Case Report

Web Based GIS for Public Health Management in Andhra Pradesh

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ABSTRACT

Public health and public healthcare are important social issues with deep implications for government administration and with large effect on individual standards of living. The current existing healthcare IT applications in public or private sector have been working for years and have a huge database. The data need to be analyzed and represented in graphical/map form of the application specific concepts for appropriate decision making in time. To achieve this, the frontier technologies like Geographical Information System (GIS), Geo-informatics and Global Positioning System (GPS) have been effectively used to convert the data into information in the form of visually effective maps for quick decisions. In the present study an attempt is made to develop an integrated system to provide a single point of access to wide variety of reports on public health by visualization of day-to-day activities of Health Management Information System (HMIS), Integrated Disease Surveillance Programme (IDSP) and Mother & Child Tracking System (MCTS) programmes at sub centre level in Andhra Pradesh. The analysis revealed that the integration of statistical health data with GIS is helpful for analysis and display in the form of simple maps and reports which convey the information to the planners easily. The Health GIS web portal acts as a Decision Support System (DSS) to the health officials to take quick and effective decisions.

Key Words: Public Health, Geographical Information System, Geospatial mapping, Decision Support System, Web GIS, Health GIS.

INTRODUCTION

In many countries, healthcare institutions are being pushed to their limit by an aging population and increased urbanization, which may lead to additional health issues. To improve and maintain the quality of life along with good health of a society plays a significant role in the economy. Most of the factors affecting human health depends on the environment, population density, industrialization, transportation, etc. which varies from place to place. Public health organizations aim to understand the social, cultural and economic determinants of the community, and are being focused more on prevention than treatment. Due to lack of education on health, there are incidents where damage has occurred already before any actions taken. The key factors to reduce the risk can be prevented by planning and awareness/ education on health, risk reduction by warning and evacuation, control by immunization, etc. Andhra Pradesh is experiencing a rapid health transition and it is responsibility of the state to ensure efficient delivery of cost-effective interventions for health promotion, disease

prevention and affordable diagnostic and therapeutic health care. The tremendous potential of GIS to benefit the health care industry is not only realized but also adopted for integration and spatial visualization of health data. GIS systems make it possible for public health professionals to visualize population health problems within the context of available social services, demographic factors and changes in environmental variables. [1]

OBJECTIVE
The main objective of the study is to create a web application which will be used as a decision support system in public health care and to make the effective utilization of GIS in Health sector for updating, storing and maintenance of spatial and non-spatial data of Health Centers for IDSP, HMIS & MCTS programmes.

LITERATURE REVIEW
GIS is a tool for data collection, store, analyze, manage and visualization. As it is known that in health sector many of the changes have strong geospatial components, GIS can provide an integrated approach to the public health departments in planning and analysis. It is defined as the science and technology related to the gathering, storage, manipulation, analysis and visualization of geo-referenced data. [2] It integrates non-spatial tabular data with its geographically referenced spatial data. Rohan et. al., (2011) [3] discussed in his case study in eastern Indonesia, how the simple GIS software can be used to view public health data with minimum resources and proven the efficiency of the geographical health maps. George et. al. (2013) [4] demonstrated the use of GIS mapping as a public health tool from cholera to cancer and it concludes that the capacity of GIS to link disease information with environmental and spatial data makes it an asset in the progression of worldwide healthcare. The capacity of GIS

lies in mapping the population at risk, health dynamics, aspects of risk and relationships between them. Web searchable metadata will help public health agencies to communicate and make known their geospatial resources to internal and external users. [5] The usefulness of GIS is in the ability to view maps and identify areas of prevalent diseases, pest breeding grounds, spatial population distribution for health studies, doctor-to-patient ratio and location of health facilities. [6]

