Creation of a Web GIS of Rural drinking water sources in Punjab using FOSS tools

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Abstract- ***Use of free and open source GIS (Geographic Information Systems) tools (FOSS-GIS) to create Web GIS applications is increasing day by day. Technical features provided by FOSS tools are comparable to their proprietary peers. There is a variety of open source web GIS software freely available on the internet and they differ on parameters like ease of use, technology, complexity, support etc. In this research, open source software combination of MapServer and pmapper has been used to create a web GIS which provides information about the rural drinking water supply sources of Dept. of Water Supply & Sanitation (DWSS) in Punjab. Rural drinking water source (RDWS) information contains the details of the type of water source, date of commissioning, Scheme, Tube well size, depth, coverage information, number of villages covered, strainer material and length, motor details, discharge, lithology details and location etc. Base layers like road, rail, canal, drainage, settlements, village, block and district boundaries add value to the database of RDWS in the state. This application has various tools like Pan, Zoom, Search, Identify and other common tools with the help of which a user can browse and search the data. The application also provides a comprehensive view about the spatial and non spatial data and can act as a decision support system for the DWSS officials, decision makers and planners.***

Keywords-FOSS, Web GIS, Rural drinking water sources

I. INTRODUCTION

Water, a precious gift of nature is vital for the very existence of life. Moreover, water is finite and vulnerable natural resource, therefore it is essential to use it optimally for maintaining the health of global ecosystem. Ecosystem's health in turn is critical to the quantity and quality of water supply. The provision of safe water is essential for the well being of the world's population. In spite of the considerable progress in the development of water resources since 1990, one third of the global population lives under water stress conditions. If this trend continues, by the year 2025, two third of world population may face serious water crisis. The scarcity of water in the face of exponentially increasing demand may lead to disputes and conflicts both within and among states over water resources. United Nations is celebrating 2005-2015 decade as "Water for Life".

The availability of surface and ground water resources is not uniform, certain areas have plenty of it where as other areas may be deficient. Further the topography and rainfall virtually control runoff and ground water recharge. Due to rapid growth of population, urbanization, industrialization and agricultural activities, the water sources are now getting stressed leading to decline in per capita availability of water. The availability of ground water is neither unlimited nor it is protected from deterioration. After ascertaining the quality of ground water for potability, it can be developed incrementally, at points near the water demand, thus avoiding the need for large scale storage, treatment and distribution system. Safe water is the greatest lifesaver and an essential input for industrial and agricultural development.

India is exploring and developing water resources to meet the ever-increasing demand for diverse uses. The occurrence of ground water in the country is significantly affected by the geological, geomorphological and climatic conditions. Ground water is the major source for meeting the growing demand for water in India. More than 88 per cent of rural and nearly 30 per cent of urban population use it for drinking purposes. It accounts for nearly 60 per cent of the total irrigation potential in the country, irrigating about 32.5 million hectares. Extraction of excessive quantities of ground water has resulted in drying up of wells, damaged ecosystems, land subsidence, salt-water intrusion and lowering of water level. The quality of ground water is being increasingly threatened by agricultural, urban and industrial wastes, which seep into under lying aquifers. The deterioration in quality of potable water, as a consequence of pollution, is affecting the health of a larger population.

The State of Punjab forms a part of Indo Gangetic alluvial plain extending over a distance of 2000 km from Punjab in the west to Assam in the east and constitute one of the largest and potential ground water reservoirs in the world. The aquifer systems are extensive, thick, inter connected and moderate to high yielding. Punjab is an agricultural state and the economy and well-being of farmers depends to a large extent on the availability of water. The ground water resources in Punjab are continuously under severe pressure due to ever increasing population and increasing demand of water for diverse uses. At present, 68 per cent of the irrigation requirements of agriculture are met through tube wells sunk in shallow unconfined aquifers. There are about 11.7 lakh shallow tube wells to meet the irrigation requirements, besides this, a number of deep tube wells have been installed for supplying drinking water to urban and rural population of the state. In Punjab, 25 per cent of 12267 rural habitations fall in NC (not covered) category of drinking water schemes. In about 45 per cent villages, poor quality ground water is available. Whereas, 60 per cent households have inequitable, short duration (2 hours) distribution of unreliable drinking water.

