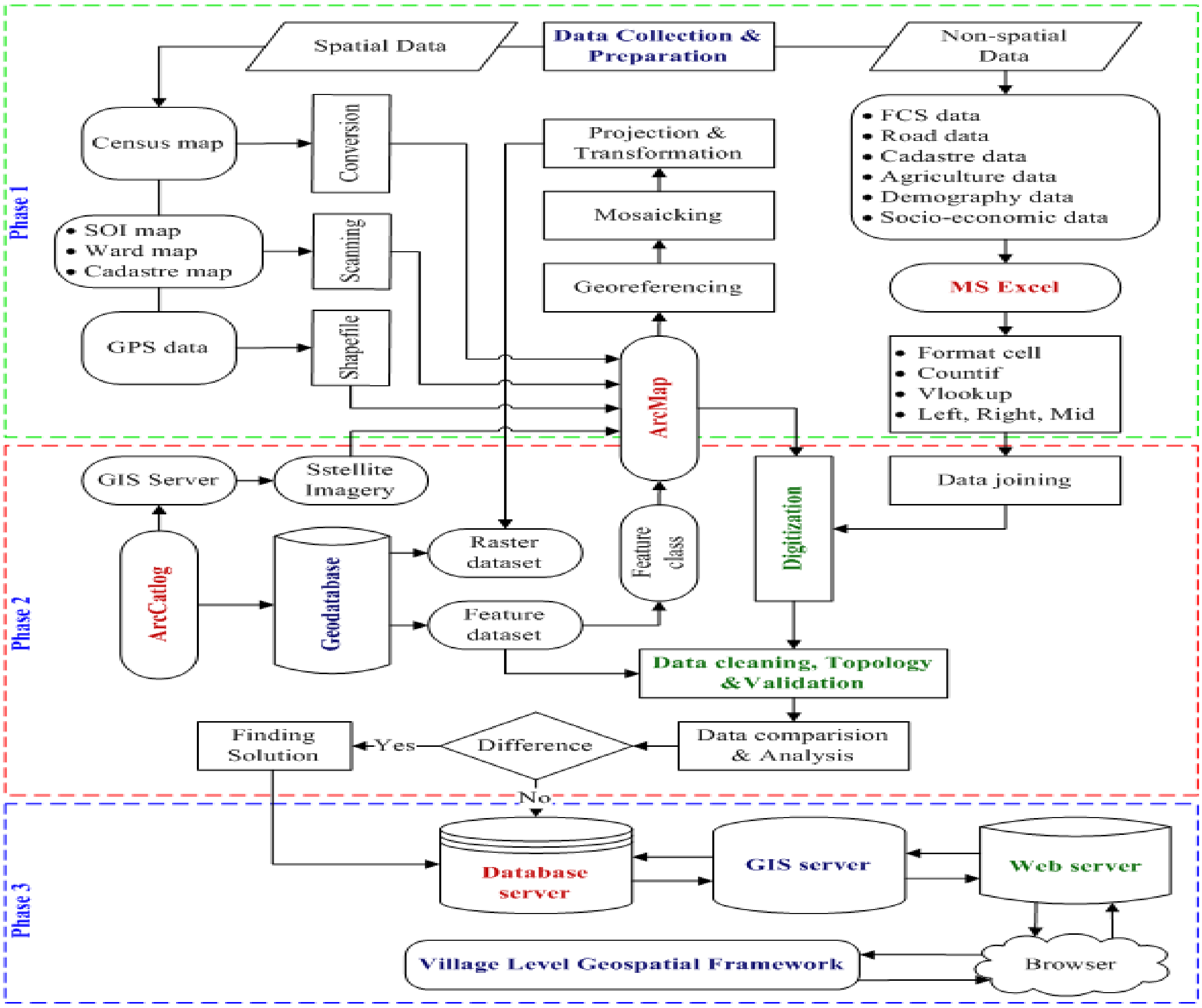


Figure 5: *Methodology*

3.3. Village level Geospatial framework

The village level geospatial framework consists of GIS based software development intended to provide information and services accessible through the mobile device. Database server is developed using SQL server, PostgreSQL, MySQL or Oracle. It gets the information of feature layer (spatial layer) in csv format processes and sends it to the GIS server.