PUBLIC HEALTH SCENARIO IN ANDHRA PRADESH STATE
Andhra Pradesh is one among 29 states of India and has second longest coastline in India. The state is the eighth largest state covering a geographical area of $160,205$ km^2. Around 70% of its population lives in rural areas and 30% in urban. The health centers such as Community Health Centers (CHC) - 225 no's, Primary Health Centers (PHC) - 1075 no's and Sub Centers (SC) - 7162 no's are well distributed in the state. Most of the schemes were sponsored by Government of India, which are implemented by the state for health sector. Under the framework of National Rural Health Mission (NRHM), the central government supports the health sector reform initiatives in Andhra Pradesh for health stabilization and creates an equitable health system with fixed goals. Accordingly, the state government has given very high priority to the strengthening of public health services with focus on Maternal and Child Healthcare (MCH) and Population stabilization. Andhra Pradesh is one of the first states to successfully plan and implement the state population policy. As a result the Total Fertility Rate (TFR) reduced from 2.6 (NHFS-1: 1992) to 1.8(2014). [7] The Infant Mortality Ratio (IMR) reduced from 63 to 39 from 1997 to 2014 respectively. The Maternity Mortal Ratio (MMR) was attributed in 1997 as 154 and it

is drastically reduced to 92 in 2014. When, the Andhra Pradesh statistics is compared to the national values, CBR, MMR & TFR values for the total country are much more compared to the State values, IMR values are almost synched but CDR for the state is little higher than the nations value. Table-1 shows the comparison of health statistics of the state with the nation.

Table: 1. Comparison Health statistics of India and Andhra Pradesh.

Details		India	Andhra Pradesh
Census 2011 [8]	Population Census 2011(Final)	1,210,854,977	495,77,103
	Sex Ratio(Females per 1000 males) 2011	940	992
	Child Sex Ratio	914	943
Annual Health Survey, 2012-13 & SRS Bulletin, 2012-13, [9] WHO [10]	C.B.R. (Crude Birth Rate) 2013	21.4	17.4
	C.D.R. (Crude Death Rate) 2013	7.0	7.3
	I.M.R. (Infant Mortality Rate) 2013	40	39
	Maternal Mortality Rate (MMR) / 1 Lakh live births	178 (2010-12)	92 (2014-15)
	T.F.R. (Total Fertility Rate)	2.5 (2013-14)	1.8 (2014-15)

Health Programmes in A.P. sponsored by Govt. of India

Integrated Disease Surveillance Programme (IDSP): Integrated Disease Surveillance Programme (IDSP) is to strengthen the disease surveillance in the country by establishing a decentralized State based Surveillance system for epidemic prone diseases to detect the early warning signals, so that timely and effective public health actions can be initiated in response to health challenges in the country at the District, State & National level. [11] Under the project weekly disease surveillance data on epidemic prone disease are being collected from reporting units such as sub centers, primary health centers, community health centers, hospitals including government and private sector hospitals and medical colleges. The information is collected on three specified reporting formats, namely "S" Form (Suspected Cases), "P" Form (Presumptive cases) and "L" Form (Laboratory confirmed cases).

Health Management Information System (HMIS): Health Management Information System (HMIS) aims to improve ability to collect, store and analyze accurate health data. Management of vital patient records, analysis of the critical health related data so as to provide an updated planning & policy tool towards provision of quality health services. It aims to provide better care for patients by automating all the major functional areas of the hospitals. A web based Health MIS (HMIS) portal was launched in October, 2008 by Government of India to facilitate data capturing at District level. The HMIS portal has led to faster flow of information from the district level. The HMIS portal is now being rolled out to capture information at the facility level.

Mother and Child Tracking System (MCTS): The health of women and children has been an abiding development concern in India right since Independence. It is estimated that around 60 thousand women in the country die every year due to complications associated with pregnancy and delivery while many more suffer from pregnancy and birth related ill-health. It is also estimated that every year around 1.25 million new born fail to survive up to their first birth day. Mother and Child Tracking System (MCTS) facilitate monitoring of universal access to maternal and child health services by all pregnant women and children. The broad objective is to reduce infant mortality rate (IMR), to improve the nutritional level of the child, to ensure completion of immunization in children by tracking the proper growth of the individual child, and to reduce mother mortality rate

(MMR). Mother and Child Tracking System (MCTS) is an IT enabled application (http://nrhmmcts.nic.in) which will facilitate monitoring of universal access to maternal and child health services by all pregnant women and children. The system is developed jointly by the Ministry of Health and Family Welfare and National Informatics Centre and it was launched by the Government of India in December 2009 in collaboration with States/UTs. MCTS is designed to capture and track all pregnant women right from conception up to 42 days post-partum and all new born up to five years of age to ensure that the pregnant woman and children receive 'full' set of medical services thereby contributing to the reduction of maternal, infant and child mortality and achieving the goals laid down in the National Rural Health Mission as well as Millennium Development Goals.

