GEOSPATIAL HEALTH MANAGEMENT INFORMATION SYSTEM: A BASELINE AND MONITORING STUDY

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ABSTRACT
Mapping of the health infrastructure to the micro level is the ultimate requirement for successful monitoring of the healthcare system and distribution of amenities. The present paper mainly focuses on the application of Remote Sensing, Geographical Information System (GIS), Global Positioning System (GPS), in health such as visual analysis of health management information, health service mapping and geographic analysis of health services and its coverage. The main emphasis has been given to generation of Geospatial Health Management Information System (GHMIS) it will be easier for the governance of health sector and infrastructure in the rural areas. At each level, data would be viewed geospatially which would help to make rational decisions and hence better healthcare. The study area has been chosen as Bemetara District of Chhattisgarh, which is one of the important agriculture district of the state. The main objective of the study are to create buffer around the health centres mainly the CHCs, PHCs & SHCs to denote the catchment area; allow for overlay analysis of different pieces of information; calculate distance between two points; permit interactive quarries of information contained with the map, tables, graphs in web-GIS. The present study is mainly based on both primary and secondary data. Secondary data has been collected from Health & Family Welfare Department, Govt. of Chhattisgarh, Census of India, 2011, hardcopy village map from Land Record Office. Primary data mainly consists of GPS point information of each and every health centre spread over the District. It has been found that creation of GHIMS design the function of healthcare service and administrative service to monitor health status and service needs according to National Rural Health Mission (NRHM) norms. It can help in set priorities for the allocation of healthcare resource. The user can access the data of any level by logging into the central service without having the hassle of visiting every website. It can be act as a single window service station. It will give entire system a speed, sense of competitiveness and finally sustainability through increase in revenue generation in the physical sector and improve healthcare system in case of social sector. The range of expectation about the performance of health information system will depend on the role of the people involved. “People” comprises of three categories Doers, Users & Viewers.

1. INTRODUCTION

Public health is a serious challenge in India. The problem of health are increasing in both spatial and temporal dimension to many place in India, especially in rural areas due to increase risk of disease transmission fuelled by unawareness of environment and health, developmental activities, demographic changes, lack of medical facilities and in hospitals, lack of qualified doctors and also unavailability of doctors in health centres is also a major factor contributing to the poor health of rural populations of India. National Rural Health Mission was launched by Government of India in 2005 to provide effective health care to rural community in the country with special focus on state which have poor health outcomes and insufficient public health infrastructure and manpower. There is a strong need to remove the inadequacies in term of buildings, manpower and provisions of drug supplies and equipment constitutes major impediments to full operationalisation of rural primary health care system (Verma, 2010). Geospatial technology has various applications in human health. Tools like Remote Sensing, GIS, GPS, mobile phones have now come in usable in India to address the issues on the disease surveillance control, monitoring and assessment. The rural health care information system based on GIS domain has explained that how it can be formulate towards the overall rural development and thereby substance of plan at all levels. At grass root level, the complete research and practice domains within healthcare and management are strongly grounded in the spatial dimension (Meade & Erickson, 2000). The application of Mobile Technology integrated with GIS for Better management of health services (Sharma, 2011).

2. MATERIALS AND METHODOLOGY

2.1. STUDY AREA

Study area has been chosen as a newly formed district of Chhattisgarh that is Bemetara district. Bemetra district has been bifurcated from Durg District in the year 2012. The main purpose of bifurcation and formation of new district is for decentralized planning and for effective planning and proper implementation of different government scheme. The study area lies between 21°20'79" to 22°1'24" latitude and 81°10'22" to 81°56'8" longitude. It covers an total geographical area of 2886.94 sq.km. Bemetara district is also known as 'Unhari District". It mainly comes under Chhattisgarh plain and it is agriculturally sound district. Important river flowing in the district is Sheonath river. As per 2011 census, total population of the district is 599737 in which 298374 is male population and 302363 is female population. Density of population is 104 person/ sq.km. Literacy rate of the district is 71%. Sex-ratio has been found is 1015. Bemetara district has been divided in two sub-division that is Bemetara and Saja. Total number of block is four namely, Bemetara, Berla, Nawagarh, Saja. Total number of Gram Panchayat in the district are 334 and total number of villages are 700. The district is divided into total 8 RI circles. Figure 1 shows the Location Map of Study Area.

