Sustainable Urban Planning Strategies for Cities in Karnataka

Volume I: Urban Observatory

CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

Sustainable Urban Planning Strategies for Cities in Karnataka

Volume-I

Urban Observatory Platform for Bengaluru and Karnataka

Final Report

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Abbreviations and Acronyms

API	Application Programming Interface
BMRDA	Bangalore Metropolitan Region Development Authority
CGWB	Central Ground Water Board
CRUD	Create, Read, Update, Delete
DB	Database
DDL	Data Definition Languages
E-waste	Electronic waste
GIS	Geographic Information System
GPS	Global Positioning System
HTTP	Hypertext Transfer Protocol
JDBC	Java Database Connectivity
JPA	Java Persistence API
JSON	JavaScript Object Notation
KGIS	Karnataka Geographic Information System
KMDS	Karnataka Municipal Data Society
KSCST	Karnataka State Council for Science and Technology
KSPCB	Karnataka State Pollution Control Broad
KSRSAC	Karnataka State Remote Sensing Applications Center
KSSDI	Karnataka State Spatial Data Infrastructure
MRC	Municipal Reforms Cell
MVC	Model View Controller
NBSS & LUP	National Bureau of Soil Survey and Land Utilisation Planning
NIUA	National Institute of Urban Affairs
NRDMS	Karnataka Natural Resources Data Management System
ORM	Object Relational Mapping
PoC	Proof of Concept
POJO	Plain Old Java Object
REST	Representational State Transfer
UO	Urban Observatory

Executive Summary

The Government of Karnataka has engaged the Center for Study of Science, Technology and Policy (CSTEP) as a Technical Resource Institution to conduct a study titled 'Sustainable Urban Planning Strategies for Cities in Karnataka'. The scope of the study includes: (a) developing a Proof of Concept Urban Observatory platform for Karnataka and (b) suggesting a set of sustainable strategies for cities in Karnataka with specific reference to water, sanitation and transport sectors. This draft report (Part-I) presents our work on developing a Proof of Concept Urban Observatory platform for Karnataka.

Urban Observatory platforms for cities enable data analyses and visualisation in a manner that can evoke policy response to tackle liveability and sustainability challenges in cities. The Proof of Concept Urban Observatory for Bengaluru and Karnataka developed under this study provides the basic architecture of such a platform. It further demonstrates how a complete data story can be presented by collecting, integrating, analysing and visualising data from multiple sources around a specific theme. The key features of this Urban Observatory platform include: (a) ability to crowd-source data, (b) ability to access and collate third party database and portals, (c) ability to generate spatial and temporal analysis and visualisation.

The Karnataka Urban Observatory dashboard generates GIS-based visual analysis on user defined queries for various administrative divisions of Karnataka state. It also offers the user to visualise changes in spatial direction of built-area growth based on ward-wise building permissions issued in a city over specific time intervals.

The Bengaluru Urban Observatory dashboard demonstrates innovative data collection, analyses and visualisation techniques around the theme of noise pollution. The primary data used in the Urban Observatory has been collected through the noise pollution measurement app *Shabda* (available in https://drive.google.com/open?id=1YoU72l4gTYMU9dBMOxnJ4RvrAg6UGnEY). This dashboard offers analyses and visualisation of noise trends in decibels for past 24 hours and for any other user defined time period in the past. It also offers analyses and visualisation of noise pollution levels around silent zones during different times of the day and compares the same against the permissible noise levels prescribed by the Karnataka State Pollution Control Board.

The Urban Observatory for Karnataka and Bengaluru can be accessed in http://cstem.cstep.in/uoapp/#/. All the components of this platform (i.e., database, middleware and front-end) have been developed using open source software and tools.

This Proof of Concept Urban Observatory can be expanded to explore other urban themes and can be replicated to create similar observatories for other cities in Karnataka.

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1. Introduction

Urban data, especially spatially and temporally disaggregated data is key to tracking the sustainability and liveability challenges faced by cities. Measuring performance of indicators that are comprehensive help in understanding baseline conditions and invoke critical policy responses, an important step forward in this regard. Innovations in data science combined with state-of-the-art analytical and visualisation techniques are enabling newer and more accurate ways of measuring liveability of cities. For example, capturing a large amount of geospatial data is possible by using mobile crowdsourcing and social media analysis. The data thus captured can be used for finding solutions to urban challenges in a cost and time efficient manner. In this context, the concept of Urban Observatories is significant.

Urban Observatories are meant for aggregating urban data at various scales, creating appropriate analysis and visualisation, facilitating participation of communities and stakeholders, and supporting good governance practices in decision making. The concept of Urban Observatories was initiated at the HABITAT-II Conference in 1997. Bengaluru was one of the foremost cities in India to have an Urban Observatory, with the Bangalore Metropolitan Region Development Authority (BMRDA) as the anchor agency[1]. However, the initiative did not seem to progress thereafter.

This study aims to build a Proof of Concept (PoC) Urban Observatory platform for Bengaluru and can be replicated across cities in Karnataka.

2. Progress Review: Existing Situation Analysis

Globally, there are successful examples of urban data collation, analysis and visualisation platforms. Some relevant examples are mentioned in Table 1.

Table 1: Examples of Urban Observatory platforms and their features

Dublin Dashboard	
Usage	Evidence-informed analysis for everyday decision making in the city (Dublin)
Targeted Audience	City officials, citizenry, public sector workers, companies
Data Type	Real-time and time series data
Data Visualisation	Interactive charts and maps

[1] Adapted from the newspaper article in the Times of India titled ‘B'lore to launch first urban observatory’ published on 17th January, 2001.

Aspects Covered	Demography, Environment, Transport, Industry, Employment & Labour Market, Housing, Heath & crime, Urban Planning
Data Sources	Dublin City Council, Dublinked, Central Statistics Office, Eurostat, government departments and other existing applications
Data Availability	Data used in the platform is freely available
City Dashboard (for cities in the UK)	
Usage	Aggregates simple spatial data for cities around the UK
Data Type	Real-time
Data Visualisation	Dashboard and map
Aspects Covered	Weather, Traffic, Cycle Hire services, Tube line status, Air pollution, News, Open street Map updates, Electricity, etc.
Data Sources	Department for Environment Food and Rural Affairs, National Oceanic and Atmospheric Administration, OpenStreetMap (& Pawel's Static Maps API), Port of London Authority, Transport for London, MapTube, Google, Twitter
Urban Observatory at Newcastle	
Usage	Aggregates data on air quality, traffic, etc. from sensors installed
Data Type	Real-time
Data Visualisation	Map and charts
Data Availability	Open-Data available for download
Urban Observatory Project (collaboration between Richard Saul Wurman (TED), Jon Kamen (Academy Award-Emmy Award), Radical media and ESRI)	
Usage	Compare and contrast maps of cities around the world
Targeted Audience	City officials, urban planners, citizenry
Data Type	Real-time and time-series data
Data Visualisation	Comparative visual analysis through interactive maps
Aspects Covered	Real-time metrics like traffic, road speed, weather etc., demographics like population density, distribution of education, age and income etc., other urban aspects like urban footprint, housing density, accessibility of parks etc.)
Data Sources	ArcGIS Database Cities across the world can also share the data with the platform

Source: http://www.urbanobservatory.org/, http://www.dublindashboard.ie/pages/index, http://citydashboard.org/london/, http://www.urbanobservatory.ac.uk/explore/research

In the Indian context, under the UK-India Joint Network on Sustainable Cities, the University of Nottingham and National Institute of Urban Affairs (NIUA) are looking at possibilities to develop urban observatories for a few Indian cities. Some of the cities and states under consideration include Mumbai, Chennai, Kolkata, Vishakhapatnam, Chandigarh and Kerala.

