'GeoSlum[1]' - Empowering local authorities for slum improvement through an opensource Geospatial Platform

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Abstract

Urbanization has emerged as a key policy and governance challenge in India in recent years. Cities and towns contribute to more than 60 percent of GDP. While urbanization can be an engine of economic development and inclusion, unless managed properly, it can create serious socio-economic consequences which would potentially negate the benefits of urbanization. With the rapid growth of urban population, expected to occur due to the underlying structural transformation of the Indian economy, and as India moves to double-digit growth, the backlog, current and future needs of urbanization need to be addressed comprehensively. There is an urgent need to address the lack of consistent and coherent urban development policy, faulty and improper urban planning, coupled with poor implementation and regulation overload in India's cities (MoHUPA G. , 2011).

Some prominent critical issues in Indian urban centers at present include a) lack of a comprehensive planning approach, leading to haphazard growth and proliferation of slums around industrial locations and peri-urban areas, b) rigid planning processes c) lack of plan-finance linkage d) lack of institutional clarity and adequacy and d) lack of capacity and enabling platforms like GIS enabled decision making support systems. (MoHUPA G. , 2011)

In 2001 slum population in India was 52.3 million, increased to 65.4 million in 2011[2] which is a 25% increase. 38% of the slum population is located in large cities. Progressive efforts have been made by the Government to improve the living conditions in slums since independence like the Low Income Housing Scheme (1954), Environmental Improvement of Urban Slums (1954), Indira Awas Yojana (1985), Urban Basic Services for the Poor (UBSP, 1990-01), National Slum Development Program (NSDP, 1996), JNNURM (2005)[3], Rajiv Awas Yojna (RAY, 2009) and many others in between as well. A recent report by PWC and 'save the children' demonstrates that the major urban development schemes in India do not adequately take into account issues related to children's health, education, growth, safety and participation. The focus may need to be on smaller urban centres where most of the urban population is concentrated (68% of India's urban population lives not in metros but in towns with a population of less than 100,0008). It is largely believed that any successful reaping of the demographic dividend will require focus on the

[1] This platform in its original form is called 'GeoMap'. However, for the purpose of this paper, it has been renamed as 'GeoSlum' so as to enable reader connect with the context of slums.
[2] India-Slum data (PPT) from ORGI website, Primary Census Abstract for Slum Population, Directorate of Census Operations
[3] Government of India, Fifth year plan since 1952

following key areas: a) Urban governance, b) Health, c) Water and sanitation, d) Education, e) Child protection and f) Urban resilience (PwC, 2015)

The quality of planning and decision making for slum improvement by Government authorities can be substantially improved by using well managed spatial and socio-economic information of the slums. This study is an attempt to create an innovative system for managing, analyzing and publishing city's slum information (spatial and non-spatial) on a WebGIS platform so as to provide spatial insights on basic infrastructure and other services and facilities, including the state of environmental condition of slums enabling empowerment of local Government authorities in planning and executing the slum improvement plans. This platform has been developed using open source technology. It has been made simple enough to be used by professionals working in Government departments, without any dependency on GIS experts. No prior knowledge of Geospatial Technology is required to use this platform. An easy user interface allows slum community representatives regularly update the stored information. This platform can also be used as 'community mapping' platform for needs and service assessment, thereby enabling slum residents to use the information and exert their rights. With its scalable web-based architecture it can be used by government officers and slum representatives of a city and the data and analysis can be made accessible anywhere across the country or the world.

Introduction

Slums are a clear manifestation of a poorly planned and managed urban sector and, in particular, a malfunctioning housing sector. Each day an additional 120,000 people are added to the populations of Asian cities, requiring the construction of at least 20,000 new dwellings and supporting infrastructure. In Latin America and the Caribbean current housing needs are estimated at between 42 million and 52 million dwellings, respectively. Estimates concerning total housing needs in Africa have been set at around 4 million units per year with over 60 per cent of the demand required to accommodate urban residents. [4]

Fifty-five million new slum dwellers have been added to the global population since 2000. Sub-Saharan Africa has a slum population of 199.5 million, South Asia 190.7 million, East Asia 189.6 million, Latin America and the Caribbean 110.7 million, Southeast Asia 88.9 million, West Asia 35 million and North Africa 11.8 million.