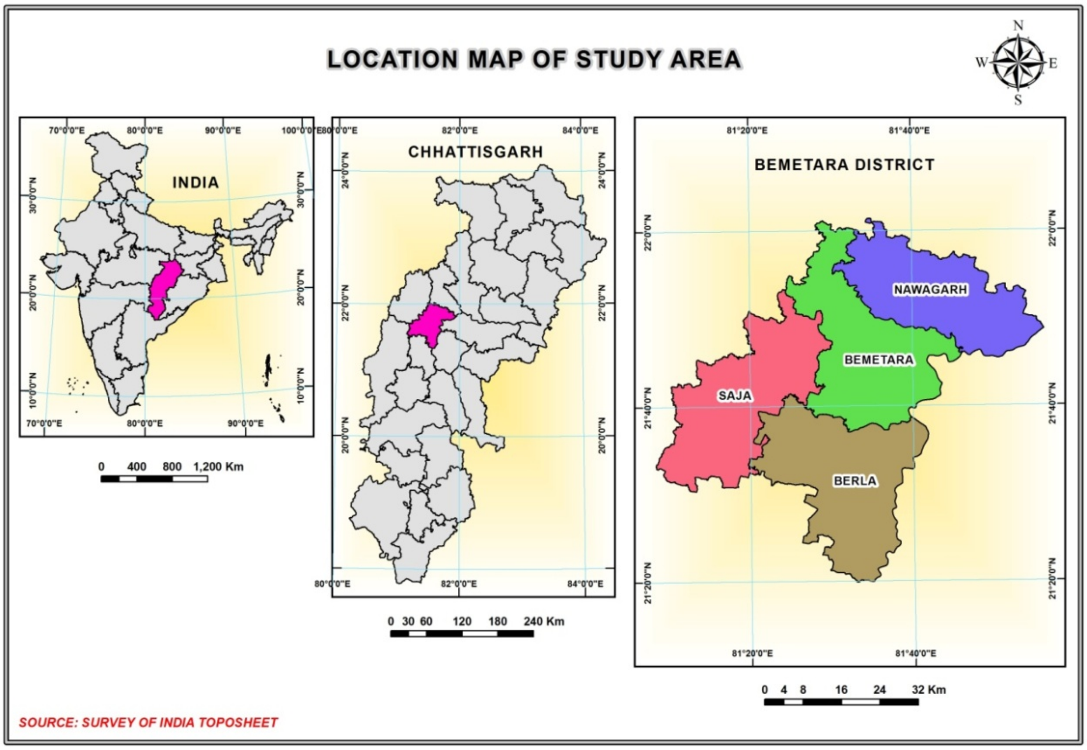


Figure 1 Location Map of Study

2.2. DATASETS

For the concerned research work following datasets has used:

- Open Series Survey of India Toposheets on 1: 50000 scale, SOI Office, Raipur
- Hardcopy village map from District Revenue Department
- Hardcopy rural health data , District Health Department
- High resolution Satellite data- Google Earth Image, Orthorectified Cartosat-I Image
- GPS coordinates of all health centres (Field data)
- Population data, 2011 from Census of India office, Raipur
- Geotagged health centres photographs (Field Data)

Software used for the research work:

- Eardas Imagine 11 for georeferencing, registration and mosaicing of scanned maps and satellite image.
- Arc GIS 10 for digitizing, spatial and statistical analysis,
- Microsoft Excel & Microsoft Access for database creation
- Geoserver & Open Map for Web GIS platform creation

2.3. METHODOLOGY

The research work is based o availability of data related to rural health care services in the district and geographical accessibility of the health services. Important factor which considered for baseline and monitoring study are rural population, service area of health centres, available health centres, roads. All the spatial and non-spatial data are integrated into GIS environment for storage, retrieval, manipulation, analysis. The capability of GIS to overlay separate map layers of same geographical area to produce a composite or new map of the study area combining the characteristics of the various maps has explored in GIS. In overlay analysis the location is held constant and several other variables are simultaneously evaluated. Figure 2 shows the methodology adopted.

