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Improving Healthcare Management System using Efficient Geo-Spatial Data Analysis – An Approach using QGIS

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Abstract: ***Chronic medical diseases take a huge toll on lives of growing people and are a major contributor to the rising costs in healthcare. Information Technology (IT) can be used greatly to bring improvement in healthcare domain. A further dimension proposed in improving public management is to add non-spatial and spatial data to create a management system that provide support and logical approach to manage public health using Geographic Information System (GIS). The knowledge of medical geographic information systems (Medical GIS) has become very important in having larger picture and understanding of public health. A GIS can be used as a source of data repository. Electronic health records of patients will be served as input to GIS, on which knowledge engines and study systems will operate to create support systems for taking appropriate decisions by professionals of public health domain. Electronic systems can be additionally embedded to generate and communicate results, alert and alarm public automatically. The proposed analytical tool in the current study focuses on introspection of GIS in public health, provide awareness and take responsible decisions related to geographical, demographical and socio-economical factors linked to epidemics, diseases and health of public. The proposed knowledge system is capable of predicting many other concerned consequences like disease spread, requirement of clinicians, equipment and medicines requirements etc. to help sustained management of resources. Such proposed systems hence if replicated in developing nations like India will help eliminating rise of epidemics by making government and public both vigilant.***

Keywords: Healthcare Management System, Geospatial Analysis, Geographic Information System, Health and QGIS.

Nomenclature:
CRS: Coordinate Reference System
CSV: Comma Separated Value
FOSS: Free and Open Source Software
GIS: Geographic Information System
GPL: General Public License
GPS: Global Positioning System
SMS: Short Message Service
QGIS: Quantum Geographic Information System
WGS: World Geodetic System

1. Introduction

Every year, known and unknown epidemics and diseases spread through the world affecting all age groups and prevailing in different regions, making its analysis tougher and complicated[1]. In, Recent years health has been both an economic as well as social concern for the governments mainly of the developing nations having high mortality rates, lesser life expectancy and uncontrolled spread of deadly diseases[2]. Therefore, it is the call of time to improve the healthcare system especially analysis of patients data efficiently to expose out some unfound patterns in disease spreads and reframe the plan of action to improve the health care system prevailing in the nation. There is requirement to follow an integrated approach based on visual geospatial mapping, data analysis and corresponding report generation to improvise on the current healthcare system.

QGIS is a simple yet powerful open source GIS tool that allows users to create and design their own geospatial maps with custom features. Currently, GIS is being used in many fields because of its strong capability in large data management and information display and patterns discovery, which makes data visualizations easier [3] [4]. QGIS being a completely open source project means that the source code is free and openly distributed for non – commercial purposes (under GPL license). The code can be modified and/or be extended for the purpose of benefiting the researchers, academics and other end users. Moreover, the Free and Open Source Software reduces the basic cost of project drastically as proprietary software's in the software market are very expensive. In the recent past there has been researches using GIS/QGIS like Vehicle tracking using QGIS [5], natural hazard prevention using QGIS [6]. The current study proposes use of QGIS to build plug-ins across multiple platforms for visual geospatial mapping, analysis and generate efficient strategies for improving the healthcare system in a nation.

The discipline of GIS provides a solid framework for increasing capability to monitor diseases and fetch their root causes[8]. The integration of GIS into health industry has been long beginning with disease maps evolving to digital

maps and still continues to evolve. Such intervention will enable government and other concerned authorities to gather insight about diseases such as Cholera and Bronchitis (as studied in current research), thereby improving the knowledge of health issues in developing nations like India where lack of planning and improper implementation of decisions has always been government's liability. Unhealthy practices such as tobacco intake, smoking and health problems such as high blood pressure and obesity and both unhealthy and healthy behavior tend to cluster in populations[15]. The GIS spatial and visualization capability to integrate multiple datasets and assess multiple disease causing factors simultaneously, enable health professionals to identify interdependence among environmental, behavioral and socioeconomic factors and suggest strategies for their prevention. GIS is best designed to assist public health professionals to respond to the challenge of disease and epidemics in their localities.