Improving the living conditions of slum dwellers has been an integral part of the global development agenda. An important target of the seventh Millennium Development Goal had been to 'achieve a significant improvement in the lives of at least 100 million slum dwellers by 2020'. The proposed eleventh Sustainable Development Goal also calls for making 'cities and human settlements inclusive, safe, resilient and sustainable', where the first target of the goal aims to

[4] UN Habitat. 2016, Housing & Slum upgrading, http://unhabitat.org/urban-themes/housing-slum-upgrading/

ensure 'access for all to adequate, safe and affordable housing and basic services, and upgrade slums by 2030'[5]

Governments often contribute to slum growth by failing to provide for the needs of the poor and incorporating them in city planning initiatives or development plans. Some governments lack the capacity to respond or lack the methods to deal with the deteriorating conditions of the slums.

Formalizing informal settlements and redeveloping them to become sustainable communities was found to be one of the prominent solutions towards dealing with the sprouting of slums and this process is called slum upgrading. However, experience accumulated over the last few decades suggests that in-situ slum upgrading is more effective than resettlement of slum dwellers and should be the norm in most slum-upgrading projects and programmes (Habitat, 2003). The PMAY (Pradhan Mantri Awas Yojna) Housing for All Plan of Action (HFAPoA) also considers in-situ (Pradhan Mantri Awas Yojana , 2015) as one of the ways to build houses for urban poor. Rajiv Awas Yojana (RAY) launched in Feb 2014 (Press Information Bureau, MoHUPA, 2014) was an Indian government program that attempted to help slum dwellers gain appropriate housing and address the processes by which slums are created and reproduced. It was introduced by the Indian Government's Ministry of Housing and urban poverty Alleviation.

Improving the living conditions of slum dwellers calls for both substantial and comprehensive policy design[6], but it is difficult in the absence of proper understanding of the characteristics of slums and its inhabitants. Some slums in certain cities are more old, organized, and have reached a saturation limit; whereas, the slums in other cities are still growing. There are also differences in governmental approaches to slum redevelopments (owing to property rights issue) or interventions through welfare schemes across cities. In certain cases, slums have been removed and relocated to resettlement colonies, whereas in other cases existing slums are redeveloped in the same place. In the development economics literature, a number of studies focus on slums within cities to explain rapid urbanization and its ills[7]. However, there is, unfortunately, dearth of comparative studies on slums across cities[8]. A comparative study may be useful in pointing out the commonalities and the differences between slums across as well as within the cities, which may also help policy makers to design more targeted and effective policy options. In most of the cases the information on a) characteristics of slums and its inhabitants, b) household level

[5] A/RES/70/1 - Transforming our world: the 2030 Agenda for Sustainable Development, www.sustainabledevelopment.un.org.

[6] Marx, Stiker and Suri (2014) argue that there has not been enough theoretical and empirical economic research about how to address various public policy challenges posed by slums in low-income countries

[7] Swaminathan (1995) considered poverty and deprivation among pavement dwellers and households living in a designated slum area and concluded that a comprehensive approach considering housing and living conditions looking beyond income is required; Kumar and Aggarwal (2003) studied the patterns of consumption and poverty in Delhi slums; Mitra (2005) examined the standard of living of Delhi's slum population and analyzed the determinants of standard of living; Banerjee, Pande and Walton (2012) studied deprivation, preferences and political engagement among the urban poor in Delhi; Mallik (2014) study gender inequality in literacy and school education in slums of Kolkata

[8] Kundu and Sarangi (2007) studied the migration pattern and employment status in urban centers using the Indian NSS 55th round dataset, but did not conduct any comparative study across slums; Hina (2013) studied living conditions across two different slums but both within Delhi.

infrastructure and economic condition, c) household level services and facilities, d) growth of slums over period of time, e) comparative information on slums of various locations within city and between cities are inaccessible to community and stake holders in general and rarely updated.

The living conditions in slums can be potentially improved if the above information is accessible, usable and regularly updated. This study is an attempt to explore the mechanisms and instrumentality of such a possibility, with the intention of developing a civil society-government interface. We may like to re-visit the product interface after some time so as to understand it's utility in the context of slum improvement. The focus of this paper is to highlight the underlying steps in developing such an interface.