SQL server is compatible with C# and VB, PostgreSQL with Python, MySQL with PHP and Oracle with Java. Map severs, Geoserver, MapGuide (pen source) and ArcGIS server (commercial) are the GIS server used for providing the result in graphical (map) form and associated with interactive tool. It gets the request from web server and responds accordingly. It is intermediary platform between web server and database server. IIS, Apache and Tomcat are the web server used for developing the framework. It gets the request from user and responses according to its rule. The proposed framework is developed using object-oriented concepts (Use case, UML diagram and sequence diagram) which provides all the services (previously described) for village level planning.

4. Result and Discussion

Services along with their location on earth, incorporated with the developed framework, will support in decision making of planning as well as site selection. Electricity distribution network, providing the information and location about substation connected with HT and LT network along with consumers, building, support structure (pole), service line and other electricity component makes the easy updating and replacement. Water and waste water supply management system ensures the site suitability for establishing water resource and waste disposal. Route system gives coordination to follow the appropriate route for arriving to the government institution, commercial places, hospitals and educational institution. Barren land can be used for rain harvesting and fisheries. It also gives the demographic status about the village.

Geodatabase and feature layer

Digital village record is maintained in the geodatabases as feature dataset and feature class that provides the not only mutually matched village boundary but gives the geospatial detail also. These feature classes are used to design the thematic and topographic map (Figure 6), which helps to decision maker for rural planning and other development.