2. Problem Statement: Public Health Delivery

In India, as per statistics it is observed that at least a quarter of strategies made by the government for the welfare of the citizens ends even before reaching the implementation phase. This is because either the adopted action plan is a debaco, due to inefficient planning or the time taken for finding solution to a problem is so elaborated and long that before reaching to the public, either the problem severity crosses the threshold and becomes uncontrollable or the sufferers i.e. inhabitants finds an alternative local solution to the problem before the government support is provided. In India, the healthcare facilities is majorly provided and managed by government where majority of population tries to find assistance when their health condition begins to deteriorates which is wrong. Therefore we see, public hospitals are always flooded with people. The planning done by government in response to spread of epidemic is based on data collected from various government healthcare organizations. The data collected then undergoes sorting, collaboration and processing to generate report which is tedious and time consuming and hence not suitable for quick response to any epidemic. Most of government's existing health data are paper based as a medium for recording transactions which have two serious disadvantages:

1) Dearth information can be recorded leading to recording of austere essentials.
2) Data is less amendable to automatic electronic processing medium, thus manual compiling reports out of the recorded transactions is tedious, erroneous and requires large number of iterations[1]. Thus minimal and insufficient reports are generated as shown in Fig. 1 which shows the records present with a group of private medical healthcare groups in India, collected over a period of 1 month i.e. from 1st June'2015 to 30th June'2015. These reports with their erroneous statistics then become part of process for study of current scenarios and lack capability to undergo any planning and decision making in short span of time.

S no.	Type Of Patients	Male	Female	Child	Total
1	New	2164	1910	146	4220
2	Old	2101	2609	130	4840
	Total	4265	4519	276	9060

* New patients = The pateints registered on the same day as the day or Report Generation
** Old patients = The pateints registered till the day before the day of Report Generation
*** Child = Any individual below the age of 11 as on the date entered

Figure 1: Monthly Medical Reports in Majority Hospitals

Another problem being faced is the incapability of government in tracing the growth of the epidemics, their causal factors, the maximum affected areas and the potential areas under threat. Even after technical developments in Healthcare Department, there is no visualization to problem adopted, everything is predicted on basic assumptions such as ~~t~~his may happen", "this could be solution", ~~t~~he problem may rise here too" and so on without any substantial proof of what is being predicted and what factors has lead to this prediction. Other problems being faced in provision of quality healthcare facilities are shortage of doctors, paramedics, non-working equipments, shortage of medicines, over burdened and under utilized departments, lack of skilled professionals.

3. Methodology of Proposed Knowledge System

The current research proposes knowledge system which aims at providing better healthcare management for public by integrating visualization to public health domain with the help of QGIS. The growing uses of GIS are contributing to unmatched inspection of the environment and increased understanding of known and suspected environmental disease relationships with pubic health[9]. The proposed solution aims to beat the current rising problem in health care domain by automatically and accurately alerting the government about regions which are at potential threat of an epidemic. The proposed knowledge system focuses on visual geospatial mapping of heath records present with concerned authorities instead of paper studying which will enable better functionality of government in field of public health management and disease prevention. GIS is making indisputable contributions in public health at pragmatic level. Applied questions such as `Where is the best place for the new medical camp?', `Where is mortality rate highest?', `What are the causes of diseases?' are inherently spatial and quickly addressable using proposed GIS knowledge system[11]. By mapping cases of diseases in geographical space domain, both national and local governments can easily locate the distribution and spread of disease across regions, optimize their planning of intervention locations and monitor their effectiveness. Thus giving them more time for physical implementation of the solution rather than wasting time evolving a strategy. This will even eradicate the manual analysis done to draft a plan of action which is both tedious and erogenous at the same time. Important features of proposed knowledge system in public health management are:

1) Identification of prevailing and notifiable conditions of living.
2) Identification of spatial patterns in spread of disease.
3) Identification of disease causing factors and their relationship with environmental conditions.
4) Initiating generation of daily reports for analysis for communicating with concerned departments to evolve strategies for pre-planning.
5) Diverting attention towards appropriate medical attention and medication, thereby helping government invest their funds in right direction.
6) Support decision making to take appropriate steps to reduce and prevent distribution of disease in adjoining localities.