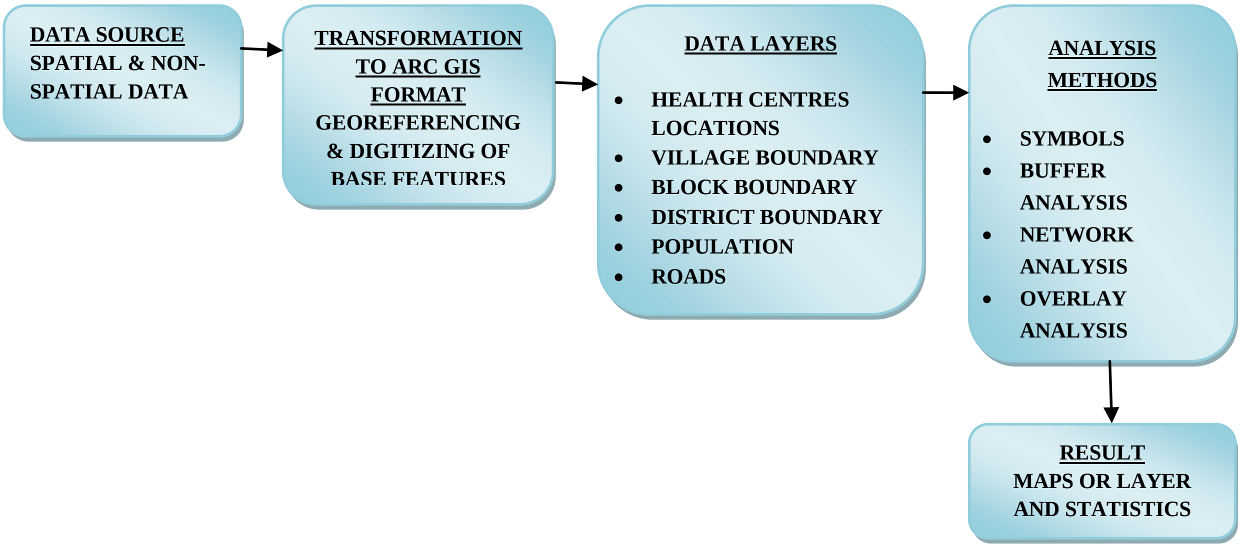


Figure 2 Methodology

3. RESULT & DISCUSSIONS

3.1. Generation of Spatial Village Map

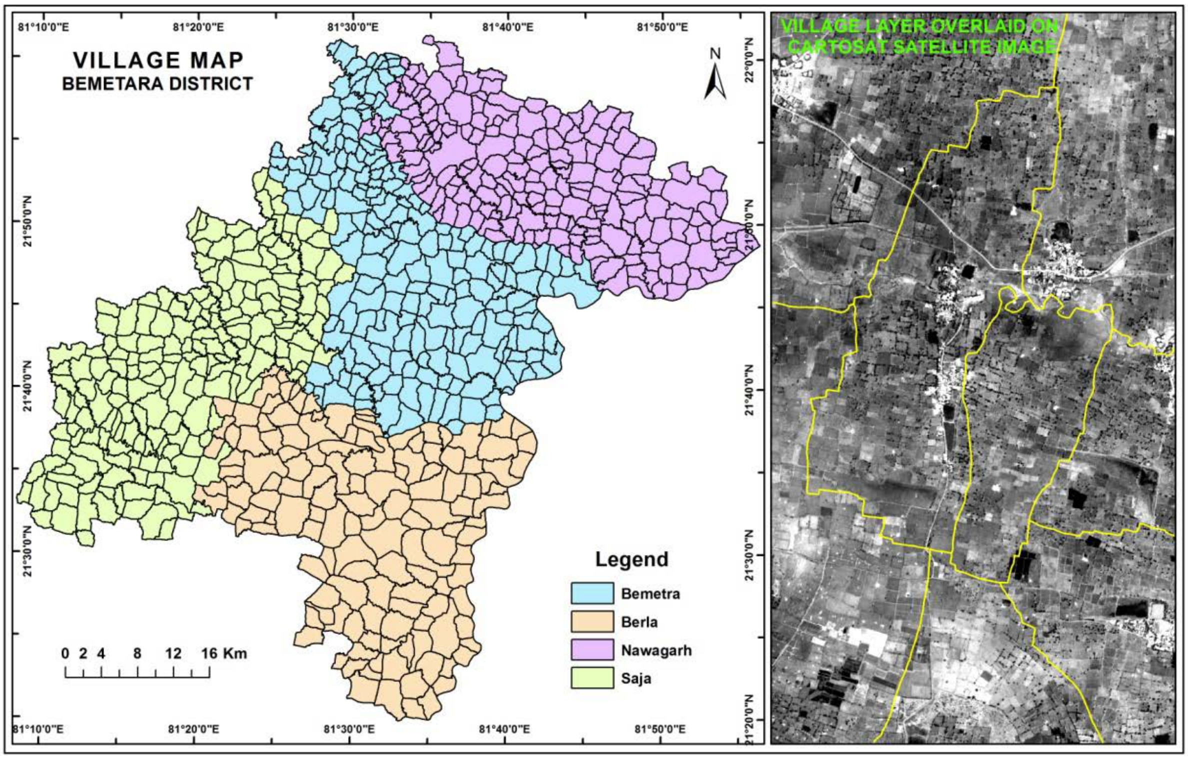


Figure 3 Spatial Village Map

Survey of India Topographical maps have used to drawn District and Block boundaries. After that these boundaries were brought in to ArcGIS, following the standard procedure that is digitizing, georeferencing, merging etc. Block map collected from the local government offices in the district, contain village boundaries. These block maps which do not show geographical co-ordinates system were traced, marked the GCPs with respect to the SOI base map, digitized and brought to the real world coordinates system after projecting the maps. Each village in this map was assigned unique ids (user defined) in a regular sequence. Thus, Block map with village boundaries within built table have arial extent, village ids, gram panchayat name & code, etc. has generated for Bemetara District. Now the village map is ready to overlay on satellite image shown in Figure 3.

3.2. Transformation of Non-Spatial Census Database into GIS

2011 census data collected from Census office. Census information can be displayed using MS Excel Sheets. This file contains vast information on socio-economic characteristics of each village, incluiding census code on region, district, block and village. Village ids same as given in the spatial village map were fed in the excel sheet for all the villages in the block. Thus spatial and non-spatial data contain similar columns in their respective tables with uniform village ids. These ids will help in joining the spatial and non-spatial data in the system. Thus an information system has been generated for the district showing the village map with its boundary and relevant census information containing socio-economic dimensions Shown in Figure 4. After creation of population database one can get spatial view of population spread over the area. This population database is very useful for the decision makers and planners. Shown in Figure 4.