In Karnataka, there have been efforts towards creating various spatial data platforms by different agencies. A brief description of some of the initiatives are given below:

- Karnataka Geographic Information System (KGIS): KGIS is a flagship programme launched by the GoK and the Karnataka Jnana Ayoga (KJA). It is envisioned as a common platform for updated 'GIS ready data' in a specific standard for enabling data consistency and avoiding duplication of efforts. The platform is expected to ensure authoritative and updated data availability to not only government departments, but also other private agencies, enterprises and citizens. Karnataka State Remote Sensing Applications Center (KSRSAC) is the implementation agency for the KGIS programme.

- Karnataka Natural Resources Data Management System (NRDMS): The Karnataka State Council for Science and Technology (KSCST) initiated the NRDMS programme (launched by the Department of Science and Technology, GoI) in 1992 as a multi-disciplinary and multi-institutional programme for encouraging the use of spatial data for local area planning. District level NRDMS centres, formed as a part of the programme, have created exhaustive databases (on infrastructure, socio-economy, natural resources, etc.) for the respective districts. The centres share need-based information (spatial and non-spatial) to planners, administration and elected bodies through maps, charts, reports, etc.

- Karnataka State Spatial Data Infrastructure (KSSDI) - Karnataka Geoportal: The Karnataka Geoportal is a central database for all the spatial data acquired and used by various departments and agencies to support planning activities at the local level. The Geoportal is a GIS-based directory having information on state demography, socio-economy, infrastructure, geography, etc. It is envisioned that the internet-based portal will eventually be opened to public.

Some of the above initiatives could be treated as preliminary attempts which could be further enhanced to create observatories. However, these platforms do not demonstrate functionalities to work at multiple spatial levels in a city, which is essential for making data actionable and hence fulfil the primary objective of an Urban Observatory. Further, reasons for the limited success of urban data platforms include absence of a demonstrable story, lack of a solution-centric and multi-stakeholder approach and lack of ownership of these platforms among policy makers and implementers.

3. Problem Statement

Cities in Karnataka including Bengaluru face multiple challenges pertaining to urban data. These include poor reliability and frequency of data, fragmented data collection and analysis efforts, duplication of datasets, absence of spatially and temporally disaggregated data, etc.

Currently, there is absence of a city level, government-owned, multi-disciplinary geospatial platform in Karnataka for data collection, analysis and visualisation that can aid problem solving and policy-making at different spatial scales such as cities and regions.

4. Theory of Change

Data analysis and visualisation are important pillars for improving the status quo. They support transparent decision-making, facilitate timely response, help in generating dialogue and awareness, encourage research and participation and support design of policies based on evidence. Thus, data and evidence-driven policy-making can make cities more prepared to address future challenges in a time and cost effective manner.

An Urban Observatory is a technology supported platform capable of producing, analysing and visualising complex data sets. It can demonstrate how a spatial data platform can be used to track urban liveability indicators. It does so by combining both static and dynamic data in a spatial format and in a user-friendly manner to invoke responses from appropriate stakeholders.

5. Objective

The overall objective of this study is to build the basic architecture of a Proof of Concept (PoC) Urban Observatory platform for Karnataka.

The specific objective of the PoC Urban Observatory developed by CSTEP is to demonstrate a complete data story around a theme for Bengaluru by collecting, integrating, analysing and visualising data from multiple sources.

6. Research Questions

The research question we examine in this study is:

What should be the design of a platform and its components that can help track urban liveability indicators?

More specifically, the research delves deeper into the following questions:

1. What modalities and protocols can be used for data collection and integration?

2. What are the innovative visualisation techniques that can make data actionable?

7. Urban Observatory for Bengaluru and Karnataka: Components and Key Features

The PoC Urban Observatory platform developed by CSTEP can be accessed from the following link http://cstem.cstep.in/uoapp/#/.

The two major components demonstrated in the platform are the Karnataka Urban Observatory and the Bengaluru Observatory.

7.1 Karnataka Urban Observatory Dashboard

This dashboard generates GIS-based visual analysis based on user-defined queries for various administrative divisions of Karnataka state. It also provides the basic architecture for developing a one-stop-data-shop for all relevant spatial and non-spatial data along with analysis and visualisation capabilities.

7.2 Bengaluru Urban Observatory Dashboard

This dashboard demonstrates innovative data collection, analyses and visualisation techniques around one selected theme. For the PoC phase of the Urban Observatory for Bengaluru, noise pollution has been selected as a theme. The rationales for selecting noise pollution as a theme are as follows:

- Ability to capture reliable data through crowd-sourcing
- Ease of deployment via an app which can be used by a large number of citizens
- Ease of validating authenticity of data
- Possibility of demonstrating all the key features of the Urban Observatory platform within a short time period.

7.3 Key Features

The PoC Urban Observatory platform demonstrates the following key features:

1. *Ability to crowd-source data*- This refers to sourcing data from citizens directly through an app for interpreting issues of relevance. For this study, CSTEP has developed an *Android* mobile application named ‘Shabda’ for measurement of noise pollution. The data received thus gets stored in a server and are then analysed and presented in the Urban Observatory

platform. The *Shabda* app can be downloaded from the following link https://drive.google.com/open?id=1YoU72l4gTYMU9dBMOxnJ4RvrAg6UGnEY.

Figure 1 shows the user interface of the Shabda noise app developed by CSTEP.

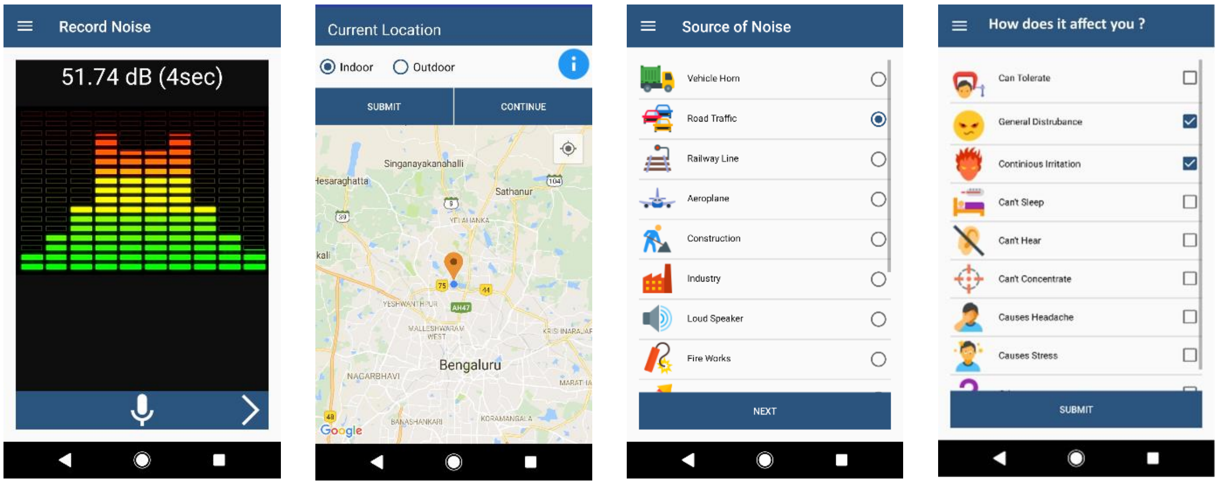

Figure 1: User interface of the *Shabda* app

Source: CSTEP

2. *Ability to access and collate third party database and portals*- This includes various government and private databases which could be static or dynamic in nature. The PoC urban observatory has demonstrated this capability by accessing and collating data from the following sources:

    - Karnataka State Pollution Control Broad (KSPCB) portal for noise pollution measurement in different locations in Bengaluru
    - Karnataka Municipal Reform Cell (MRC) portal for accessing ward level data for building permissions issued for different cities
    - Open street Map for creating basic spatial layers for Bengaluru.

3. *Ability to generate spatial and temporal analysis and visualisation*- The PoC Urban Observatory platform generates maps and graphs, updated regularly from the data collected from CSTEP's *Shabda* app, KSPCB's noise pollution monitoring data portal and MRC's data portal.

Figure 2 shows the user interface of the noise pollution theme in the PoC Urban Observatory platform developed under this study. This platform sources data from CSTEP's Shabda app and KSPCB's portal which publishes noise measurement data from its monitoring stations.

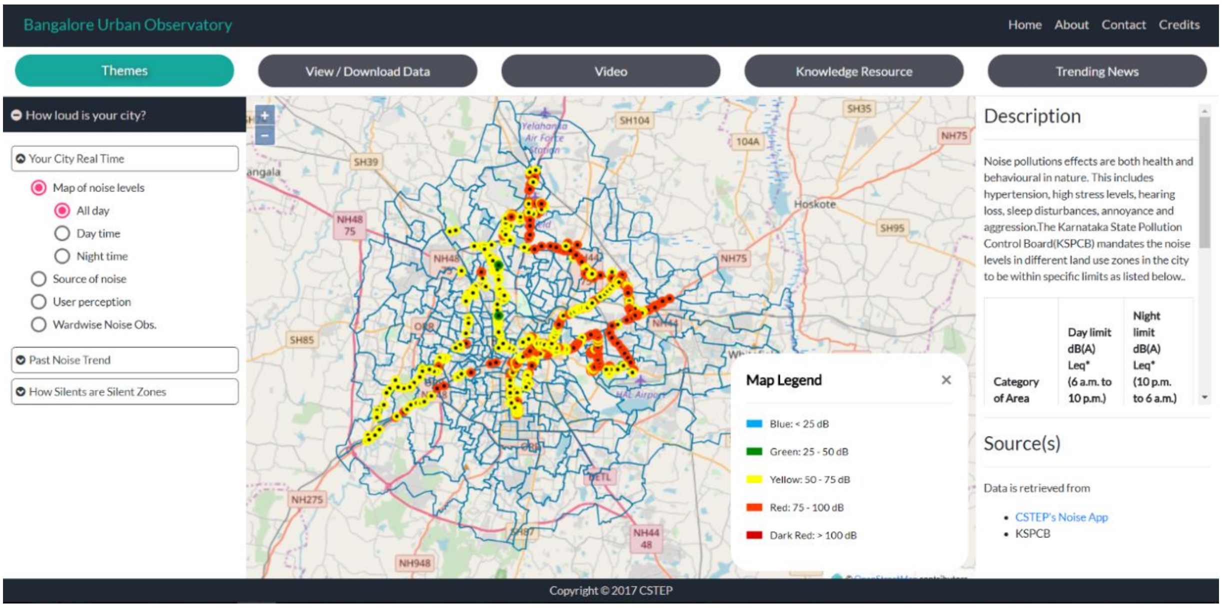

Figure 2: Screenshot of the user interface of noise pollution platform in the Bengaluru Urban Observatory

Source: CSTEP

Figure 3 shows the user interface of the state-level dashboard in the PoC Urban Observatory platform developed under this study. It generates visualisations based on both static (such as age pyramid generated from census data) and dynamic datasets (such as from MRC dashboard).

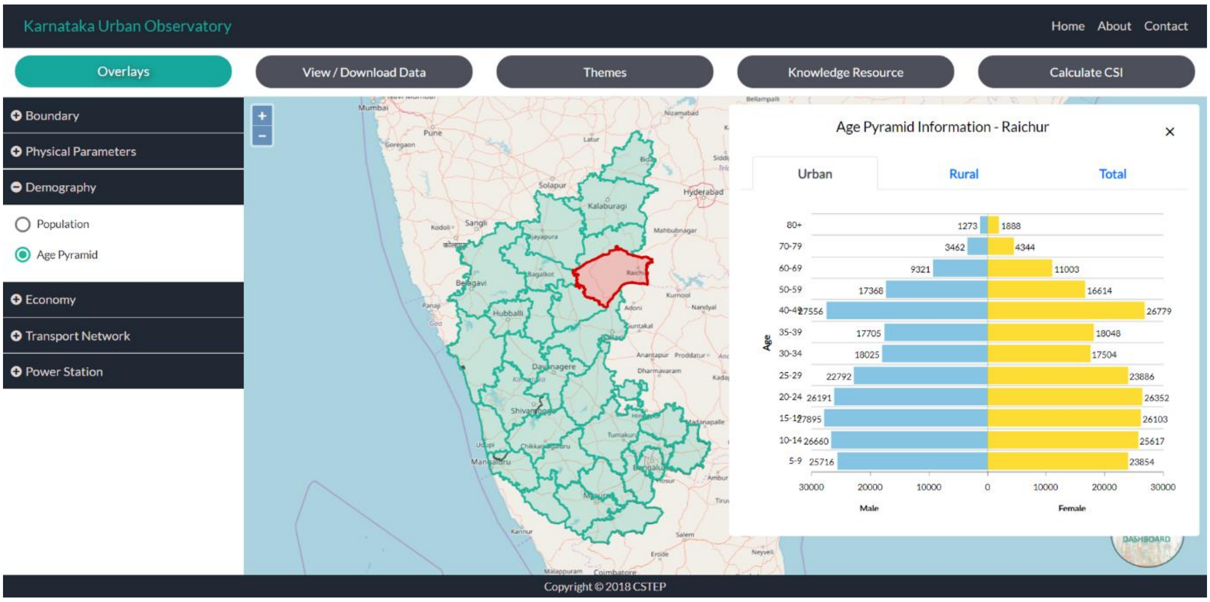

Figure 3: Screenshot of the user interface of the Karnataka Urban Observatory

Source: CSTEP

8. Methodology

8.1 Architecture for *Shabda* Application for Noise Pollution Measurement

The *Shabda* application has been built on an Android native platform in Java programming language. The minimum version required by the app is Android 5.0 (Lollipop). The app uses Google play services to get accurate location from the user. It uses a Google Map plug-in for the Application Programming Interface (API) and for displaying location marker on the map.