Therefore with introduction proposed solution, the government workflow tend to more transparent, effective and accountable. By using workflow in right direction and sharing data with the civil societies and give the authorities the power to plan strategies to overcome problems quickly and put them in action. The current study is focused on study of spread and rise of two diseases namely Cholera and Bronchitis.

4. Implementation

The proposed solution is accustomed to be operated on QGIS i.e. Quantum geographic system which is a cross-platform free and open source desktop geographic information systems (GIS) application that provides data viewing, editing, and analysis capabilities by providing wide visualisation[14]. The greatest strength of GIS is that its product is a picture[16]. It enables health professionals to indicate clearly, quickly and convincingly the outcomes of analysis of complex situation.

A. Mapping of Health Records

Firstly, map heath record details as a map on QGIS. With advancement in Information and Communication Technology tools(ICT), one can record patient data electronically. Thus patient data is collected from various organizations located in various different locations for broader analysis with attributes such as area, time, age, disease, sex type etc.

Generally this information is already present with the concerned government heath departments like the Ministry of Health and Family Welfare, New Delhi and other organizations/NGO's who periodically conduct surveys on prevailing heath conditions of different localities. This file is converted into a valid .csv format along with their accurate coordinates of the location on the basis of which spatial mapping is done and then loaded as a delimited text layer (A simple text file loaded in QGIS to visualize and analyze data spatially), where QGIS automatically maps the location record present in file along with their associated attributes [7][14] and present a complete geospatial map with all details mapped accurately along with their attributes which are inserted in form of attribute table

Whereas on the other site, i.e. for places where these pre-compiled data are not available there due to unavailability of broadband connection, the data can be sent through SMS with all required fields required to be filled in attribute table and send over to web server. Once the web server receives the SMS it can extract the location details from where it received the SMS using it's cellular location[1] and map on QGIS.

B. Implementation using Case Study (Change Heading)

Basic patient information in most of the healthcare organizations, specially in the rural regions, is collected on paper[1,2]. Due to this, the reporting authorities can only work on limited datasets (Monthly report (Fig. 1) and Morbidity report (Fig. 2)) rather than the complete datasets i.e. the complete patient information they have which can help them to analyse the situation in more depths and find unseen patterns in spread of that disease which can help them to take preventive measures to control the spread of disease to further regions.(place this para somewhere else maybe in introduction part as point 3)

Step1: Health records are collected from multiple computerized patient registration systems of healthcare organizations and is electronically sent to a central repository. QGIS is the central repository in current study where the analysis on data is carried out. The census data, along with Aadhaar number (UID number), can be used for geo-locating and referencing every resident[1]. This data can easily be stored in the QGIS data repository. QGIS has an inbuilt feature of storing and mapping data simultaneously from a well formatted CSV file having the co-ordinates of the location to be mapped corresponding to that record.

MORBIDITY REPORT (OPD)

From : 01 June 2015 To: 30 June 2015

S No.	ICD10	Diseases and related health problems	Male	Female	Child	Total
1	N/A	N/A	1337	1124	85	2546
2	J00.-	Acute nasopharyngitis (common cold)	1	1	0	2
3	C61.-	Malignant neoplasm of prostate	1	0	0	1
4	M13.-	Other arthritis	5	1	0	6
5	I10.-	Essentail (primary) hypertension	149	139	1	289
6	A58.-	Granuloma inguinale	1	0	0	1
7	R50.-	Fever of unknown origin	26	12	2	40
8	A03.-	Shigellosis	0	1	0	1
9	C50.-	Malignant neoplasm of breast	0	3	0	3
10	C23.-	Malignant neoplasm of gallbladder	1	0	0	1
11	E10.-	Insulin-dependent diebetes mellitus	1	5	0	6
12	K29.-	Gastiritis and duodenitis	0	3	1	4
13	G47.-	Sleep disorders	68	110	12	190
14	N61.-	Inflammatory disorders of breast	1	4	0	5
15	D10.-	Benign neoplasm of mouth and pharynx	1	0	0	1
16	L02.-	Cutaneous abscess, fufuncle, and carbuncle	2	1	0	3
17	E11.-	Noninsulin- dependent diabetes mellitus	44	63	0	107
18	C18.-	Malignant neoplasm of colon	0	1	0	1