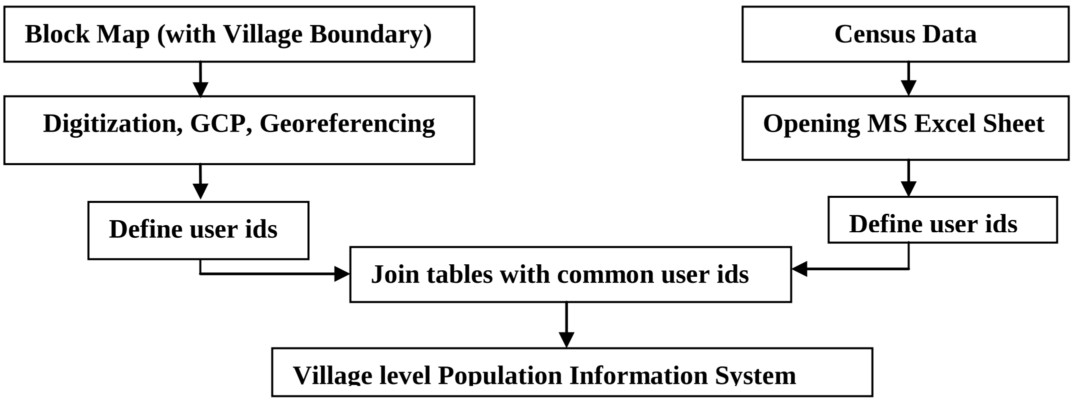


Figure 4 Flowchart of Population Database Creation

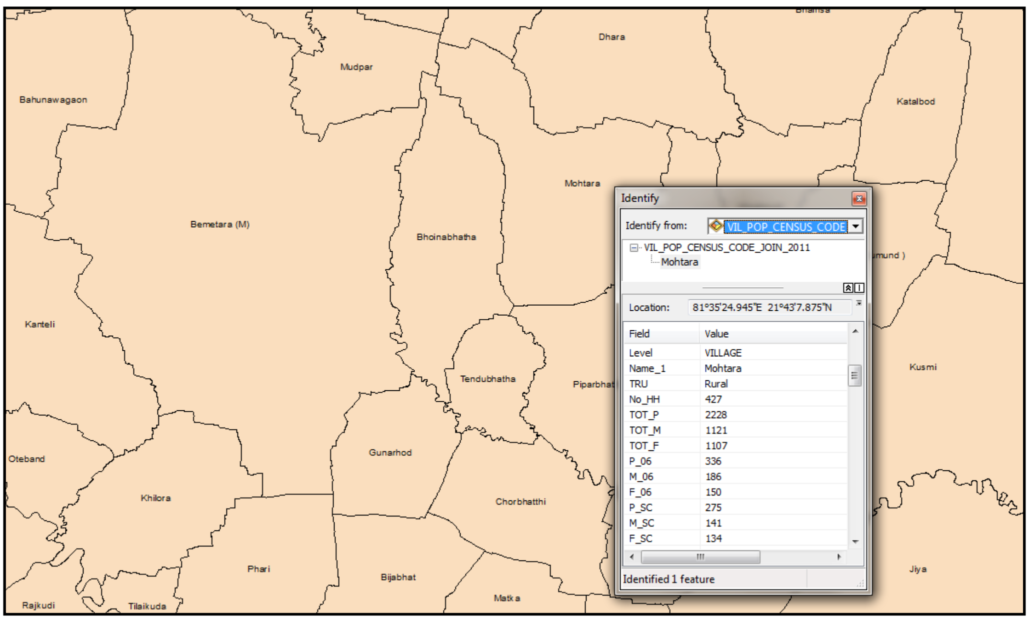


Figure 5 Population Database in Arc GIS platform

3.3. Generation of Spatial Rural Health Centre Map

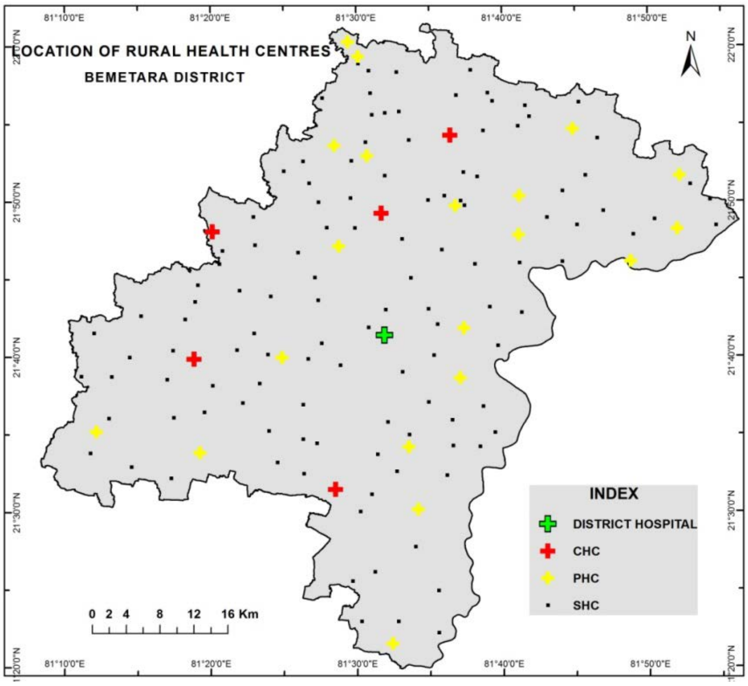
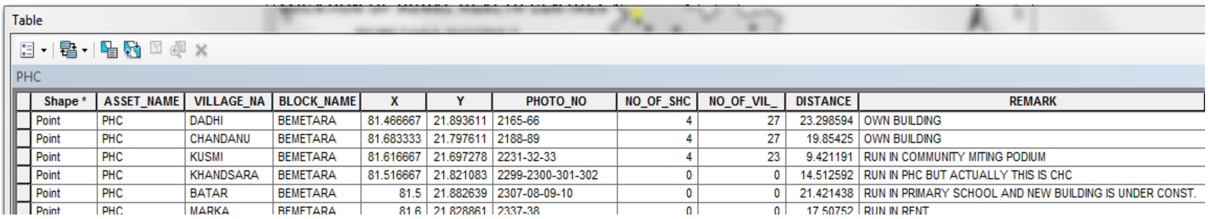


Figure 6 Spatial Health Centre Map

Rural health centres comprises of Community Health Centre, Primary Health Centre and Sub-Health Centre. The latitude and longitude information of all these health centres are marked by GPS during the field verification. Settlement boundary has digitized using orthorectified high resolution Cartosat-I satellite image so as to place GPS point on the most dense settlement area in the village. These GPS locations of health centres help to visualize the exact position on the ground for further analysis. Geo-tagged health centres photographs have also taken from in-built GPS camera, in order to see the actual condition of the building and other infrastructures. In the study region there are existing 1 District Hospital, 5 CHCs, 21 PHCs, 125 SHCs which is the serving the all rural population. Figure 6 shows the spatial distribution of all health centres. With location health centres contains all the important attribute information along with photographs in the database. This geospatial database plays an important role for decision maker and planners for further planning. It helps to see all the information in a single platform. Figure 7 shows the geospatial database of health centres.



Table

PHC

Shape *	ASSET_NAME	VILLAGE_NA	BLOCK_NAME	X	Y	PHOTO_NO	NO_OF_SHC	NO_OF_VIL_	DISTANCE	REMARK
Point	PHC	DADHI	BEMETARA	81.466667	21.893611	2165-66	4	27	23.298594	OWN BUILDING
Point	PHC	CHANDANU	BEMETARA	81.683333	21.797611	2188-89	4	27	19.85425	OWN BUILDING
Point	PHC	KUSMI	BEMETARA	81.616667	21.697278	2231-32-33	4	23	9.421191	RUN IN COMMUNITY MITING PODIUM
Point	PHC	KHANDSARA	BEMETARA	81.516667	21.821083	2299-2300-301-302	0	0	14.512592	RUN IN PHC BUT ACTUALLY THIS IS CHC
Point	PHC	BATAR	BEMETARA	81.5	21.882639	2307-08-09-10	0	0	21.421438	RUN IN PRIMARY SCHOOL AND NEW BUILDING IS UNDER CONST.
Point	PHC	MARKA	BEMETARA	81.6	21.828861	2337-38	0	0	17.50752	RUN IN RENT