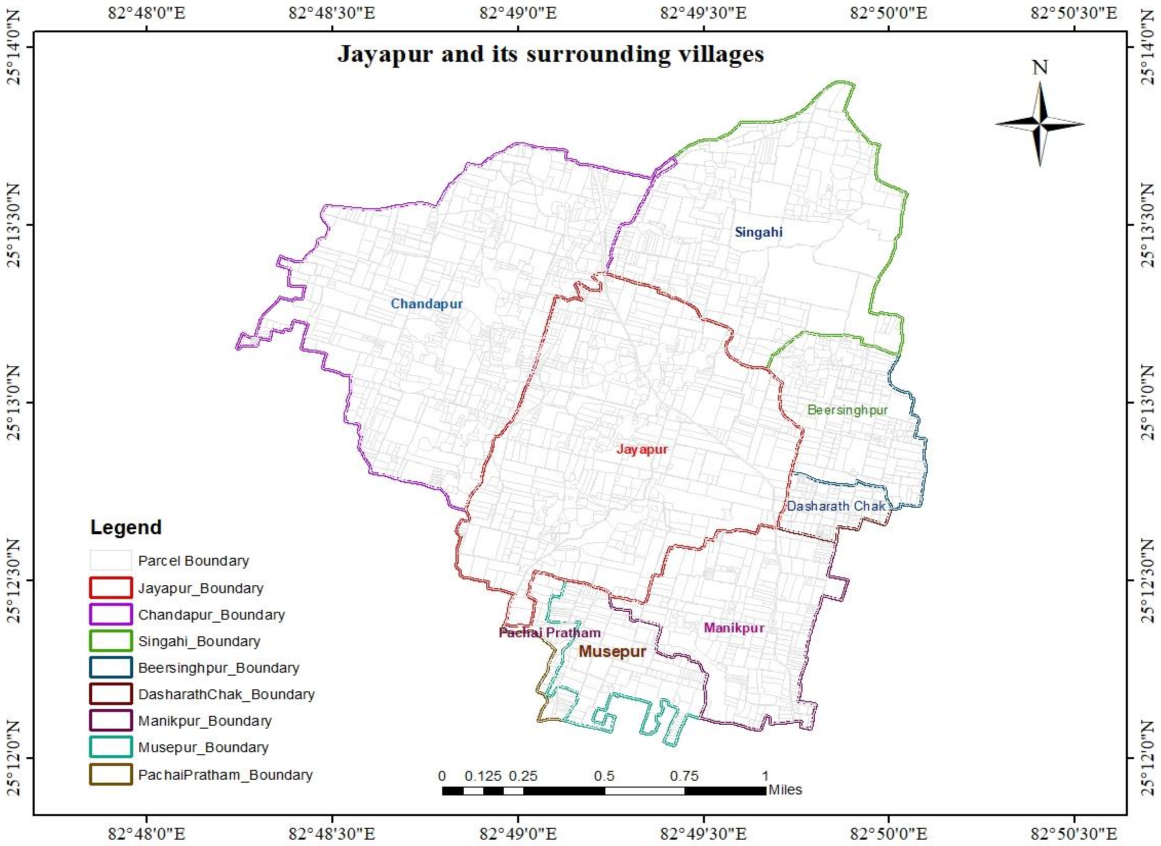


Figure 6: *Jayapur and its surrounding boundary*

Land use/Land cover map

Land use land cover was generated using the spatial and non-spatial dataset. Attribute data of land record acquired from board of revenue were incorporated with vector feature in GIS environment and processed to prepare the LULC map (Figure 7).

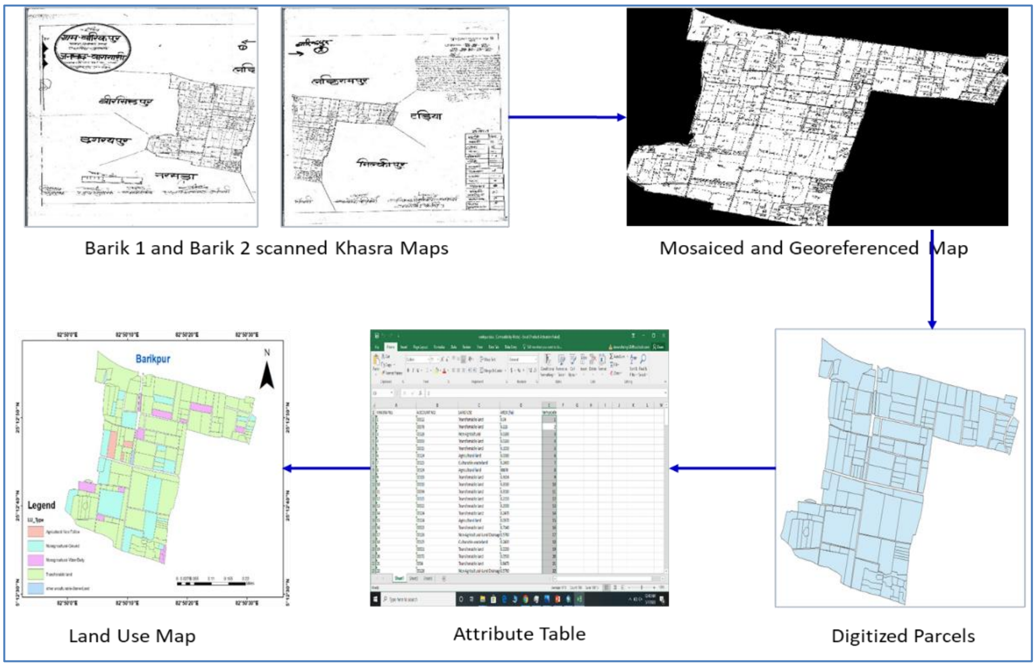
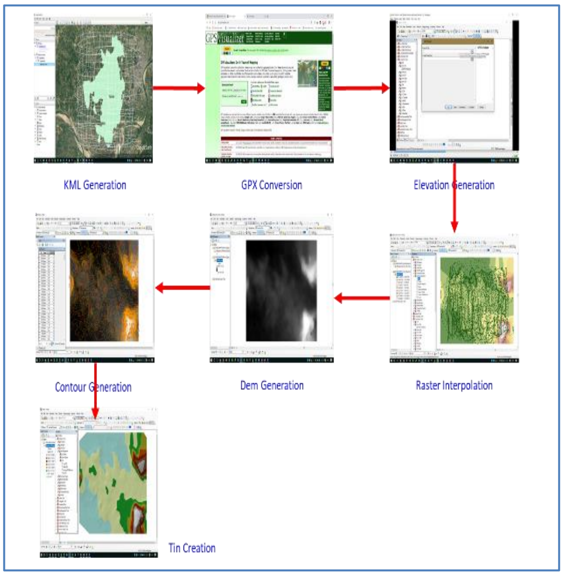