Challenge

The quality of planning and decision making in the slum upgrading initiative can be sustainably improved by well managed processes of spatial and socio-economic data collection (Togarepl, 2015). 'Slum upgrading' is the practice of alleviating poor living standards of slum households by providing water supply, sanitation, road access, housing upgrades and other basic urban services, as well as securing tenure to the settlers. Informal areas are continuously improved, formalized and incorporated into the cities. The processes include providing slum dwellers with the social, economic, legal, institutional and community services available to other citizens in the cities (Materu, 2001) (Rema, 2011).

Under RAY, Guidelines were developed for Preparation of Slum Free City Plan of Action (MoHUPA, Guidelines for Preparation of Slum Free City Plan of Action, 2013) that included mapping of slums a major component (MoHUPA, Guidelines for Preparation of Slum Free City Plan of Action, 2013) in section 2.1.2 of the Guidelines. Preparation of Georeferenced base maps for planning area, Demarcation of slum boundaries, validating list with satellite imagery and Identifying and marking of Vacant lands on the GIS base map were the major components. GIS – MIS integration was proposed to be at Slum settlement level for linking the surveyed information of socio-economic, tenability status, land tenure, land ownership and land value of the slums, but this activity was restrained only till capturing of the information. It lacks a coherent architecture where the captured information is analyzed, presented, updated in a way that can be used by Government officials and slum community representatives.

The information collected at settlement level for slums through satellite imagery and ground surveys is not sufficient as it is not able to provide information of households in slum settlements. For slum improvement the information like infrastructure facilities at slum (water, sewage, power, etc), services (health, education, security, fire, etc), socio-economic profile (BPL, family size, income, etc) and building (typology, construction status, health, etc) are the important indicators for in-situ development or even for resettlement.

This information for 162 slum locations in various towns of India were collected through Total station survey as of 1st April 2016 (MoHUPA, Progress Report, 2016). The format of this dataset is CAD and normally gets incorporated in the reports and documents sometimes in the form of maps and sometimes in the form of spreadsheets and rarely in the perspective of GIS.

(Abbott, 2003) notes that "GIS should not be used only as a technical tool to underpin physical development; it should be viewed as a tool that liberates local authorities, communities and professionals, and allowing interaction between the spatial, physical elements on one hand, and the social and economic opportunities on the other, in a three-dimensional virtual environment". (Abbott, 2003) mentioned that "Upgrading large-scale informal settlements is most efficient through applying spatial information technologies.

Slum upgrading has to mainly focus on the social and economic development of the community and GIS must support this process. The ability to represent informal settlements spatially, through the medium of a GIS, is an important component of the upgrading process. Furthermore, the visual representation of spatial and attribute data delivers the framework for the application of geospatial information management systems in the slum upgrading process. Therefore, the use of GIS in informal settlements development is now greater than before all over the world (Zeilhofera, 2008). Implementing a GIS approach in management and analysis of spatial and enumeration data is the key towards sustainable slum upgrading process. The use of GIS provides the platform to integrate spatial and socio-economic data, visual representation of data, efficient management of geospatial information, tools to analyze and aid in decision making (Bassam Saleh, Apr 2006 Volume 6, Issue 2). Of late there has been a growing call for the use of information collected from the actual residents of the settlements for analysis prior to the upgrading of the settlements (Bosiu Lefulebe, 2014).

Approach

To empower city officials with information about the slum with the facility to analyze and take decision, an innovative approach was adopted to use Geospatial platform to manage, analyze, retrieve, update and present the slum information at city and household levels. In this regard, two cities viz. Raipur (capital of Chattisgarh, India) and Tirupati (Temple town of Andhra Pradesh, India) were taken as cases[9].

Under Rajiv Awas Yojana (RAY) (Press Information Bureau, MoHUPA, 2014) GIZ has instrumented the survey of selected slum settlements of Raipur and Tirupati cities of India. The data collected through survey were represented in the form of maps and tables and a report was submitted to the municipal corporation. The data in the form of report brings constraints like its re-usability, understanding, updates, analysis, scalability and sharing. The huge spatial and non-spatial dataset used for creating maps using CAD or GIS platforms become inaccessible the moment the consultant completes their work.