Figure 7 Attribute Database of Health Centres

3.3.1. Building Condition of Available Health Centres

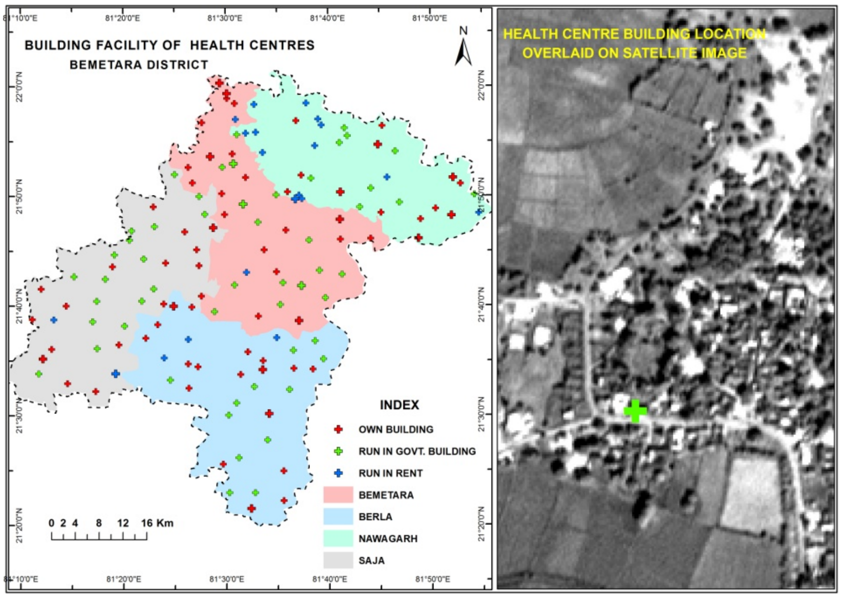


Figure 8 Building Facility Map of Health Centre

The building condition of all health centres can be assessed by using primary field data. Govt. Don't have record of such type of data. One can add this data to the database and can generate important information for proper planning of buildings. The information extracted from data base is that out of total 151 buildings 73 health centres run in own building, 55 centres run in Govt. Building and 23 centres run in rented building. Figure 8 shows the spatial condition.

3.4. Generation of Spatial Catchment Area of Health Centre Services

Catchment area of health services refers to those area where each pHC & SHC serve number of villages and serve total number of population live in that villages. First of all information regarding villages served by each PHC & SHC served has gathered from hardcopy data provided by Health Department. This data then put into excel sheet and joined with village database. After joing the data number of villages served by single PHC & SHC has dissolved to obtain the spatial catchment area. Like this way population of those villages have also dissolved to obtain the total rural population served by each PHC & SHC. Shown in Figure 9. From this database planners and decision maker can view the actual ground condition. According to National Rural Health Mission (NHRM) plan one can query about the shortfall of PHCs & SHCs. According to NHRM norm PHC can set up with thirty thousand and SHC can set up with five thousand populations in plain areas.

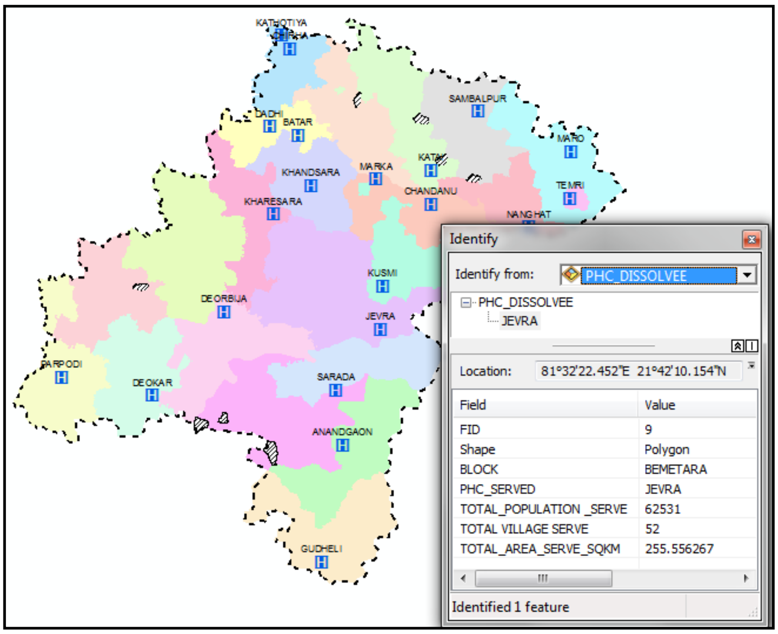


Figure 9 Building Facility Map of Health Centre

3.5.1. Proximity Analysis of Health Centres & Identification of Un-served Areas

Proximity analysis is used for identifying areas surrounding geographic features. It is also used to show the served and un-served areas for PHCs and SHCs in Bemetara district. It has used to identify the village within a given proximity limit of facility. Euclidean distance drawn around each PHC and SHC using ArcGIS software buffer tool. The village of an area can be easily determined whether they are served or un-served. The villages within the proximity are considered to have access to a facility, while those outside the proximity are assumed not to have access. In the present research work the proximity are drawn from each PHC at a distance of 5&7 kilometres and each SHC at a distance of 3 kilometres to define different service areas. Over the proximity layer village boundary layer is overlaid in order to identify exact villages which are served and un-served, Figure 10 illustrate the proximity of health centres along with served and un-served area. With the help of overlay analysis it has found that about 28 percent of villages out of 700 villages is un-served by health centres. Along with 36 percent of total rural population is un-served by health centres as well.