The app captures noise using the microphone feature embedded in android phones. As a security measure, the app requests user permission for the first time after installation to capture noise via microphone and to track the GPS coordinates of the user. The app exits if the user chooses not to grant permission. Upon submitting all the details, information captured is collected on the central server. It uses the same back-end services developed for Urban Observatory platform using RESTful services (refer Figure 4).

8.2 Information Technology Architecture for Urban Observatory Platform

The Urban observatory application has three major components:

- Database (DB)
- Middleware
- Front-end for visualisation

A schematic diagram of the architecture is shown in Figure 4.

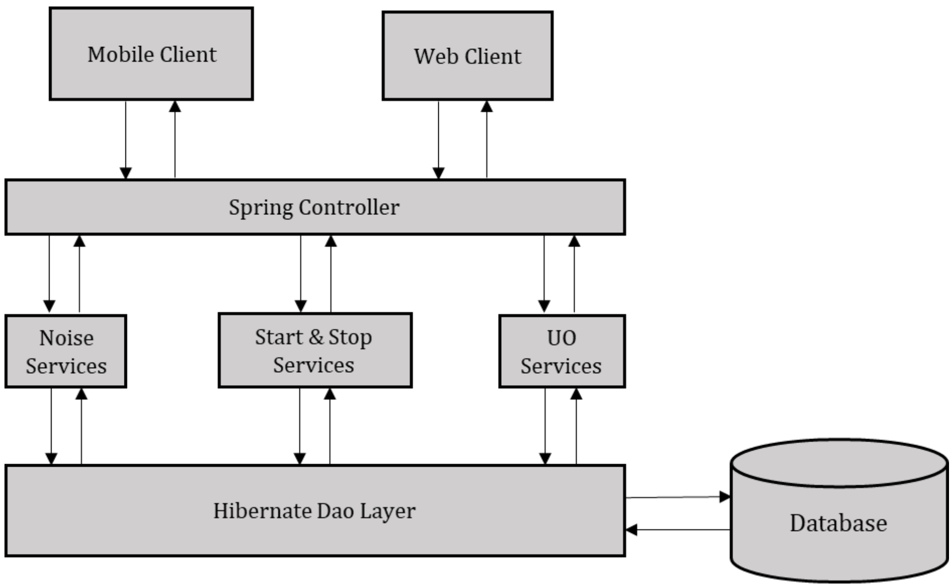

Figure 4: Urban Observatory Application Architecture

Source: CSTEP

The application development for the Urban Observatory follows the Model View Controller (MVC) concept. This advocates the loose coupling of each of the three modules shown in Figure 4 (model, view and controller) in order to provide high maintainability of the code base.

Additionally, to provide the various functionalities (which are mostly used by clients, such as mobiles or via the web) required, Spring RESTful micro services have been used as part of development. These services mostly consist of CRUD (Create, Read, Update, Delete) operations, along with necessary business calculations. All clients have to communicate with the server using REST (Representational State Transfer) services over HTTP protocol.

8.3 Methodology for Developing Urban Observatory Application Components

8.3.1 DB Schema Design

The PostgreSQL relational database has been used for storing data in various relational tables. PostGIS plugins are used to convert the shape files to respective database tables (that contain the GIS information as a geometric object in the respective columns).

The Data Definition Languages (DDL) are created first and then the same process is executed in PostgreSQL to generate tables automatically.

8.3.2 Middleware

The middleware has been developed using RESTful micro services. The following frameworks are used in the development:

- Spring 4.3.9
- Hibernate 5.2.12.Final
- Jackson 2.7.5

Spring Framework

A Spring framework has been used to build the micro services. These micro services are broadly categorised into three sections:

- Noise services (to measure the noise intensity across the city)
- Start & Stop services (to keep track of the origin and destination of a person's journey inside a city)

HibernateThe middleware is developed using Java and Hibernate, which provides Object Relational Mapping (ORM) along with other capabilities such as caching, session management and cross database portability.

Jackson

Communicating with a service from outside the server (or from the client side) requires a platform-independent serialised data format. JSON is one such format, which has been used here. The Java server has to serialise and de-serialise its objects into the respective JSON format so that they can be accessed by the client side. Hence, the JACKSON framework has been used (in addition to spring framework) to perform the serialisation and de-serialisation. Figure 5 depicts the internal mechanism of this process in the middleware stack.

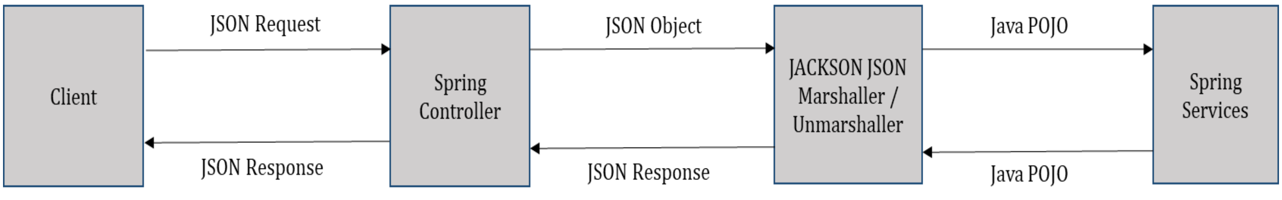

Figure 5: Internal mechanism of client-server communication in middleware

Source: CSTEP

8.3.3 Front-end and Visualisation Development

The front-end of the Urban Observatory is developed using the following frameworks and tools:

- Frameworks: Angular 5, Open layer3, Bootstrap 4, jQuery, Material design, and chart.js
- Icons: Font awesome and icons8.com

The list of APIs used in the Urban Observatory platform is given in Annexure

Annexure I.

Further details of the IT infrastructure used in the Urban Observatory platform is given in Annexure II

9. Data Collection and Analysis

The secondary datasets used for analysis and visualisation in the Urban Observatory platform has been collected from various government departments and their respective websites. A list of data and their sources in given in Annexure III

The primary data used in the Urban Observatory has been collected through the noise pollution measurement app *Shabda*. A snapshot of the data collected through the app is given in Annexure IV. Some of the analyses generated under different tabs in the Urban Observatory platform are presented below.

9.1 Bengaluru Urban Observatory

9.1.1 Noise levels in past 24 hours: point locations

This tab shows the noise pollution levels at specific point locations collected by both *Shabda* app and KSPCB noise monitoring stations over the past 24 hours (refer Figure 6).