Department of Water Supply and Sanitation (DWSS), Punjab is responsible for rural water supply by developing surface and ground water resources. Ground water forms the major source of potable water. The department has implemented various schemes for the supply of safe drinking water by exploiting deeper confined aquifers. Presently, there are 5000 operational deep tube wells drilled all over the state. However, in majority of the cases scientific data base on ground water quality and quantity, which facilitates identification of prospective ground water zones and selection of appropriate sites for the drilling of new bore wells is not available. In many cases tube wells have been drilled in a short period of time to tackle the drinking water problem, without giving enough time to undertake systematic hydrogeological studies. In addition, the tube wells have been drilled and commissioned over the years and there is no benchmark year from which the data base in respect of ground water quality and water level could be updated. The deteriorating water quality of shallow aquifers and increasing reliance on deep aquifers as the preferred water supply source requires the evaluation of water quality of deeper aquifers through a systematic and scientifically planned approach.

Realizing the need of reliable and up to date data base in respect of water table and water quality for drinking purposes, the DWSS, Punjab decided to create such data base for various water sources under World Bank aided project from the year 2006, so that changes in water table and water quality could be monitored periodically. DWSS has been tapping deep confined aquifers for supplying drinking water in rural areas; however, there is no systematic bench mark data base in respect of water quality and water level for various water sources. Under this project, a serious attempt has been made to create benchmark data base in respect of water quality and water level for all the DWSS water sources in remaining sixteen districts of the state.

In this research, FOSS tools have been used to develop a web GIS. The main advantage of FOSS is that it is free of cost. Also, since the software is open source, the core software framework can be used by the application developers to build complex applications. Combination of pmapper and MapServer has been used globally to create various web GIS applications. Ground water quality maps [1] have been published using open software for bringing the generated ground water quality maps information to the authority and the community. It also alerts the local community about the steps to be taken about the contaminated water and decision making. [2] & [3] has used MapServer for natural resources management. [4] has used this combination to develop a collaborative system for environment and tourism information authoring and Web publishing. Details about the design and implementation of spatially explicit online decision support systems for disaster management has been provided by [5], it also uses free or open source GIS tools. Steps to publish health maps on the internet using MapServer have been defined in [6].

II. OBJECTIVES

The main objectives of the research work are as given below:

- Geo-referencing of DWSS rural water supply sources (tube wells/ canal/ hand pumps) and collection of water samples for water quality evaluation.
- Creation of digital data base w.r.t. location (latitude and longitude), scheme details, water level, lithology, aquifer and water quality parameters for all the georeferenced water sources.
- Development of a web GIS using FOSS tools, with the help of which officials and public can view and query the collected data about the rural drinking water supply sources.

III. METHODOLOGY

The methodology of the research work is as given below:

1) Geo-referencing of DWSS rural drinking water supply sources (tube wells/ canal/ hand pumps) and collection of water samples for water quality evaluation was done for the whole state in the period October-2010 to Febuary- 2013. The scheme, water level, litholog and, aquifer details of the sources was also collected. This information included the type of water source, date of commissioning, scheme, tube well size, depth, coverage information, number of villages covered, strainer material and length, motor details and discharge etc.

2) The following water quality parameters were analyzed in the lab: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity, Hardness, Chloride(Cl), Sulphate(SO4), Nitrate(NO3), Iron(Fe), Calcium(Ca), Magnesium(Mg), Fluorine(F), Aluminium(Al), Lead(Pb), Selenium(Se), Chromium(Cr), Mercury (Hg), Arsenic (As), Nickel(Ni) and Cadmium(Cd). Information about Uranium was procured from DWSS.

3) Digital data base w.r.t. location (latitude and longitude), scheme details, water level, lithology, aquifer and water quality parameters for all the georeferenced rural drinking water sources was prepared in the Arc GIS environment.

4) Base information like settlements, road, railway line, canals and drainage were digitized in the Arc GIS environment from the LISS III satellite data of the period 2009-2012. The Village boundary was digitized from the Punjab Land Records maps and the Block and District boundaries were extracted from it.