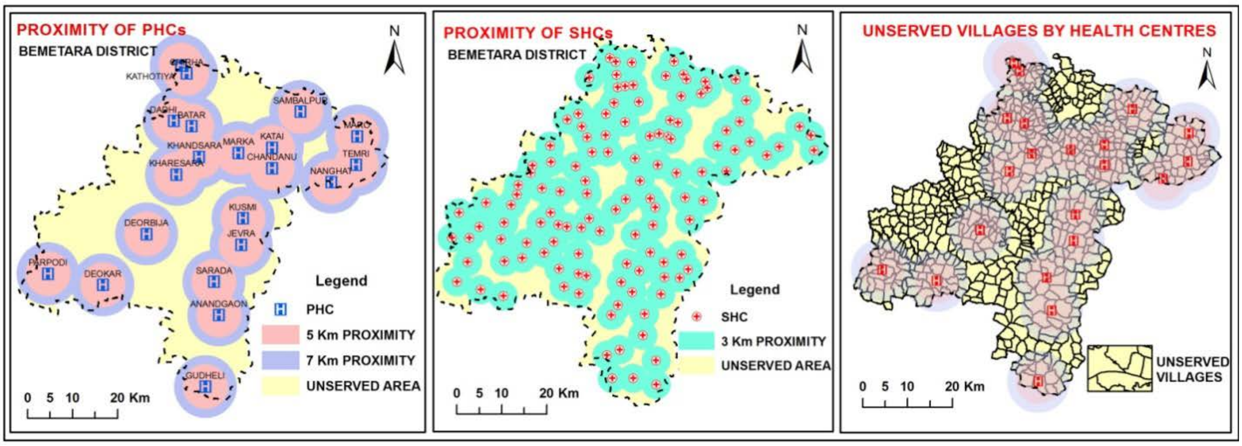


Figure 10 Proximity Map of PHC, SHC, Unserved Villages

3.5.2. Creation of Thiessen Polygon – Population 2011

Thiessen polygons are named for the American meteorologist Alred H. Thiessen. Thiessen polygon are an essential method for the analysis of proximity and neighbourhood. These are used to assign space to the nearest point features. Thiessen polygon defines individual areas of influence around each of a set of points. This method has been applied to show the serving population and area of PHCs as associated centres of Bemetara district. In the study region Thiessen polygons are generated and the population and area of villages within the catchment area of each Thiessen polygon are calculated. Based on population the Thiessen polygons have been categorized into three categories low, medium and high. This method is applied to recognise the population pressure existing on the individual facility as the population is considered as basic criteria for the allocation of PHC, SHC, CHC (IPHS, 2006). Shown in Figure 11.

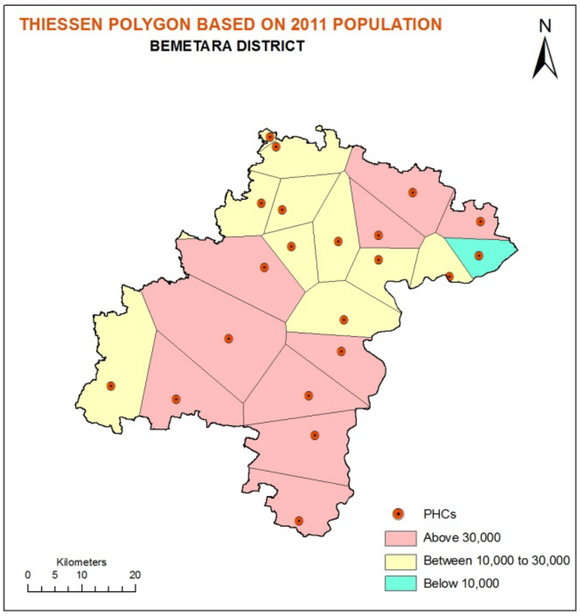


Figure 11 Thiessen Polygon Map of PHC

3.5.3. Network Analysis of Health Centres

Network Analysis is an important tool in ArcGIS that has used to model travel distance and time to health centres in Bemetara district using 151 health centres and approximately 700 settlements. The approximate travel time and distance from each centroid to the closest health centre has calculated. The vector layer of road network has converted into network dataset for network analysis. Depending upon the road hierarchy and characteristics roads are allotted an average vehicular speed. On the basis of speed, travelling time and travelling distance required to be covered to teach the nearest facility service area has calculated, which are used as an impedance in the analysis. Shown in Figure 12. A network service area is a region that includes all accessible roads. Service area created by network analysis tool help to estimate accessibility. Concentric service areas show how accessibility differs with impedance. Service area on the basis of time and distance is also helpful to predict the travelling time and travelling distance from demand point to health centres. In the present research work the service area has generated by fro PHC as service points on the basis of distance and time. The service areas on the basis of time has generated by taking the interval above 30 minutes, between 15 to 30 minutes and below 15 minutes. While as on the basis of distance service areas have generated by taking interval above 14 km, between 7 to 14 km and below 7 km. Population of each service area zone has calculated. Shown in Figure 12.