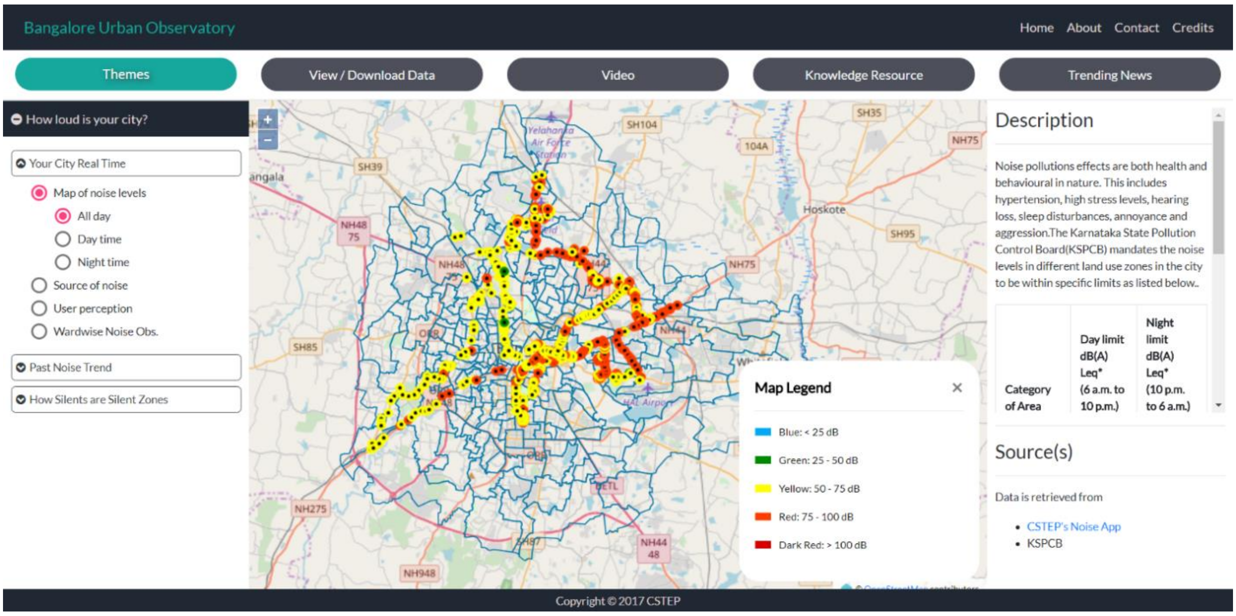

Figure 6: Noise levels for the past 24 hours: point locations

Source: CSTEP

9.1.2 Noise levels in past 24 hours: ward-level averages (day-time, night-time, all day)

This tab shows the ward-level average noise pollution levels in the last 24 hours for three different time range options, i.e., day time, night time and all day (refer Figure 7 for example).

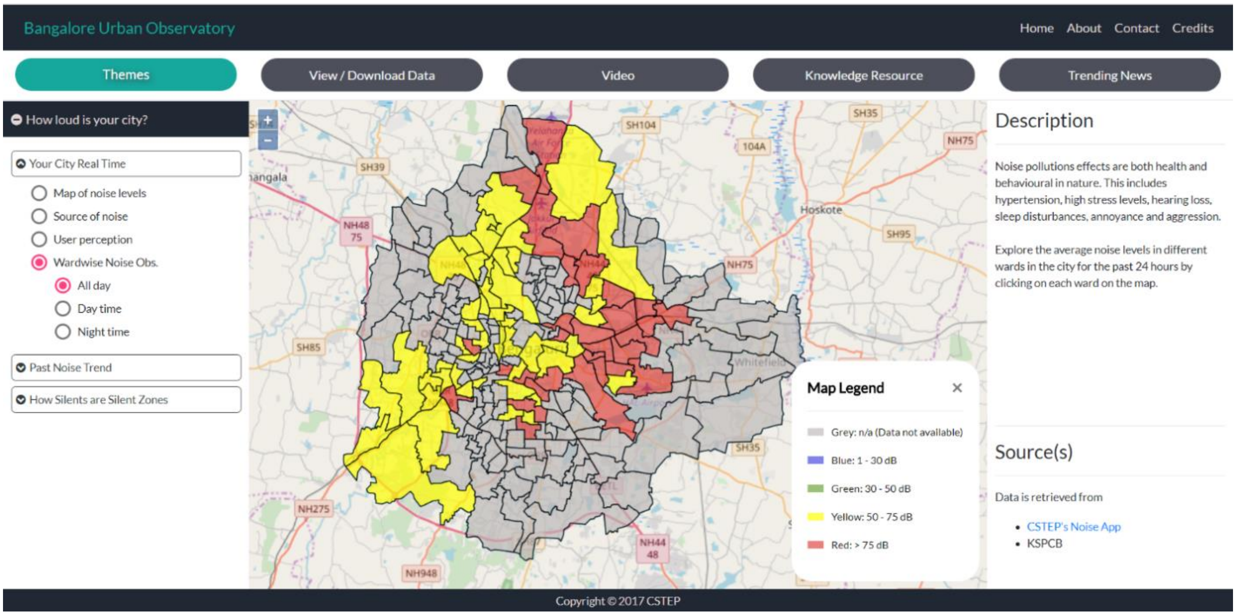

Figure 7: Noise levels for the past 24 hours: ward averages

Source: CSTEP

9.1.3 Past noise trends

Under this tab, the user can select a particular date and time range in the past and can see noise levels in a particular ward (as shown in Figure 8). It also lets the user select three wards concurrently and visualise the comparison between noise levels during a specific date and time range.

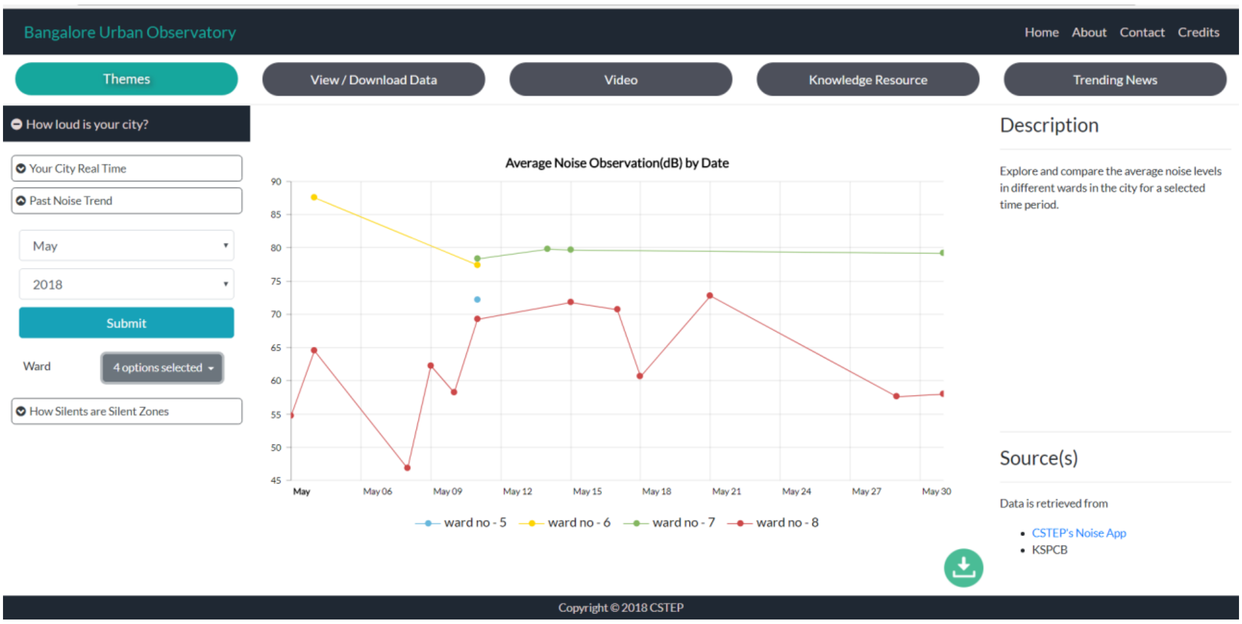

Figure 8: Past noise trends

Source: CSTEP

9.1.4 *Noise levels in silent zones*

A silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by a competent authority. The standard range for permissible noise levels within silent zones are prescribed by KSPCB. Figure 9 shows that in many of the silent zones, the noise levels crossed the permissible limits during a particular date and time.

