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Smart City

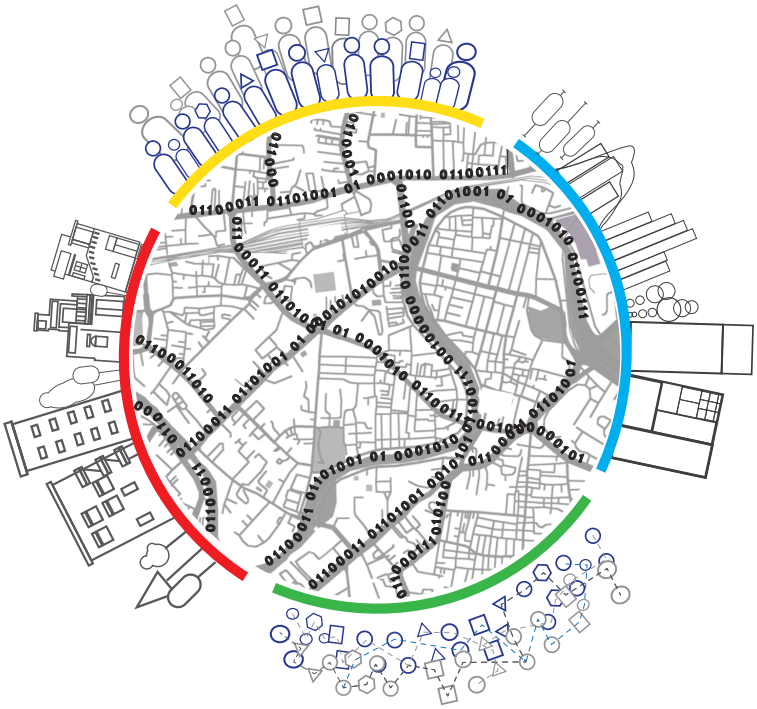
Ministry of Housing and Urban Affairs
Government of India

आत्मनिर्भर भारत

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Designing Systems for Water Security

SCADA Based Water Management System in Nava Raipur



CASE STUDY 10 | MARCH 2021

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Data Driven Governance

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ABOUT SMART CITIES MISSION

The Ministry of Housing and Urban Affairs is the apex authority of Government of India at the national level to formulate policies, sponsor and support programme, coordinate the activities of various Central Ministries, State Governments and other nodal authorities and monitor the programmes concerning all the issues of housing and urban affairs in the country.

Ministry of Housing and Urban Affairs' Smart City Mission was launched on 25 June, 2015. The main objective of the mission is to promote cities that provide core infrastructure, clean and sustainable environment and a decent quality of life to their citizens through the application of 'smart solutions'. The mission aims to drive economic growth and improve quality of life through comprehensive work on social, economic, physical and institutional pillars of the city. The focus is on sustainable and inclusive development by creation of replicable models which act as lighthouses for other aspiring cities.

100 cities have been selected to be developed as Smart Cities through a two stage competitive process. In the context of our country, the six fundamental principles on which the concept of Smart Cities is based are (i) Community at the core of planning and implementation; (ii) Ability to generate greater outcomes with the use of lesser resources; (iii) Cooperative and competitive federalism; (iv) Integration, innovation and sustainability; (v) Technology as means, not goal; and (vi) Sectoral and financial convergence.

ABOUT TATA TRUSTS

Since inception in 1892, Tata Trusts, India's oldest philanthropic organisation, has played a pioneering role on bringing about an enduring difference in the lives of the communities it serves. Guided by the principles and the vision of proactive philanthropy of the founder, Jamsetji Tata, the Trusts' purpose is to catalyse development in the areas of health, nutrition, education, water, sanitation and hygiene, livelihood, digital transformation, migration and urban habitat, social justice and inclusion, environment and energy, skill development, sports, and arts and culture. The Trusts' programmes, achieved through direct implementation, partnerships and grant making, are marked by innovations, relevant to the country.

The Data Driven Governance (DDG) portfolio within Tata Trusts, works with rural & urban governance systems to enable inculcation of data as a way of life in the planning and delivery of government schemes-thereby creating significant impact for underserved and marginalized communities. The urban engagements under the portfolio, provide directed technology and capacity building support to urban administrations at central and city levels. Under their capacity building initiative, Delta Ace, DDG portfolio, has focused on addressing the capacity needs of officials within urban local bodies (ULBs) and municipalities to carry the mandate of Data Smart Cities forward. The first City Data Officer Training Program was rolled out in joint partnership with Smart Cities Mission to train CDOs across all smart cities, as the data leaders within their ULBs.