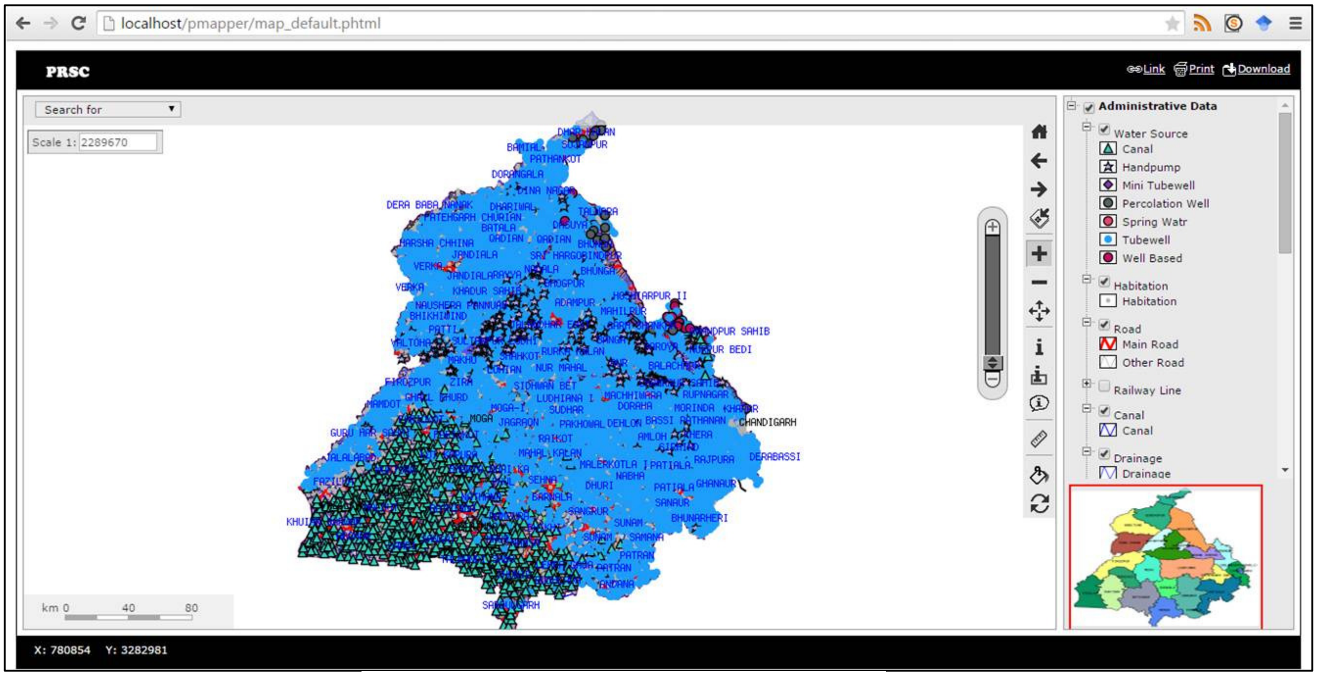

Figure 1. Full View of the Web GIS

5) FOSS combination of MapServer and pmapper has been used to create a web GIS which provides information about the rural drinking water sources. This application has various tools like Pan, Zoom, Search, Identify and other common tools with the help of which a user can browse and search the data. Various software used for the development work are : pmapper 4.3.2 and MS4W 3.1.0 (MapServer 4 Windows) which contain the packages : Apache 2.2.24 HTTP server, PHP 5.4.14, Map Server CGI 6.2.1 etc. The details regarding the development of the web GIS are provided in [7].

IV. RESULTS

The outcome of the research work is a web GIS with the help of which a user can browse and search the spatial data. Fig.1 There are various tools like pan, zoom, search, identify, distance/area measurement, hover etc. provided in the application. The application includes ten GIS layers namely water source, habitation, water bodies, road, railway line, canal network, drainage, village, block and district boundaries. On the click of a water source feature, scheme, water level, litholog and chemical parameters are visible, as shown in Fig.2. The lithologs are in the image format and hyperlinked with the water source point. Search is provided to find any village/settlement, a particular water source scheme, administration block or a district. The web GIS provides information about 7305 rural drinking water sources. Table 1 displays the rural drinking water source data, district wise, which is further classified by water source type and by the tube well status. Patiala district has the maximum number of water sources while Muktsar has the least.

The study amply demonstrates the use of Remote Sensing, GIS and FOSS tools to develop Decision support systems for administrators and public which provide a comprehensive view of the data.