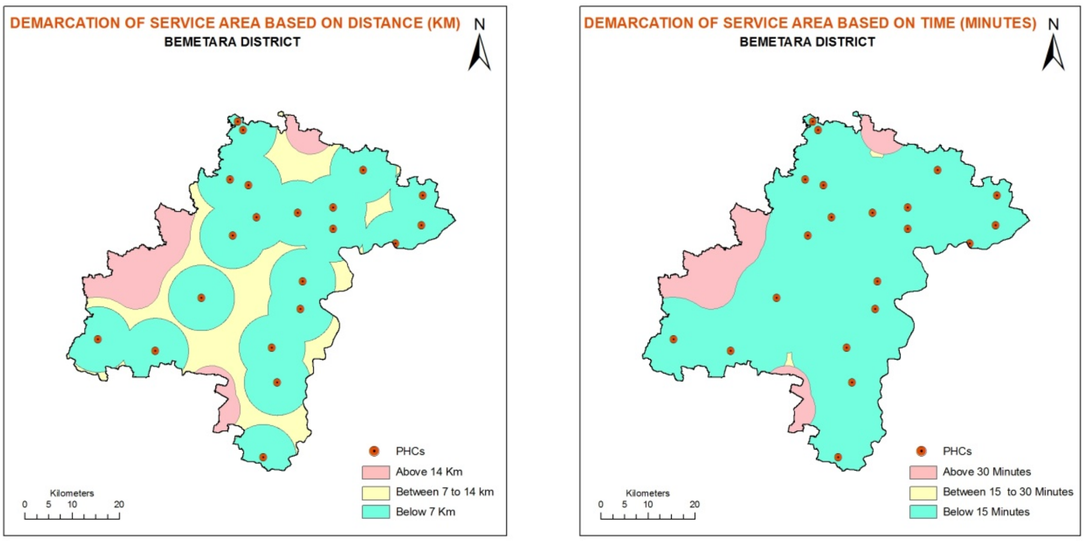


Figure 12 Service Area Based on Travelling Time and Travelling Distance

Figure 13 shows the closest facility based on distance and time. Distance above 14 km from PHC shows high density in the study area. Between 7 to 14 km shows low density and below 7 km shows medium density. Most of the PHCs cover 30 minutes to travel from other settlements. 15 to 30 minutes shows very less density whereas below 15 minutes cover most of the area of the study region.

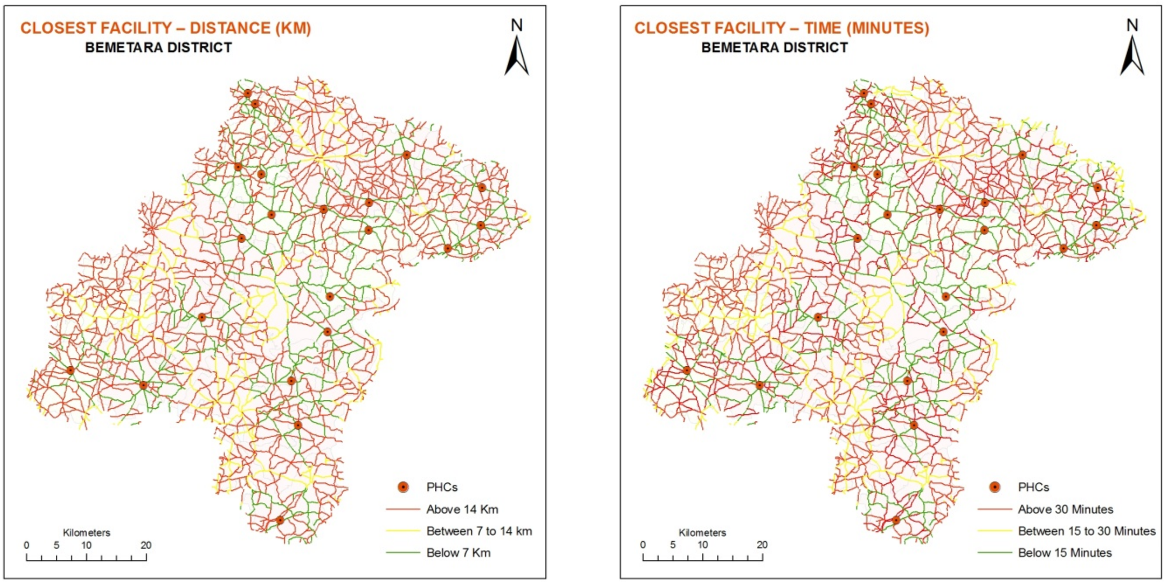


Figure 13 Closest Facility Based on Travelling Time and Travelling Distance

3.6. Geospatial Analysis of Health Centres Manpower & Other Facilities

The availability of manpower is one of the vital requirements for the efficient functioning of the Rural Health services. As per Government norms CHCs, PHCs and SHCs have their own staffing pattern. But there is shortfall in manpower in health centres. To study this shortfall a geospatial database has created with all available hard copy data obtain from health department of concerned study area. All those data entered into excel format and linked with the existing health centres database. From this database decision maker and planners can perform query in order to find out the shortfall of doctors and other medical staffs. It also performs various type of query according to users need. This database plays an important role in proper spatial monitoring of available health centres. The overall database can now termed as of Geospatial Health Management Information System (GHMIS).