Figure 7: *Land use/Land map work flow*

DEM generation and delineation of watershed

Digital elevation model (DEM) was generated by tracing on google earth and gathering the elevation points of the villages. A geoprocessing technique, interpolation was implemented to produce the DEM. These DEM data are utilized to delineate the watershed (Figure 8 and Figure 9).



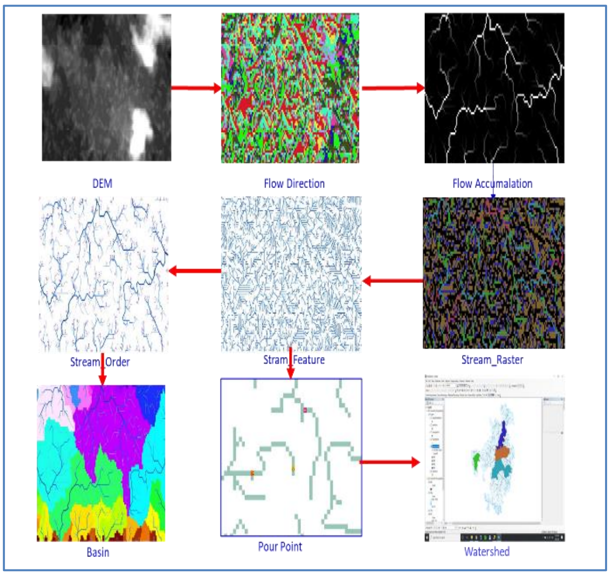


Figure 8: *DEM generation*

Figure 9: *Watershed delineation*

Electricity Network

Figure 10 shows the electricity distribution network which is designed using feature classes of building, roads, electric poles and household data.