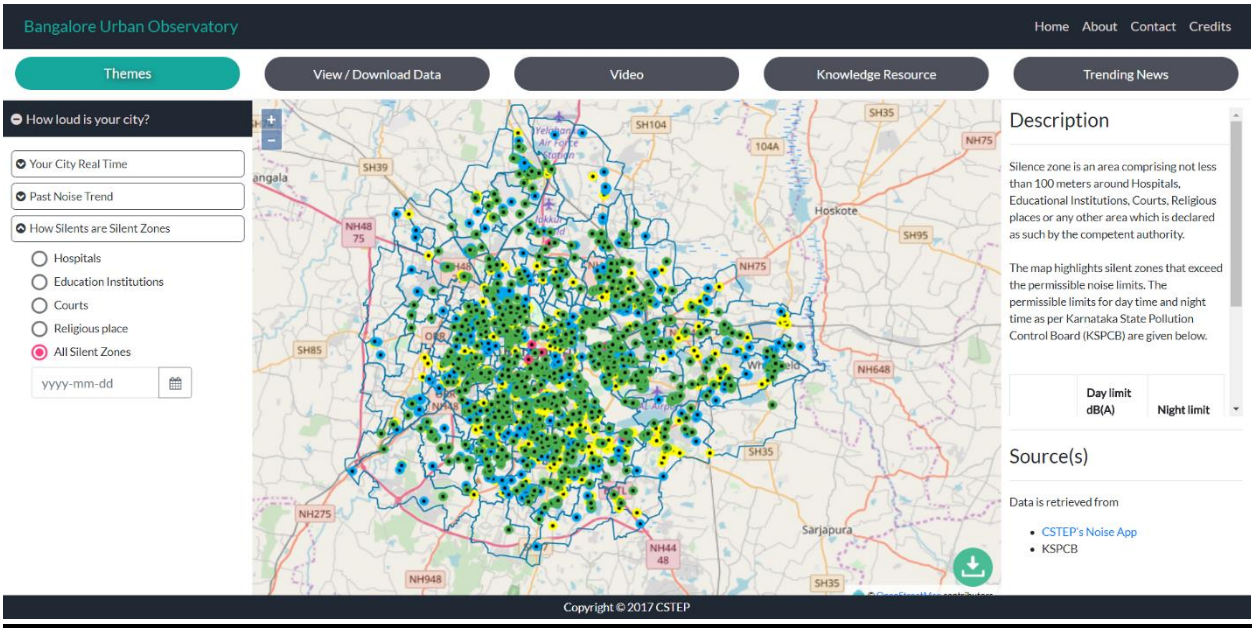

Figure 9: Noise level in silent zones

Source: CSTEP

9.2 Karnataka Urban Observatory

The Karnataka dashboard in the Urban Observatory aggregates multiple spatial and non-spatial data layers into one platform. It aims to demonstrate spatial analysis and visualisation for different cities across the state and also allow comparison between cities. For the PoC stage of the platform, the likely trend of growth in built-up areas has been explored by analysing building permission issuance data from the MRC dashboard. Details are given in the following section.

9.2.1 *Spatial comparison of how cities are growing*

This tab presents a visualisation of ward-wise trends of building permissions issued in a city over four quarters in a year (Figure 10). A user can select a specific quarter and view the square metres (sq.m.) of building area for which licences have been issued in that quarter. The objective is to help the user identify the spatial direction of built growth likely to happen in future. This will help city managers in proactive planning for future infrastructure creation and service delivery. This analysis can help in understanding the impact of specific infrastructure created in an area based on the change in the trend (if any) of built growth speculated before and after the infrastructure creation. The tab also lets the user compare the above analysis between two cities.

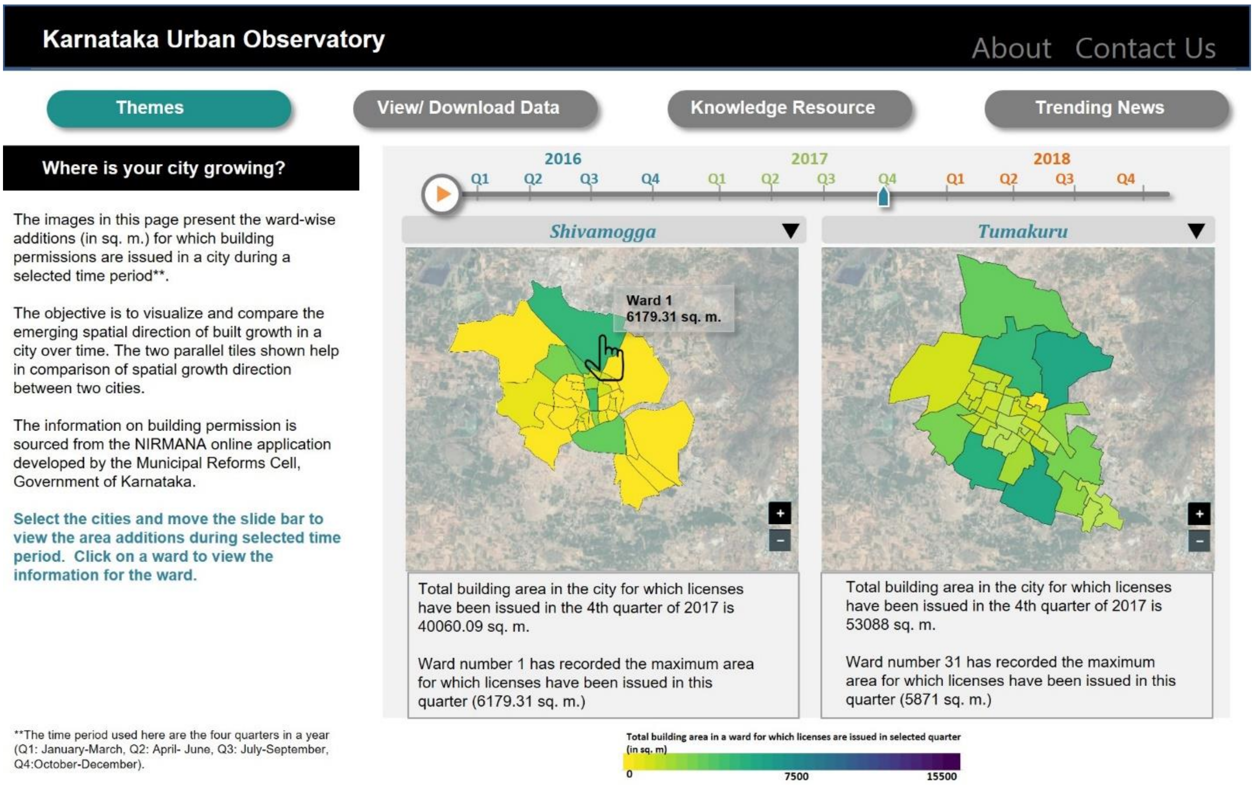

Figure 10: Spatial comparison of how cities are growing

Source: CSTEP

Apart from indicating the spatial direction of growth, additional information provided in the tab include: (1) total building area for which licenses have been issued in a city for the selected time period and (2) the city ward which has recorded the maximum area for which licenses have been issued in the selected time period.