To address these constraints where immense amount of information and spatial dataset is to be dealt with, technology can play a vital role in finding out solutions for slum improvements.

[9] GIZ was the technical partner for GoI in its implementation of RAY. Through this exercise, surveys were administered and information at slum household level was generated.

At present, from the technology perspective, government officials use 'Google Earth' for identifying the location of slums. The other proprietary software platforms are cost intensive with a high learning curve and with a need for a dedicated technical resource to use it.

There was an obvious need for a low cost, data intensive, feature rich, user friendly, web based platform that has a minimum learning curve. Also a platform that can be used by any government officer and slum settlement representative without any location dependency for the slum upgrading process using a participatory approach.

Also, the improvement plans for slums settlements cannot be dealt in silo. The slums settlements should be seen with a holistic approach of looking at all the slums in a city with respect to each other for prioritization of funds and resources.

For city level information of slums, sewage network, water network, roads and master plan, the details were collected from the studies and surveys carried out under 'City Sanitation Plan' (CSP) scheme of India (GIZ Support for the Preparation of City Sanitation Plans, 2010). Under this program, GIZ provided the technical support for preparation of CSP for the Varanasi, Kochi, Raipur, Tirupati, Nasik and Shimla (GIZ Support for the Preparation of City Sanitation Plans, 2010).

Details of the Geospatial Platform – 'GeoSlum'

This study involved multiple steps: need assessment, design, GIS dataset collection, database creation, platform architecture, execution and result analysis; which are subsequently explained at various places in the section below.

Inputs

Combination of data types viz. GIS (.shp), CAD (.dwg) and Spreadsheets (.xls) were availed by GIZ as they have already executed the CSP project and surveying of households for the slums of Raipur and Tirupati:

a) At city level – GIS, CAD, Spreadsheet dataset about slums, water network, sewer network, roads and city master plan
b) At Slum level – GIS, CAD and Spreadsheet dataset having information about social, economic and infrastructural status of households
    - For Raipur, data used was for slums in Ward no 7 at Baramdeipara, Sahupara and Satnamipara, along with slum of Ward no 68 at Jhorapara
    - For Tirupati, data used was for Uppanki Harijanwada slum.

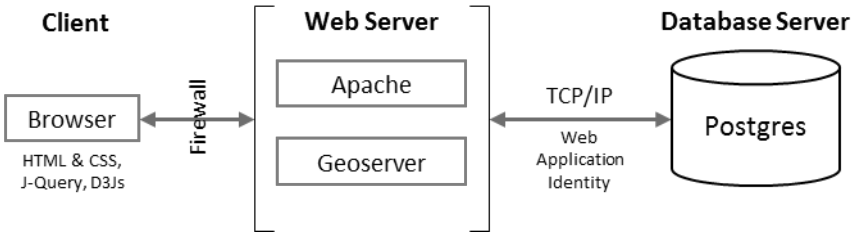
Database creation (collection, creation and processing)

The integration of spatial and non-spatial dataset in the form of CAD, GIS and spreadsheets was challenge in this project. The data obtained was further processed with regard to topology checks, data validations, extraction of geographical features (like roads, water bodies, railway lines, etc), reformatting, cleaning of the complete dataset, adding unique IDs to all the households, removing duplicates information from the spreadsheets and integrating all the dataset into a single data repository.

Platform Architecture

Platform (Software application) architecture is the process of defining a structured solution that meets all of the technical and operational requirements, while optimizing common quality attributes such as performance, security, and manageability. It involves a series of decisions based on a wide range of factors, and each of these decisions can have considerable impact on the quality, performance, maintainability, and overall success of the application (Microsoft, n.d.).

The 'GeoSlum' platform has been developed on an opensource technology. This WebGIS platform uses PostGRES as database to store all the spatial and non-spatial dataset, Apache and Geoserver as web servers and Java script libraries, HTML, CSS as front end frameworks.