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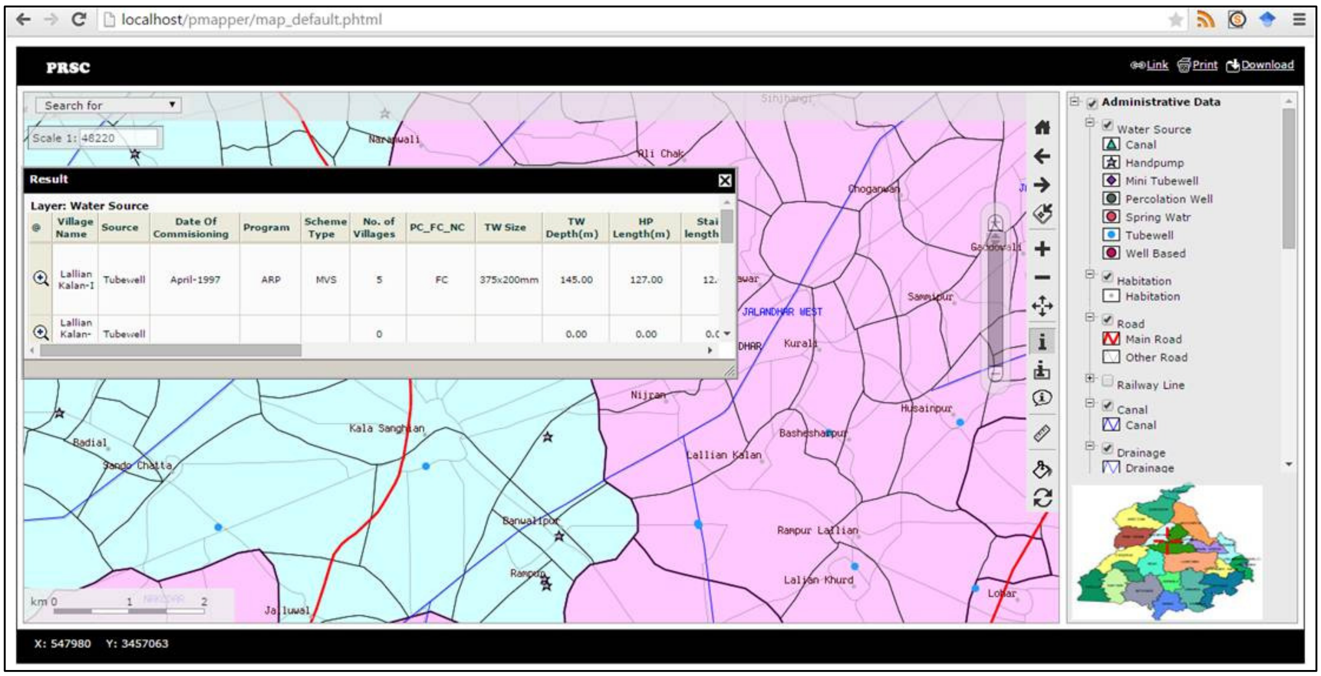

Figure 2. Zoomed Map in the Web GIS

TABLE I. RURAL DRINKING WATER SOURCE INVENTORY

S.No	District	Rural Drinking Water Sources				Tube well Status					Total
		Hand Pump	Tube well	Canal	Others	Abandoned	Functional	Temp.Failed	Non Sampled	Test Bore	
1	**Amritsar**	4	512	0	0	5	467	18	0	0	**516**
2	**Barnala**	0	131	3	0	39	81	0	0	0	**134**
3	**Bathinda**	0	66	185	0	17	220	13	0	1	**251**
4	**Faridkot**	0	19	87	0	8	97	0	0	0	**106**
5	**Fatehgarh Sahib**	26	244	0	0	13	243	11	0	0	**270**
6	**Firozpur**	15	422	122	0	86	459	14	0	0	**559**
7	**Gurudashpur**	7	482	0	10	17	470	12	0	0	**499**
8	**Hosiarpur**	106	544	0	17	71	562	4	0	0	**667**
9	**Jalandhar**	11	376	0	0	8	375	4	0	0	**387**
10	**Kapurthala**	231	340	0	0	40	520	11	0	0	**571**
11	**Ludhiana**	34	471	0	0	56	439	10	0	0	**505**
12	**Mansa**	0	23	116	0	1	136	2	0	0	**139**
13	**Moga**	5	310	10	0	51	152	0	0	0	**325**
14	**Patiala**	1	601	0	0	75	493	1	0	0	**602**
15	**Rupnagar**	28	266	12	1	62	234	3	0	0	**307**
16	**SAS Nagar**	2	355	0	1	59	289	3	0	0	**358**
17	**SBS Nagar**	9	218	0	7	28	189	6	1	0	**234**
18	**Sangrur**	0	369	15	0	90	261	3	0	0	**384**
19	**Shri Muktsar**	0	2	182	0	5	179	0	0	0	**184**
20	**Taran Tarn**	22	283	2	0	21	266	20	0	0	**304**
	Total	**501**	**6034**	**734**	**36**	**752**	**6132**	**135**	**1**	**1**	**7305**