Figure 2: Morbidity Report –with limited information

Step 2(Data Analysis and Conclusion Drawing): Also, once the mapping is done on the QGIS, the visualisation capability of QGIS is exploited to determine the reason for spread of the disease by seeing the contiguous areas and the environmental conditions of that place. Once the areas of cause of disease have been identified the by geospatial data analysis in first phase, the focus shifts to the identifying and best delivery of resources to eradicate the problem that is conclusion drawing phase[12].

Case Study-1

Step 2 (a) Data Analysis:
Considering the case of cholera, Figure No. 5 prompts that the majority of cases reported are the ones laying adjacent or adjoining water bodies – generally polluted water bodies. This intelligence based knowledge model by correlation of health/patient record with QGIS helps to identify root causes to prevailing environmental conditions of the area. After the first step of data analysis, the next of conclusion drawing is performed.

Step 2 (b) Conclusion Drawing:
From the above analysis, the conclusion drawn are the public health officials can initiate quick plans such as requesting water and sewerage department to check the sewerage in the diseased prone areas. A medical camp could be setup to treat the affected people. The further processing conclude that the camp should be further well adequately staffed with doctors, paramedics, medicines, equipment to treat people with cholera based on number of reported cases.

Case Study-2
Step 2 (a) Data Analysis:
In the Fig. 5, an unclosed sewer can be located adjacent to the plot of cholera cases (orange) reported. This is well indication of relationship between open sewer and cholera cases reported.
Step 2 (b) Conclusion Drawing:
The above analysis is useful in concluding that sewer might have contaminated the ground water or fresh water which is use by the residents of that area resulting in origin of disease spread.

Case Study-3
Step2(a) Data Analysis: Similarly, cases of bronchitis have been reported road side in Fig. 5 by analysis of mapped data on QGIS.
Step2(b) Conclusion Drawing: This is again useful in concluding that, the particular road may be a busy road suffering lot of traffic jams and congestions which have aggravated inhaling and exhaling problem, thereby leading to asthma among those living along the road.

Step 3 (Report Generation): The decisions made will be then well documented to be communicated to concerned healthcare organizations. Birds eye view reports will be generated for other organizations to work efficiently and effectively. Thus, The proposed solutions will also improve the inter-departmental communication between government organizations ensuring effective and quick knowledge base exchange leading to draft of effective action plan and collaborative focus on its implementation.

Case Study 1 and Case Study 2:
In Fig. 6, one can conclude that the number of cases of Cholera reported have increased. Also one can observe from report study and conclude, the number of cholera cases reported are greater for low income groups. Daily reports of such kinds are therefore helpful for concerned officials with easy understanding of data and consequently helpful in taking decisions and take required actions. For the cholera case given in Fig. 5, public health officials by studying the report generated using the proposed knowledge model can take required actions such as request for clean water. Sewerage department can initiate sewer checks at places where cases have been reported and sewers are concentrated. Similarly, a medical camp could be setup to treat the affected patients. This will further require the camps to be adequately

appointed with doctors, paramedics, medicine and other required equipment to treat cholera affected patients.

Case Study 3:
For the cases of Bronchitis reported as in Fig. 6, the public health officials after analyzing the reports could take decisions such as asking the traffic control officials to redirect traffic to reduce congestion on the roads under consideration, appointing traffic policemen at junction to manage traffic. The officials could undertake road improvement projects such as widening of road to reduce congestion.

Step 4: This intelligence will be useful in predicting future environmental conditions such as spread of diseases, likelihood of occurrence of same diseases and preemptive action to be taken to prevent it's recurrences[13]. One can gather information about patient's place of dwelling, it's environment and other non-spatial information such as type of dwelling, sanitary and livelihood conditions, income and other social economic information which are helpful along with patients data to enable public health management professionals to take quick, relevant decisions in treatment, prevention and future eradication of diseases. The proposed knowledge management system is certainly preferable over a stand alone GIS.