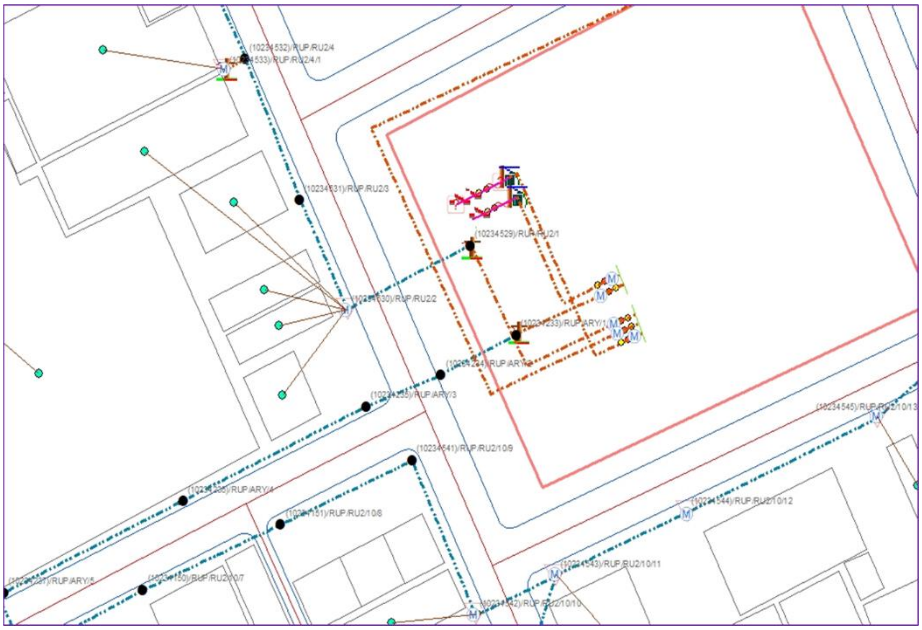


Figure 10: *Electric distribution network*

5. Conclusion

Thus, Village Level Geospatial Framework is a need indeed for the Digital India giving the support to villagers, administrators and authenticated users. It will play an important role in geoenabled e-governance, location-based information to all, decision making for planning and electronic delivery of services.

References

Balram, S. and Dragicevic, S., 2006. Modeling collaborative GIS processes using soft systems theory, UML and object-oriented design. *Transactions in GIS,* 10(2), pp.199-218.

Bình, T.Q., Thuy, P.T.H., Hanh, N.T.H.H and Tho, N.S., 2013. Designing a Web GIS System to Support Active Participation of Citizens in Land Use Planning. *VNU Journal of Earth and Environmental Sciences*, 29(1), pp.1-13.

Koregaonkar, K.T., 2016. Digital India: A Program to Transform India into a Digitally Empowered Society. *International Journal of Business quantitative Business Economics and Applied Management Research*, 2(9), February, 2016.

Mbilinyi, B.P., Tumbo, S.D., Mahoo, H.F. and Mkiramwinyi, F.O., 2007. GIS-based Decision Support System for Identifying Potential Sites for Rainwater Harvesting. *Physics and Chemistry of the Earth*, 32, pp.1074-1081.

Mondal, S., Chakravarty, D. and Bandyopadhyay, J., 2014. Cadastral Maps for Socio-Economic Data Visualization and Integration for Land Use in Raniganj Mining Areas. *International Refereed Journal of Engineering and Science (IRJES)*, 3(10), pp.55-63.

Mondal, S., Chakravarty, D., Bandyopadhyay, J. and Maiti, K.K., 2016. GIS based Land Information System using Cadastral model: A case study of Tirat and Chalbalpur rural region of Raniganj in Barddhaman district. Springer, *Modeling Earth System Environment*, 2(3)

Munywoki, B., Obura, D. and Maina, G.W., 2008. Development of a Web-based Geographic Information System as a Decision Tool to Support Fisheries Science and Management: A Case Study of Diani-Chale, Kenya. Ten years after bleaching–facing the consequences of climate change in the Indian Ocean. Cordio Status Report, pp.345-351.

Rao, S.S., Banu, V., Tiwari, A., Bahuguna, S., Uniyal, S., Chavan, S.B., Murthy, M.V.R., Arya, V.S., Nagaraja, R. and Sharma, J.R., 2014. Application of Geo-Spatial Techniques for Precise Demarcation of Village/Panchayat Boundaries. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2(8), p.123.

Sayin, S.B., Hill, C., Ramesh, C.R. and Birchler, J.R., 2002. QA/QC and Process Development for Utility GIS Data. *International Symposium on GIS*, Istanbul-TURKEY.

Singh, K. and Agarwal, H., 2013. Design of e-Land Record Information System with Google Map Using Mobile Commerce. Scientific Research, *Journal of Software Engineering and Applications*, 6, pp.221-228.

Singh, P.S., Chutia, D. and Sudhakar, S., 2012. Development of a Web Based GIS Application for Spatial Natural Resources Information System Using Effective Open-Source Software and Standards. Scientific Research, *Journal of Geographic Information System*, 4, pp.261-266.