GIS BASED DECISION SUPPORT SYSTEM FOR PUBLIC HEALTH MANAGEMENT

GIS techniques may be used to determine spatial correlation between health and environment. It plays a critical role in determining where and when to intervene, improving the quality of care, increasing accessibility of services, finding more cost-effective delivery modes and preserving patient confidentiality while satisfying the needs of the research community for data accessibility. The geospatial data on the web displays the information in the form of maps, graphs and reports and it also illustrate risk zones. Web GIS is the system to share the geospatial data among respective agencies for the analysis. The user can access the information through internet from anywhere and get the visually effective output through maps, graphs and tables. This, in turn will help the public health department to improve the performance by making quick decisions. Web GIS application also provides the option to compare the legacy data with the present, which will be helpful to take preventive measures. The temporal data along with geographic information helps to get events on spread of the disease in the particular season. GIS replaces the legacy model of maintaining information in the form of papers and it means to maintain the database of the information linked to its geographical location. [12]

Using the spatial analyst tools, a model can be created for identification of magnitude, spreading and causing of diseases, which is very essential for public health department officials to concentrate more on the vulnerable areas. By overlaying different spatial and demographic data the direction of disease spread can be predicted. [13] Decision makers can prioritize not only the affecting factors of the disease, but also the actions and regulations required for fighting the disease. It is useful to monitor the performance of different government schemes and their achievements against targets. Monitoring nutrition values of the pregnant women and a new born child in a community through GIS will be helpful to the government to decide on where to concentrate more. Health GIS on web will boost new opportunities to pursue the mission of disease surveillance, prevention, antenatal and postnatal care, immunization track, and administrative management.

MATERIALS & METHODS

Health data: Health services are provided through the network of health centers spread throughout rural and urban areas of the country. The statistical data in the form of tables for the year 2014 was collected from Health & Family Welfare (H&FW) department and compiled at Sub Centre level for MCTS, IDSP and HMIS. These are having different forms with fixed number of indicators in each. Administrative boundaries, CHC, PHC and Sub Centers are mapped using High Resolution Satellite data

in conjunction with Survey of India topo-sheets.

Methodology

The information provided by Health department is used as an input to generate spatial layers in GIS environment. Influence boundaries of health centers like CHC and PHC are generated using administrative boundaries of Andhra Pradesh. The locations of Public health centers and hospitals were also created. Unique codes provided by Health department were assigned to each Cluster, PHC, Sub centre and Hospital, which acts as a primary key to connect to the Database. ArcGIS Server 10.2 and ArcSDE are to integrate geographic information query, mapping, spatial analysis and editing within a multi-user enterprise in DBMS environment, ArcGIS API for Javascript as an interface, HTML5 and .Net programming for the web page.

The developed web portal Health geographical information System(HGIS) analyses the data based on the query by user, virtual link is created between both spatial and SQL Databases in the backend. The results are displayed in the form of heat maps, graphs and tables. Query tool gives an option to display severity of a selected indicator for a particular geographic area. The detailed methodology of Health GIS system creation is shown below in the form of schematic diagram.
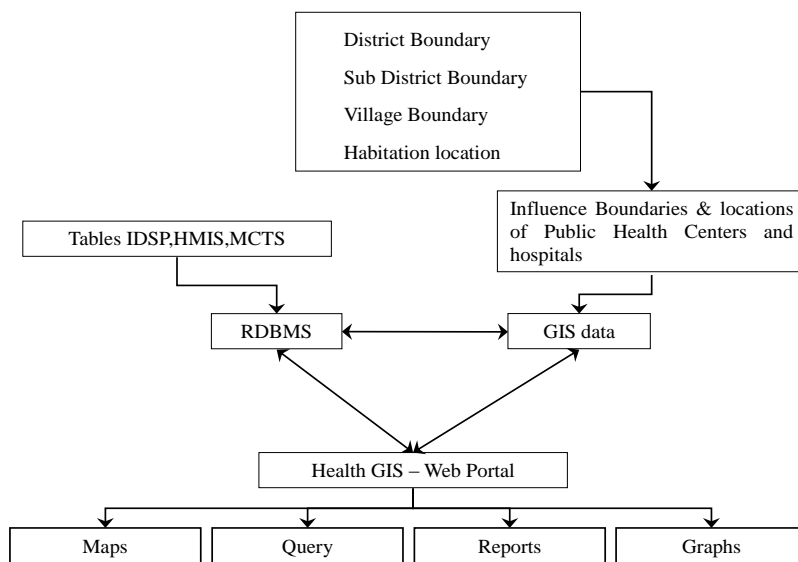
Fig: 1. Methodology