C. Use of ICT and GIS can be at various levels of involvement/Results
Implementation within GIS of spatial tools for analysis appropriate for collected data over a locality will multiply the use of GIS beyond easy GIS operations in public health domain [10].

1) Level 1 : Basic data collection and report generation using IT tools like a mobile based application which can take input in the desired form helps in following a uniform protocol of patients data collection. Moreover such devices have inbuilt GPS systems so that the co-ordinates of the place where the data is being collected is automatically saved and so can be easily mapped on a QGIS system.
2) Level 2 : Patient data collected at the source using live applications as in Level1 is used for internal use of the organization and management.
3) Level 3 : Data analysis and decision support system to regulate the spread of diseases/epidemics , where the data is communicated, with little or no latency, to other organizations for collation and analysis. The analysis is used for taking decisions. In properly designed processes, the analysis can provide real time scenarios for decision makers.

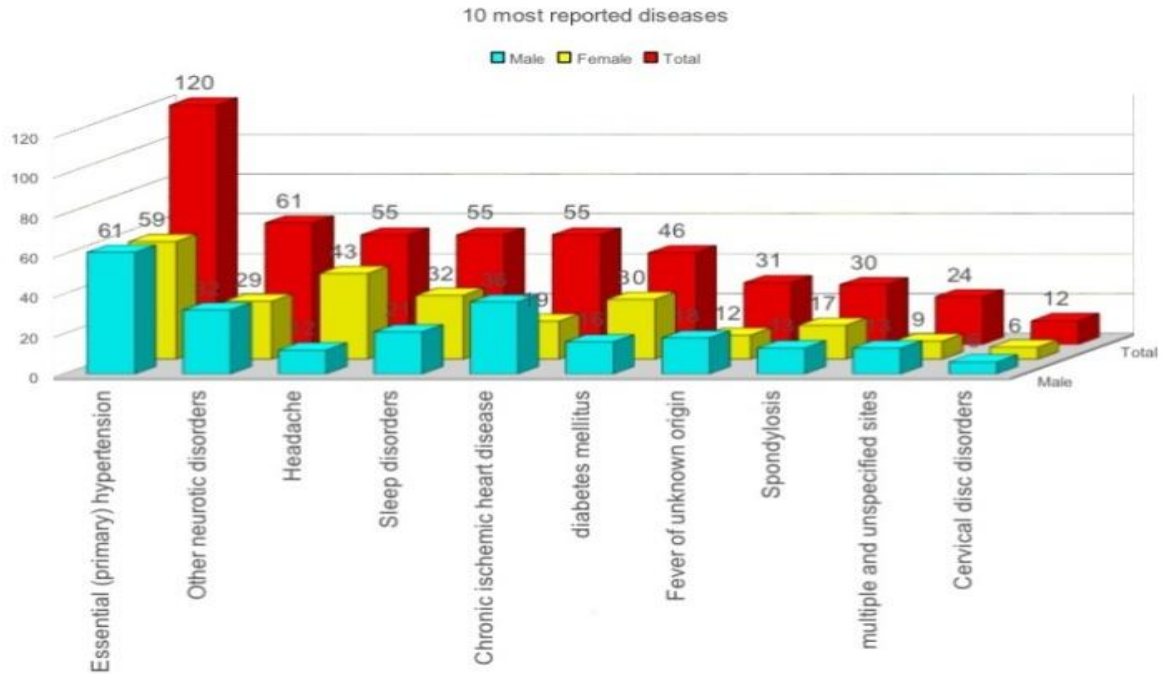

Figure 4: Different diseases reported in the selected locality for study

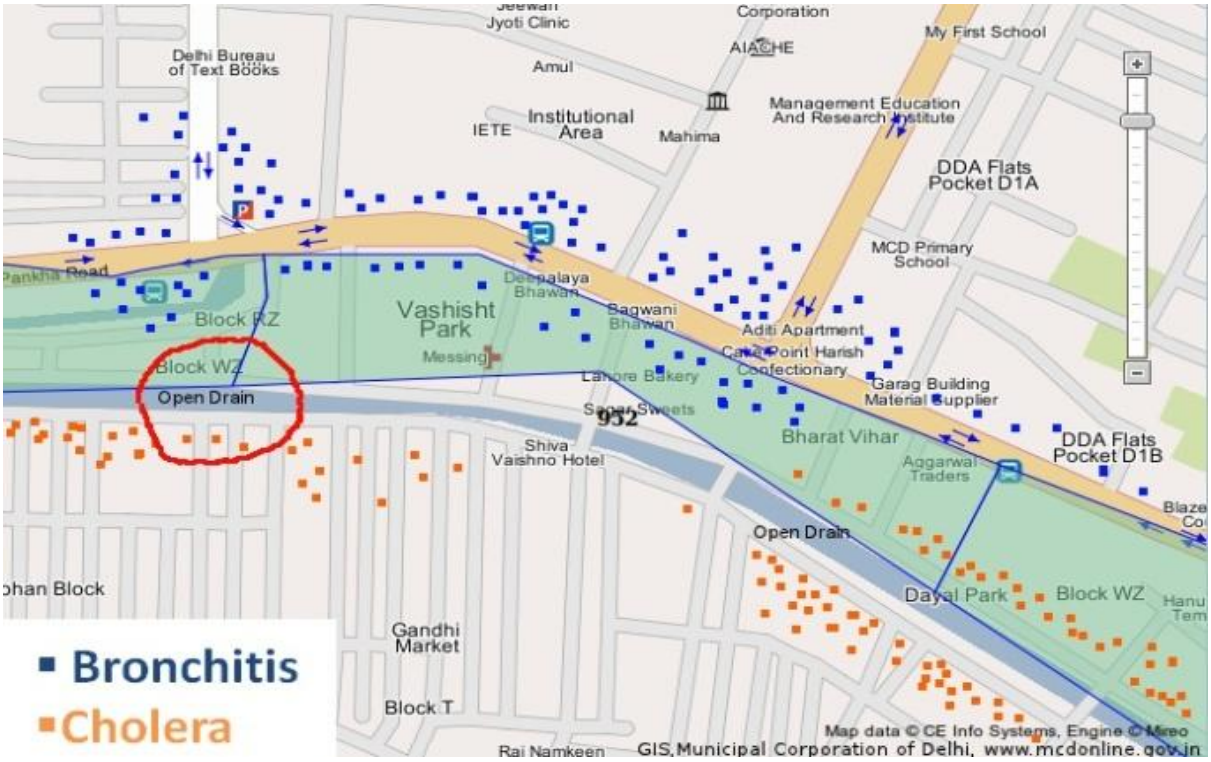

Figure 5: Geospatial Visualization of the Reported Cases

Level 4: The proposed system is helpful in generating intelligent analytical reports that will help the management to take two kinds of action to promote public health which are:

1) ***Constructive Models*:** In case of cholera reported cases, the analysis concluded the venerable factors are low income groups, conditions like scarcity of water, low literacy rate, location propinquity to sewers, inadequate amount of fresh water etc. These parameters could be further studied to locate localities prone to similar vulnerabilities stated above.
2) ***Precautionary Actions*:** This involves planning for eradicating the cause of rise of diseases such as closure and covering of sewers, repairing of sewer walls, supplying quality water from municipality, engaging residents to inculcate in practices such as rain water harvesting to increase their water table levels and spreading awareness about the disease to resident.

5. Results

The Count

The count of patients and types of disease as shown in Fig 4 in a locality can be helpful in deciding in creating infrastructure of the health centers and medical camps, its staffing and medicine stock etc. If the data can be collected on daily basis or better, the resource utilization can be optimal. Judicious use of labor can be helpful in improving quality of medical services provided to the people and thereby help in reducing cost of operations. Inventory of medicines can also be appropriately managed to reduce wastage due to expiry and, if required, unutilized stock of medicines can be transferred to other centers of management.