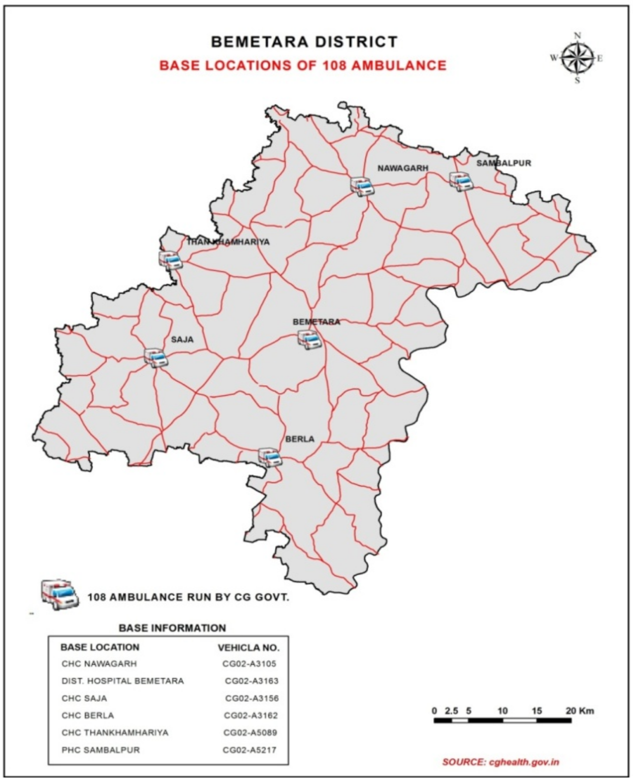


Figure 14 Spatial Location Map of Ambulance Facility

In other facilities Ambulance is also an important facility which helps rural people to reach the nearest health centres. But there should be a proper information system for ambulance which will help rural people in emergency time. GIS ia an advance tool has helped in preparing spatial map of ambulance available in the study area. From this map it can be analysed which area is lacking ambulance facility and which area is have surplus ambulance facility. It also help people to see the spatial location and can help in taking decision which ambulance they should call in emergency time. The database also contains all other information like phone number, vehicle number, location name etc. Figure 14 illustrate the ambulance facility.

3.7. Web Based GIS for Health Care Decision Support System

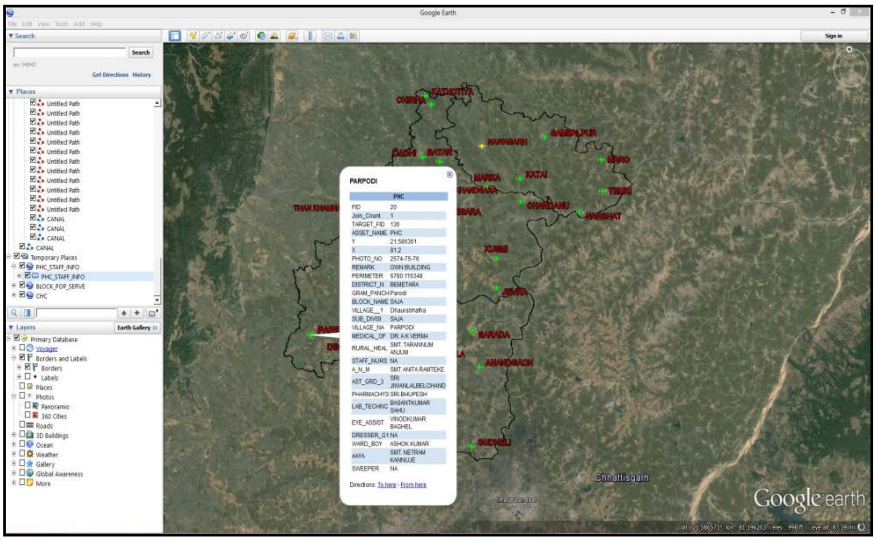


Figure 15 Web-GIS Platform for GMIS

Distributing geospatial information on the Internet is an enforcing factor for information providers. Internet allows to access geospatial information, and provides a media for processing geo-related information with no location restrictions. Unfortunately, everyone does not have access to GIS, nor able spend the time necessary to use it efficiently .Web GIS becomes easy way of disseminating geospatial data and processing tools. Internet technology has made its way to many government organizations as well as numerous households. The ability to get information through Internet made spatial data providers to explore the Internet resources for disseminating spatial information. To provide a successful web GIS implementation it is required to consider the implementation as a process rather than a stepWeb Based GIS has developed for Geospatial Health Management Information System. It is for visualisation and act as a decision support tool for users, decision makers and planners. It is dedicated to professionals and to public health care decision makers for rural area. It can be used as a multi-stored information system. A Web-Based GIS (WebGIS)reproduces the main functions of GIS on a Web interface: spatial analysis, navigation (zoom, pan), and dynamic creation of map, layer overlaying, and interactive querying. A Web-GIS is a new mean to dynamically distribute and represent spatial information, with a large access. Geo Server has used as web GIS platform. PHP and MySQL has used for interactivity, the database connection abilities. Users can access various functionalities: zooming, selecting geographic areas, viewing additional neighbouring zones by easy roll over. Moreover, this solution of a client side application is interesting allowing for time response. Unlike server side applications, geographical data are loaded one time, they are simple to operate and do not need to be reloaded when a new request is sent.

4. CONCLUSION

The purpose of this research is to address the various problems and provide new solutions for health information sharing. The handling of data heterogeneity, lack of available data and tools, and methods of health information representation constitute continuing challenges. In the development of a public information and disease surveillance network, issues of data publishing and user access are important concerns. GIS mapping technologies can generate maps for health in desktop or Web applications. Health geography is already indispensable for public health surveillance, seems useful to identify inequities in health care delivery, and to efficiently help allocate and monitor healthcare resources.The mapping technologies can create interactive interfaces for users, with the support of GIS basic functions such as zoom in, zoom out, pan, and hyperlink. GIS, remote sensing, and global positioning system technologies have all been increasingly applied to health applications. The use of GIS technology can inform health officials and the public about emerging health threats, and assist their decision making at all levels. A geospatial-enabled approach has been proposed in this study for semantic health information retrieval. To allow the access of health maps and processing functionalities, Geospatial Web Services are proposed to facilitate a loosely coupled architecture design for cross-platform health data and function sharing. If the access URLs and interfaces of the Geospatial Web Services are known, resources can be accessed no matter what underlying platforms and development background are used. . The user can access the data of any level by logging into the central service without having the hassle of visiting every website. It can be act as a single window service station. It will give entire system a speed, sense of competitiveness and finally sustainability through increase in revenue generation in the physical sector and improve healthcare system in case of social sector. The range of expectation about the performance of health information system will depend on the role of the people involved. “People” comprises of three categories Doers, Users & Viewers. It seeks decentralization of programme for district management of health and to address the inter-State and inter-district disparities. It also seeks to improve access of rural people, especially poor women and children, to equitable, affordable, accountable and effective healthcare.

5. ACKNOWLEDGMENTS

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