Development design challenges

In an ideal case of a settlement, one family resides in one flat or a house and on a Geospatial platform all the information corresponds to single geometrical entity. Whereas in slums of India there are multiple families (beneficiaries) that reside in a single house and so on a Geospatial platform there are multiple information for multiple families corresponding to a single geometrical entity. This was a challenge from database perspective and also for the visualization. This was dealt by creating appropriate number of tables in a database joined by primary and foreign keys and for displaying purpose a customized pop-up was designed.

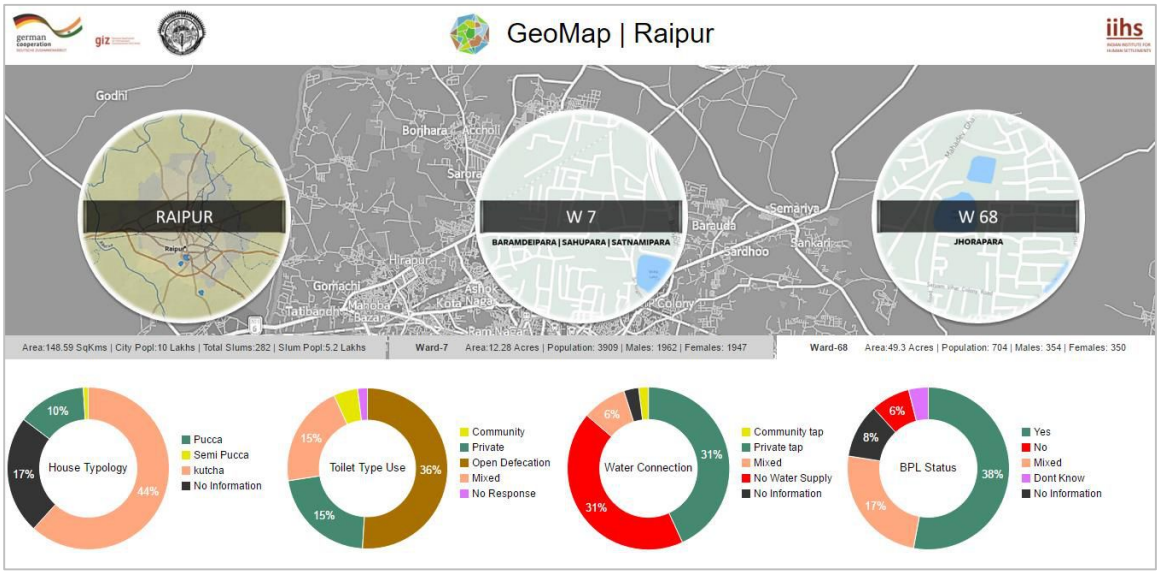
Another challenge was to design a function to update the spatial and non-spatial information for each household pertaining to infrastructure and beneficiary in a slum settlement over time. This was also to avoid any dependency on application developer for updating spatial and non-spatial information at household level that is temporal in nature. A customized function was developed for updating the spatial and non-spatial data with an administrative right of access.

Features and Functionalities

The platform is designed considering 3 user types viz., a) City Commissioner – who may like to take decisions using this platform, b) Government site officers – who may like to use this platform for enumerating the status at any given time and c) Slum representatives – who may like to use the platform for updating and assessing their status.

Platform consists of data/information for a) Dashboard b) City and c) Slum settlement.