Disease Span Models

Can be exploited to study the risk of spread of diseases. A healthy and smart population is more productive, more intelligent and contributes more to higher GDP.

Investment

Planning and operations monitoring reduce investment. Data can be used to design an optimal and appropriate logistical system that carry out resource management planning to help reduce inventory of medicines and other items and their further wastage due to expiry.

6. Conclusion and Future Scope

Usability of GIS based decision support system for promoting public health can greatly increase the quality of public health in current times of limited resources and increasing demands. The present scenario of IT advancement in India and it's availability of labor is sufficient enough to start using and promoting GIS at a much wider scale. It is possible to use free and open source software to achieve this task. The proposed system can reduce cost of operations vastly and can help prevent rise of diseases in India. The usability of proposed system can be extended to encompass:

1) Targeted regions and communities with required health education and awareness.
2) Evaluating potential causal factors contributing to rise of disease.
3) Generate reports with indepth analysis (daily reports).helping the government to put in their efforts in the right direction

References

[1] Patel, Vikram, and Martin Prince. "Ageing and mental health in a developing country: who cares? Qualitative studies from Goa, India." *Psychological medicine* 31.01 (2001): 29-38.
[2] Ahmad, Omar B., Alan D. Lopez, and Mie Inoue. "The decline in child mortality: a reappraisal." *Bulletin of the World Health Organization* 78 (2000): 1175-1191.
[3] Daniel A. Keim, ―Visual Exploration of Large Data Sets*", Communications of the ACM* August 2001/Vol. 44, No. 8
[4] Daniel A. Keim."Visual Exploration of Large Telecommunication Data Sets. Visualization Blackboard", *IEEE Computer Graphics and Applications*, May 1999.
[5] Adela B. Crisanin, Dejan D. Rancic, ―Architecture of Integrated GIS and GPS for Vehicle Tracking System", *1st Logistics International Congress*, Serbia, November 2013.
[6] Ishwar Das, Kapil Oberai, Partha Sarathi Roay, ―Database Organization in a web enabled free and open source software environment for spatio – temporal Landslide modeling", *XXII ISPRS Congress*, 25 August – 01 September 2012, Melbourne, Australia
[7] Importing .csv file in QGIS, [Online] *http://www.qgistutorials.com/en/docs/importing_spreadsheets_csv.html*
[8] http://www.qgis.org/en/site/
[9] Croner, Charles M., Jonathan Sperling, and Frederick R. Broome. "Geographic information systems (GIS): new perspectives in understanding human health and environmental relationships." Statistics in Medicine 15.18 (1996): 1961-1977.
[10] Chung, Kyusuk, Duck-Hye Yang, and Ralph Bell. "Health and GIS: toward spatial statistical analyses." *Journal of Medical Systems* 28.4 (2004): 349-360.
[11] Jacquez, Geoffrey M. "Spatial analysis in epidemiology: Nascent science or a failure of GIS?." *Journal of Geographical Systems* 2.1 (2000): 91-97.
[12] Haining, Robert. "Designing a health needs GIS with spatial analysis capability." *Spatial Analytical Perspectives on GIS* (1996): 53-65.
[13] McLafferty, Sara L. "GIS and health care." *Annual review of public health* 24.1 (2003): 25-42.
[14] Vishal Pandey, Tanveen Singh Bharaj,Vinay Kumar Saini, "Strategy for Slum Reallocation in QGIS", Proceedings of the 9th INDIACom; INDIACom-2015 2nd International Conference on ―Computing for Sustainable Global Development", 11th – 13th March, 2015 Bharati Vidyapeeth's Institute of Computer Applications and Management (BVICAM), New Delhi (INDIA)
[15] Musa, G. J., Chiang, P.-H., Sylk, T., Bavley, R., Keating, W., Lakew, B., … Hoven, C. W. (2013). Use of GIS Mapping as a Public Health Tool—From Cholera to Cancer. *Health Services Insights*, *6*, 111–116. http://doi.org/10.4137/HSI.S10471
[16] https://www.health.qld.gov.au/epidemiology/documents/gis-ph-spatial-app.pdf