10. Findings and Discussions

The analyses presented above indicate noise pollution levels in different parts of Bengaluru at different times. Noise pollution can affect both health and behaviour of citizens. This includes hypertension, high stress levels, hearing loss, sleep disturbances, annoyance and aggression. The permissible noise limits prescribed by KSPCB for Bengaluru are given in Table 2.

Table 2: Permissible noise limits in different land use zones suggested by KSPCB

Category of Area	**Day limit in decibel [dB(A) Leq*] (6 a.m to 10 p.m)**	**Night limit decibel [dB(A) Leq*] (10 p.m to 6 a.m)**
Industrial area	75	70
Commercial area	65	55

Category of Area	Day limit in decibel [dB(A) Leq*] (6 a.m to 10 p.m)	Night limit decibel [dB(A) Leq*] (10 p.m to 6 a.m)
Residential area	55	45
Sensitive area	50	40

**Leq is equivalent continuous sound level*

Source: Karnataka State Pollution Control Board

Based on limited data collected by the Shabda app till June 2018, Figure 11 shows an aggregated representation of noise levels captured through 700 sample points. The analysis shows that close to half of the samples collected crossed the permissible limits for all the land use categories.

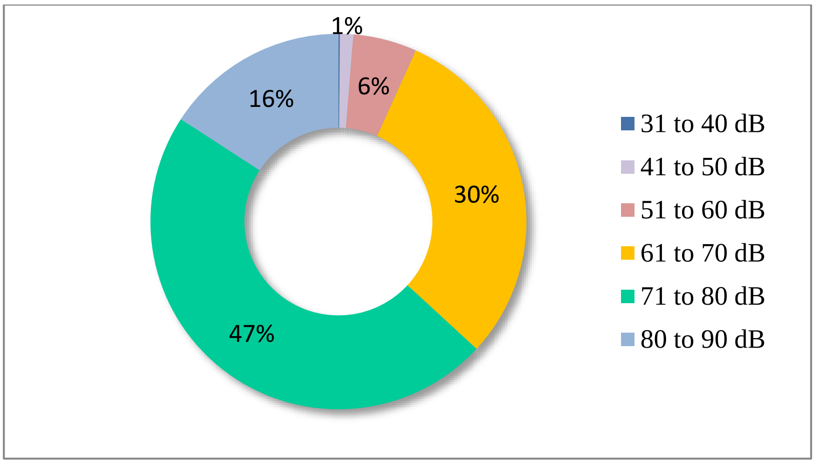

Figure 11: Share of noise data captured in different dB ranges

Source: Shabda Noise App, CSTEP

An analysis of the sources of noise recorded by the app is shown in Figure 12. It shows that the source of 68% of the noise data captured is road traffic and 8% of vehicle horns.

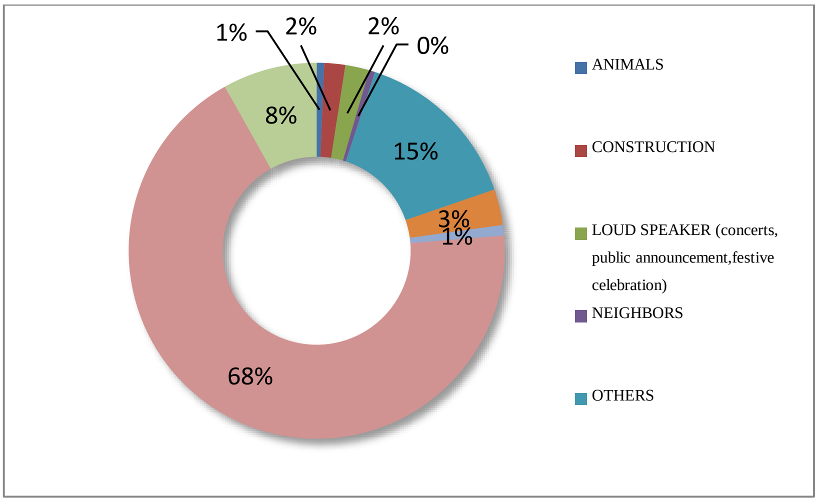

Figure 12: Share of noise data captured from different noise sources

Source: Shabda Noise App, CSTEP

The Shabda app has been made available on Google Play Store, for use by citizens. The Urban Observatory platform is expected to generate better analyses as more noise measurements are captured by the users. It is recommended that the Shabda app be popularised by making the link available in different government websites, apart from adopting other promotional measures, especially involving social media.

The analyses generated on noise pollution in the Urban Observatory platform can help cities make informed decisions in the following aspects:

- Control activities (such as traffic, shopping, loudspeaker-use, etc.) in areas and especially around the silent zones, which now appear to have noise levels above permissible limits
- Make more accurate decisions on public litigations pertaining to noise pollution. For example, it can provide valid evidence in addressing complaints by suitable authorities and hence facilitate appropriate action.

11. Conclusion and Recommendations

Following are some of the aspects that need further deliberation for enabling wider and more relevant future application, as well as ensuring sustainability of the urban observatory platform:

Dissemination and outreach: In order to enable wider use by citizens and stakeholder organisations, there is need for dissemination of the Shabda app and the noise pollution observatory platform. The following strategies could be adopted by stakeholder agencies such as KSPCB, Health Department in coordination with Bengaluru Traffic Police, public transport agencies, non-government organisations and general citizens, especially students working in this space:

- Awareness campaigns regarding the impact of noise pollution and use of the Shabda app through electronic media (such as FM radio and local television channels) and social media (such as Facebook and Twitter)
- Display of relevant information in public places, such as bus depots, metro stations, public buildings and government offices (This can include display of the noise observatory platform itself in public screens.)
- Awareness generation through government websites where users can be directed to the Urban Observatory platform and the link for downloading the Shabda app

Replication and scaling-up: The Urban Observatory platform can be further expanded to incorporate other relevant themes at the city level such as waste management including E-waste, air and water pollution, universal accessibility, etc. Similar observatories for other cities in

Karnataka can be created using this platform and the same architecture. Replication and scaling up of the Urban Observatory will be necessary for facilitating its wide use. An expanded user group will enable more and better data and hence improve the quality of analysis produced by the Urban Observatory platform.

Integration with other databases: Apart from specific problem-based queries, the observatory can be used to interpret spatial pattern of growth in a city. This will require integration of the Urban Observatory platform with the city's spatial and non-spatial database. Such integration can bring significant improvements in the way spatial planning exercises are conducted at present. It can also act as a useful tool for measuring impact of investments made and further planning the city's future in a better cognizant manner. For the noise pollution platform to facilitate more precise analyses, it is suggested that KSPCB conduct periodic drives to collect better source-apportioned noise data. The results can be analysed in the Urban Observatory noise platform from time to time.