RESULTS & DISCUSSIONS

The study reveals that the use of Web GIS application for public health is used to view the status of each indicator and to monitor the same spatially. The heat maps were generated using tabular data along with geographical boundaries, which will help the managers towards improved and undisputed decisions. In Health GIS system, data can be stored, analyzed, and retrieved in to useful information like maps, graphs and tables, where the maps give the detailed view of risk zones. [14] The common base layers including road, water body, forest, administrative boundaries, etc., can be integrated for analysis and speedy measures. The Health Geographical Information System (HGIS) is an integrated system that provides a single point of access to wide variety of reports and combined visualization of Health Management Information System (HMIS), Integrated Disease Surveillance Programme (IDSP) and Mother & Child Tracking System

(MCTS) to the Sub Centre level. It acts as a decision support system for the Health department. In HGIS system, the statistical data will be integrated with other collateral data and analyzed to provide Choropleth maps, Heat maps, graduate symbol maps, graphs & reports. The entire database is huge to demonstrate, hence only few of the examples are illustrated here.

Mother & Child Tracking System (MCTS)

<u>Maternal Mortality Ratio (MMR):</u> Under the MCTS programme, MMR is one of the key indicators to monitor the services and pregnancy women health. It represents the risk associated with each pregnancy. The number of registered maternal deaths due to birth or pregnancy related complications per 100,000 registered live births. Figure-2 describes the spatial distribution of maternal mortality rate in Andhra Pradesh of the year 2014. It is learnt that Visakhapatnam district is in highest risk compared to other districts, which are attributed in hilly area. Kurnool and Vizianagaram districts are in semi critical range.
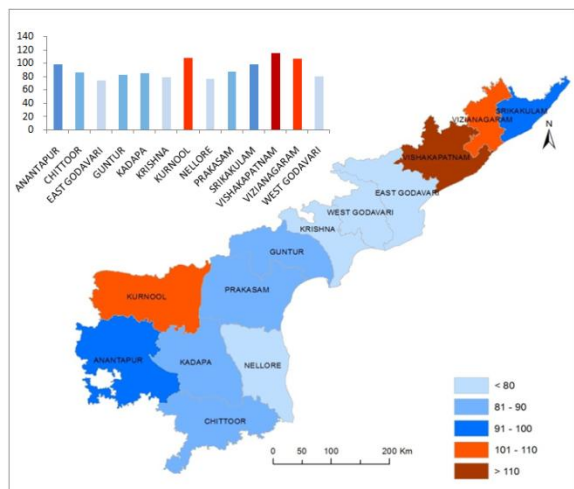
Fig: 2. spatial distribution of Maternal Mortality Ratio, Andhra Pradesh- 2014.

<u>Infant Mortality Ratio (IMR):</u> IMR is the number of deaths of children less than one year of age per 1000 live births. Figure-3

shows that Srikakulam District is in critical condition and 3 other Districts namely Vizianagaram, Kurnool & Anantapur are in 2nd critical condition.
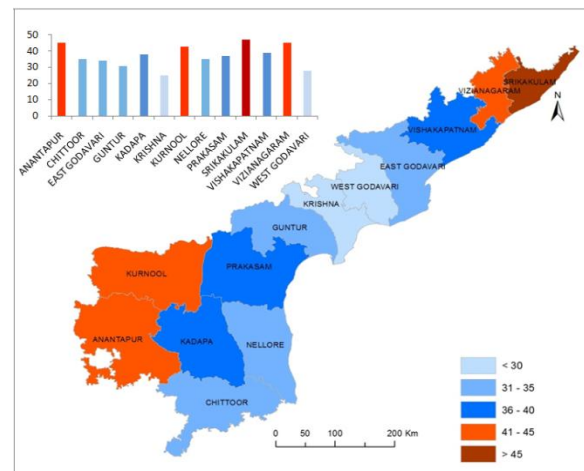
Fig: 3. spatial distribution of Infant Mortality Ratio, Andhra Pradesh - 2014.