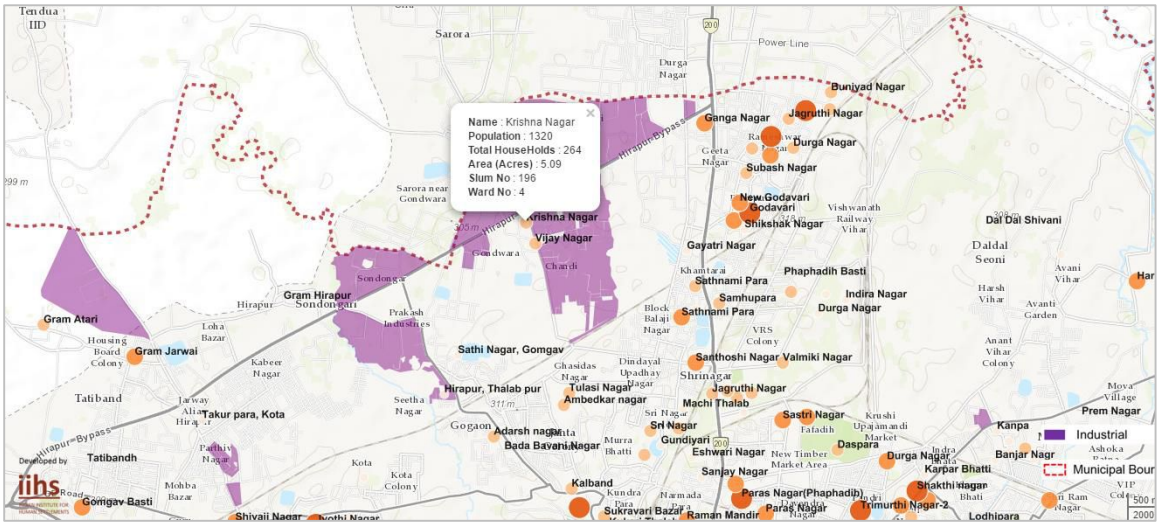
a) **Dashboard**: This has been designed for the decision makers to get the information about the important parameters of slum improvement like – housing typology, toilet type use, water connection, BPL (Below poverty line) status, Slum density, slum settlement size.



Screen capture of the platform showing Dashboard that provides summary of the indicators

b) **City level**: The city level information is categorized into thematic like administrative boundaries (municipal boundaries, zones, wards), city infrastructure (roads, drains, sewer networks, sewer pumping stations), natural features (lakes, ponds, natural drains, river) and landuse (residential, commercial, public, openspace, Industrial, others). In all these thematic, user can toggle slum location to understand the trend, pattern and connect.

While looking at a larger perspective for slum improvement, all the slum locations in a city need to be analyzed based on their population density, accessibility to existing infrastructure, near-by landuse (industrial, commercial, residential, etc) for prioritization of funding, resources and schemes.



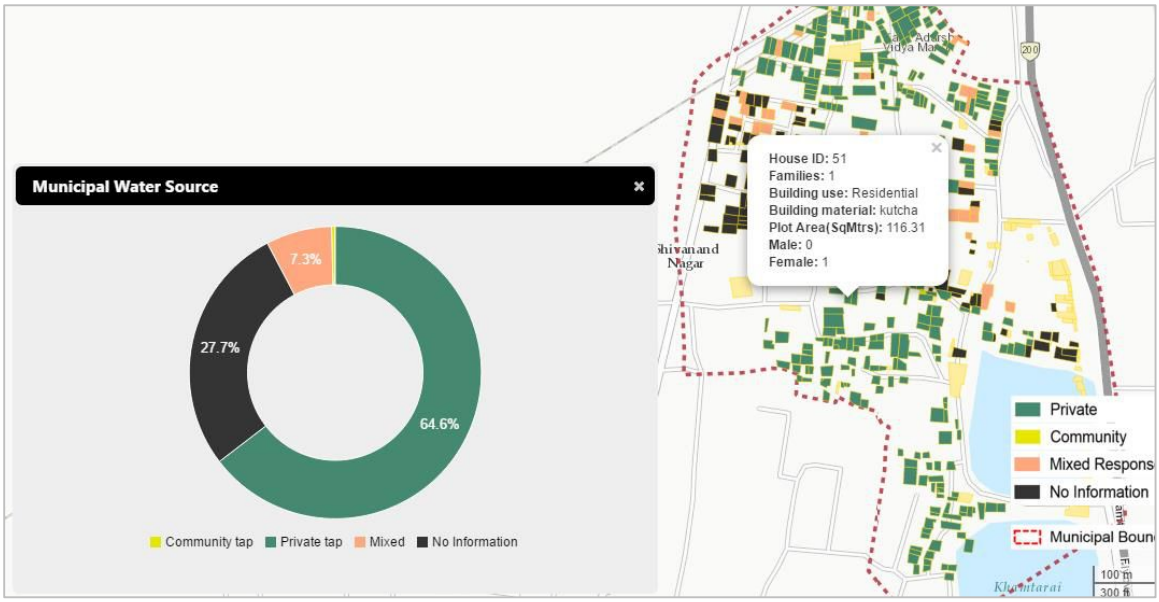
Screen capture of the platform showing Slum distribution with respect to Industrial landuse