Inter-agency coordination: As evident from the example of noise pollution, it needs multi-departmental initiative (from pollution control board, Urban Development Department and Bengaluru Traffic Police) to tackle urban liveability challenges. At present, inter-agency coordination is a challenge which needs to be overcome in order to initiate appropriate action based on the analysis available in the Urban Observatory.

Collaborative model, ownership and protocols: It is imperative to forge sustainable public-private partnerships involving government agencies, NGOs, think tanks, research organisations and corporates. Large spatial data is collected regularly by private parties such as radio taxi aggregators and private telecom service providers. An established data sharing protocol can enable use of these datasets in addressing critical urban challenges (such as mobility pattern and emerging activity nodes from geospatial data collected by radio taxi aggregators). However, ownership of such a platform and protocols for data security need further deliberation. Nevertheless, collaboration and cooperation will be the key in making the Urban Observatory for cities in Karnataka a successful initiative.

Annexure

Annexure I

List of APIs

Boundary

District : http://cstem.cstep.in/urbanobsservice/getcensusalldistinfo

Taluka : http://cstem.cstep.in/urbanobsservice/getcensusalltalukasinfo

City : http://cstem.cstep.in/urbanobsservice/getcensusallcitiesinfo

District level

Population : http://cstem.cstep.in/urbanobsservice/getdistpopulationinfo/1

Age pyramid : http://cstem.cstep.in/urbanobsservice/getdistagepyramidinfo/1

GDDP : http://cstem.cstep.in/urbanobsservice/getdisteconomyinfo/1

Per capita : http://cstem.cstep.in/urbanobsservice/getdisteconomyinfo/

Taluka level

Population http://cstem.cstep.in/urbanobsservice/gettalukapopulationinfo/1

Workforce http://cstem.cstep.in/urbanobsservice/gettalukapoplationworkinfo/1

City level

Population : http://cstem.cstep.in/urbanobsservice/getcitypopulationInfo/1

Literacy : http://cstem.cstep.in/urbanobsservice/getcityliteracyinfo/1

Sex ratio : http://cstem.cstep.in/urbanobsservice/getcitysexratioinfo/1

Work force : http://cstem.cstep.in/urbanobsservice/getcityworkforceInfo/1

Annexure II

IT Infrastructure Details

Hibernate

Java Persistence API (JPA) tools are used in Eclipse to generate Plain Old Java Object (POJO) entity classes from database tables. These POJOs contain the appropriate mapping of each member with the respective columns of the relational database table. While querying in such database tables, we get the result in the form of entities or collection of entities (objects having members) instead of iterative result sets that we get when using traditional Java Database Connectivity (JDBC).

Angular

The Angular framework is used to build client application in HTML and TypeScript. TypeScript is a superset of JavaScript and maintained by Microsoft. Angular is an open source web framework developed by angular team at Google. Angular framework provides advantage of building web applications using loosely coupled components.

Open layer

The Open layer framework provides dynamic maps in web. Open layer is an open source java script library, which is used to develop GIS-based applications or platforms.

Annexure III

Data Sources

Sl. No	Name of Data	Data Source
1	Spatial boundaries of Districts, Talukas	Survey of India
2	Agro-climatic zones	Ground Water Year Book of Karnataka State, 2015-16 (CGWB)
3	River basins	Ground Water Year Book of Karnataka State, 2015-16 (CGWB)
4	Soil type	NBSS&LUP,R.C.,Bangalore/KSDA, http://raitamitra.kar.nic.in/agriprofile/soilclass.htm
5	Land cover	Karnataka State Remote Sensing Application Centre (KSRSAC)

Sl. No	Name of Data	Data Source
6	Groundwater level	Ground Water Year Book of Karnataka State, 2015-16 (CGWB)
7	Demography • Population • Age pyramid • Sex ratio • Literacy rate • Work Force Participation	Census of India
8	Economy • Gross District Domestic Product (GDDP) • Per Capita Income	Economic Survey of Karnataka (2014-15, 2013-14, 2012-13, 2011-12, 2010-11) respective reports
9	Regional transport network	DIVA GIS website
10	Power stations	Karnataka Renewable Energy Development Ltd (KREDL) website and Karnataka Power Transmission Corporation Limited (KPTCL) website
11	Building license documents	Karnataka Municipal Data Society (Municipal Reforms Cell)- NIRMANA
12	KSPCB's spatial 10 monitoring stations	Central Pollution Control Board (CPCB) website http://www.cpcbnoise.com/
13	Real-time noise pollution monitoring	Karnataka State Pollution Control Board (KSPCB)
14	Ward level noise pollution survey	Janaagraha (Ward Quality Score Data book, 2013)
15	Location of silent zones (Hospitals, Educational Institutions, Courts, Religious Places)	BBBike extract, Open Street Maps

Annexure IV

<u>Snapshot of data collected through *Shabda* App</u>

Response Object Record_ Latitude	Response Object Record _ Longitude	Response Object Record _ Time stamp	Response Object Record _ Indoor (FALSE) Outdoor (TRUE)	Response Object Record _ Source of Noise	Response Object Record _ Max. Noise Level	Response Object Record _ Avg. Noise Level	Response Object Record _ User Perception
13.048	77.58	04-05-2018 05:14	TRUE	PEOPLE	80.483	68.019	CAN TOLERATE (No/Minimal Disturbance)
13.048	77.58	04-05-2018 05:15	TRUE	OTHERS	87.286	75.368	OTHERS
13.048	77.58	04-05-2018 05:17	TRUE	PEOPLE	83.072	71.98	CAN TOLERATE (No/Minimal Disturbance)
13.048	77.58	04-05-2018 05:32	TRUE	OTHERS	53.324	42.662	OTHERS
13.026	77.546	04-05-2018 07:12	TRUE	ROAD TRAFFIC	63.235	55.125	GENERAL DISTURBANCE(Slight Irritation)
13.024	77.643	04-05-2018 08:53	FALSE	ROAD TRAFFIC	90.217	78.498	CAN TOLERATE (No/Minimal Disturbance)
13.026	77.637	04-05-2018 08:54	FALSE	VEHICLE HORN	90.304	88.419	CONTINUOUS IRRITATION
13.029	77.632	04-05-2018 08:55	FALSE	ROAD TRAFFIC	90.304	84.956	CAN TOLERATE (No/Minimal Disturbance)
13.041	77.621	04-05-2018 08:58	FALSE	VEHICLE HORN	90.309	87.382	GENERAL DISTURBANCE(Slight Irritation)
13.041	77.619	04-05-2018 08:58	FALSE	VEHICLE HORN	90.309	87.764	GENERAL DISTURBANCE(Slight Irritation)
13.041	77.617	04-05-2018 08:59	FALSE	VEHICLE HORN	90.262	87.341	GENERAL DISTURBANCE(Slight Irritation)
12.962	77.658	05-05-2018 10:55	TRUE	OTHERS	67.989	44.453	
12.962	77.658	05-05-2018 10:56	TRUE	OTHERS	39.578	35.189	
13.048	77.58	08-05-2018 04:34	FALSE	OTHERS	62.676	50.625	

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