Health Management Information System

<u>Full Immunization Status</u>(up to 12 months): The system will provide the facility showing following status maps. The data revels that 3 Districts out of 13 have full immunization below the normal value (50-80 %). 2 Districts has full immunization between 80-90 % and other districts full immunization is considerably good.
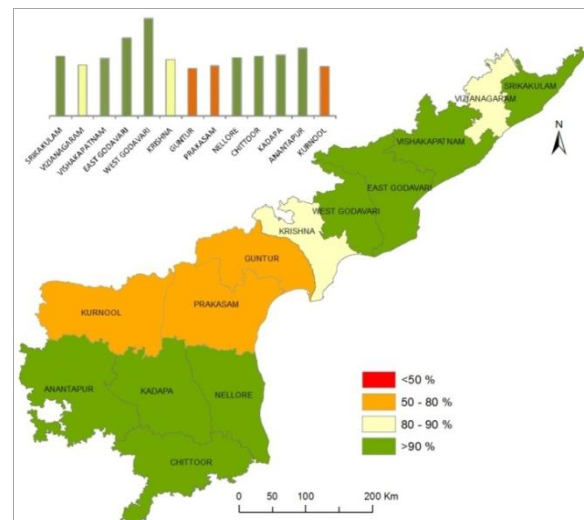

Fig: 4. District wise Full Immunization Statu, Andhra Pradesh 2014-15.

Integrated Disease Surveillance Programme

<u>Chikungunya Disease Profile</u>: From the figure-5, it can be observed that Visakhapatnam District is in high risk, Nellore and Srikakulam have moderate risk. The cases registered are increased rapidly from 2012 to 2014.

<u>Disease profile-Dengue:</u> From the figure-6, it can be seen that Visakhapatnam & Anantapur Districts are in very high risk, followed by East Godavari, Chittoor & Kurnool. Graph shows that more cases are registered in 2012 and low in 2011.
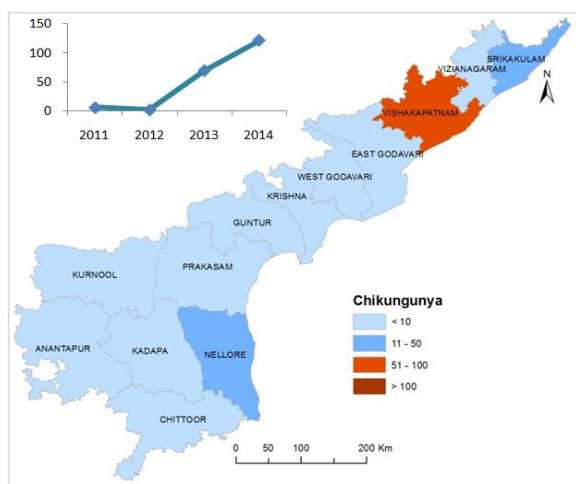
Fig: 5. District wise Disease Profile for Chikungunya, Andhra Pradesh -2014.
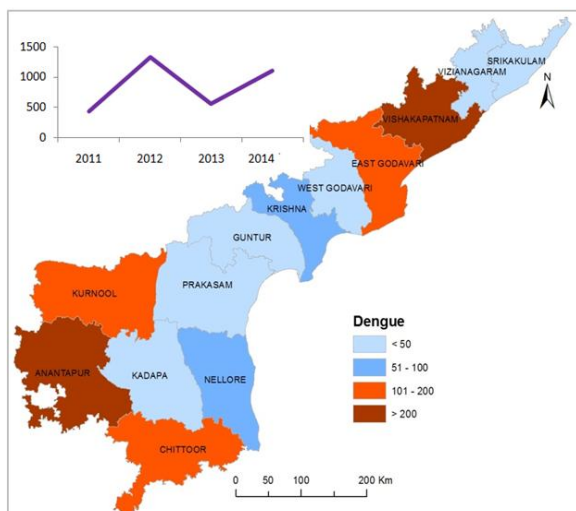
Fig: 6. District wise Disease Profile Dengue, Andhra Pradesh - 2014.

Some of the screen shots from Health Geographical Information System Web portal are depicted below.