The functions like a) identify slums within a distance from existing utility network (water/serwer/power/gas/ etc) or a road segment, river, pond, lake, etc., b) nearest landuse from a slum within a distance, c) carrying out advance analysis of identifying slums with respect to population density and area covered and d) adding new slum locations with information or editing the existing information about a slum provides an analytical approach to the question of prioritization of slums in a city[∞].

c) **Settlement level**: The slum level information is categorized into thematic like slum extent, infrastructure (roads, street lights, proposed water and sewer network, hand pumps, wells) and natural features (trees, water ponds). In all these thematic, user can toggle houses (parcels) to understand the trend, pattern and connect.

The slum improvement plan for a specific slum settlement depends on indicators like existing condition of housing (typology distribution, building use, plot size, number of families residing), socio-economic profile (water connection, water source, connection charges, lake water usage, toile type use, houses from where children go to school, type of schools they prefer, health facilities used, availability of electricity connections), and demographic (caste, below poverty, number of males and females).

[∞] These functionalities have been added in version 2.0 and is not the part of earlier deployment in municipal corporations



Screen capture of the platform showing Toilet type usage by community

For analyzing the households and beneficiaries of the slum, advance analytics option has been provided where user can select identify households with combination of above indicators[∞]. For example, to identify beneficiaries having house with flimsy construction + residential use + 50sqmt + 4-5 families + shared toilet use + below poverty line. This analysis will provide list of houses that needs immediate attention from infrastructure perspective. Similarly, other combinations can be permuted to identify the households/ beneficiaries for decision making. Also at this level user can locate any house in the slum settlement through HouseID.

Result analysis

(Richard Sliuzas, 2004) mentioned that "Dealing with slums requires an assimilated planning approach which incorporate strategic planning and decision making with effective and efficient management practices. Given resource limitations antagonizing actors in developing countries, it is preferable to develop systems that are inexpensive to construct, stress-free to use and flexible in their application. This infers a partiality for well tested tools and methods that can be combined as required". The approach adopted for GeoSlum platform is also true to this assertion as it has been developed with open source technology. The design of the application is so intuitive and easy to use that anyone with basic knowledge of accessing even an email can operate this platform with no requirement of learning GIS. The maps and graphs generated are in sync for their colors and information summary.

[∞] These functionalities have been added in version 2.0 and is not the part of earlier deployment in municipal corporations

The thematic for city and slum level information has been added with the predefined queries for the user. For in-depth analysis, the platform can perform spatial analysis at city level whereas multi-criteria analysis at settlement level.

Conclusion

Urban slum dwellers live, raise families, and work in conditions that are very challenging, (IHC, 2009) such as lack of access to basic services like potable water, sanitation, education, health facilities which are basic citizen rights, define the characteristic of slum conditions.

It is widely recognized that by setting up informational systems that provide multiple spatial and non-spatial slum information could potentially improve the lives of slum dwellers, including their living conditions. At present most of the cities lack basic information such as slum maps and maps with attribute information is a distant milestone. Many slum settlements in various cities of India have been surveyed at the household level under various national schemes, projects and programs. Most of this data is hardly used or in usable form and does not enable triggering of government or civil society action. In some cases, the surveyed data either resides with consultants or with government institutions and usually takes the shape of reports that are hardly useful in decision making. There is a need to bring all the surveyed datasets to a platform where decision makers, engineers, architects, planners, social workers can possibly use the available information to either directly or indirectly help in improving the lives of slum dwellers.

'GeoSlum' is one such attempt to illustrate the possibility of using such an informational database so as to provide household level insights across slums to enable appropriate action and decision making.

This platform is scalable and can contain large spatial databases covering all the slums in a city, and can also be used for other city functions such as city asset management, project monitoring, growth analysis. It will be premature to claim that the application was successfully used while planning for city level interventions and it will be the intention of the authors to track its use for decision making and productize this platform with enhancements for wide usage.

Acknowledgement

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