Fig-7 A & 7 B gives the choropleth maps showing number of Home deliveries (HMIS) in Andhra Pradesh state & Kadapa District respectively. Fig. 7C displays the proportional symbol values for Accute Resperatory diesease incidents (IDSP) in one CHC. Fig. 7D indicates the heat map of Accute Resperatory diesease (IDSP) in the state. The system having the facility to displly the maps along with the legend, graph & reports.

CONCLUSION

From the analysis, it is stated that GIS is a powerful tool helps in understanding public health needs of a community and plays an essential role in helping public health organizations to design effective interventions. The statistical methods like graphs and tables to display the results for comparison of different year data are time consuming to understand and to take appropriate decisions by the managers. GIS can display not only maps, but can also perform statistical analysis of geographic data, forecasting the predictions and cope up with new technologies. The digital Choropleth maps are self-explanatory, reducing the time and effort. GIS can play a significant role in database management, periodical data comparison, geographic data comparison and data navigation. Comparison of present events to previous years will be helpful to take appropriate actions and precautionary measures. The study concludes that the Geographical information system has the capability to integrate data from different sources and gives single point access for health query and reports. The transitional data through internet will be helpful to access it anywhere and give instant information of incidents. GIS helps health managers to identify areas

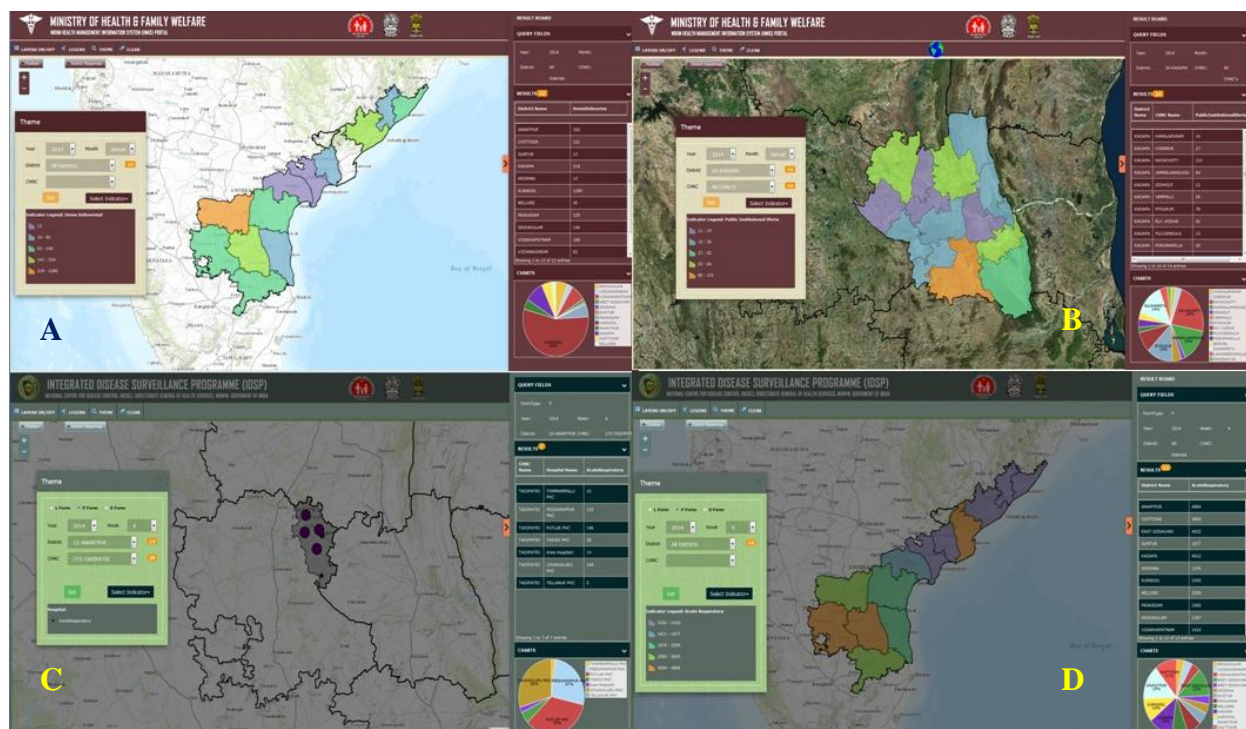with discrepancies, by helping the community to overcome the problems.

Fig: 7.Screen shots of Health GIS – web portal.

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