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Designing Systems for Water Security

SCADA Based Water Management System in Nava Raipur

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CONTEXT

Keywords: City Data Officer, Smart Cities, Urban Local Bodies, SCADA, intelligent water systems, e-governance, water quality monitoring

Nava Raipur Atal Nagar is a greenfield, planned city and part of Ministry of Housing & Urban Affair's (MoHUA) Smart Cities Mission. Being a greenfield city, it is endowed with state of art technology and software applications that equip it for intelligent city management services. Some of the initiatives by the city include.

- **Electricity**: The city has Supervisory Control and Data Acquisition System (SCADA) based electricity management to have online monitoring and control of water supply. Alternative and sustainable energy sources like solar energy are being deployed. Street lighting leverages network control and light emitting diode (LEDs).

- **Telecommunication:** Overlaying Area Network with optical fiber connectivity has allowed for easy data transmission and wireless services. Additionally, ducts have been installed for city level telecom network and for broadband and value added services.

- **Water Management:** Use of Information and Communications Technology (ICT) solutions like SCADA to monitor water availability, quality and meet the city's demands.

This case study focuses on how the city has deployed SCADA to study water utilities management, ensure uninterrupted and quality water supply, centrally maintain hydraulic parameters and early restoration of the services in case of an outage event.

Employing data centric tools, technology and planning provides insights into quantitative and qualitative development indicators, makes way for informed policy making, measurable performance indicators, facilitates meaningful collaborations and improves overall governance.

Tata Trusts, through their Data Driven Governance (DDG) portfolio have been working towards enabling stakeholders within a governance system to view & leverage data as a cornerstone for decision making. Trusts collaborated with the Ministry of Housing & Urban Affairs (MoHUA) to implement a capacity building course for City Data Officers (CDOs) and urban local body officials across the 100 smart cities.

The aim of the course is to support and enable civic officials in adoption of evidence based decision making in day to day city planning and administration. The course focuses on an urban data governance framework that can be applied in achieving key city objectives, driving effective policy decisions and improving transparency.

It includes topics such as change management, tools and techniques for data gathering, cleaning, analysis, visualization, performance benchmarking, urban data policies, data governance & regulatory framework, urban data platforms, using data for policy to name a few.

As a part of post course engagement, Data Driven Governance team is putting together a set of case studies that demonstrate cities' experiences of adopting data in various city functions. The objective is to showcase cities initiatives whilst facilitating exchange of best practices and promoting cross learning.

Laying Down Systems for Intelligent Water Management

The Challenge

Nava Raipur Atal Nagar is a greenfield city which was created after the formation of the new state of Chhattisgarh in 2000. Being a planned city, Nava Raipur has access to many opportunities for planned growth.

The city's master plan 2031 makes note of the opportunity to plan ahead for a growing population, in a way that enahnces quality of life of its citizens. Future forward planning for water access & quality is a critical aspect of this vision. The city introduced SCADA based water management, to overcome challenges in the management, operation and maintenance of the erstwhile water distribution infrastructure.

Some of these challenges pertaining to water management included:

- Lack of insights into the amount of water consumed by different groups/household units/ industries in the city.
- No data available on water leakage and the amount of water lost.
- Requirement of large human resource for maintenance and operation at every header and every section.
- The water supply system was completely human resource driven which made it difficult to regularly check and maintain water quality parameters for all underground reservoirs.
- Valves had to be adjusted manually to maintain adequate pressure and water flow.
- Lack of a single platform for consolidating all data and taking informed decisions.

The city envisions itself as the financial and economic center of Chhattisgarh.

It aims to provide its citizens access to convenient and affordable world class facilities in education, health, employment opportunities and standard of living. As the 4th planned city of India, Nava Raipur is swiftly growing. In the near future, the city is expected to generate more jobs resulting in more people moving to the city.

Keeping this in mind, the city has upgraded the existing water management system with SCADA to improve efficiency through a 24x7 pressurized water supply, real time monitoring, automatic water reading and an automatic billing software.

The Solution

A. Proposed Solution

From an early stage, Nava Raipur had the visionary leadership to think ahead and plan for digital transformation of the city. In the initial years when the city's physical infrastructure was being developed, the city administrators ensured that it should be Information and Communication Technology (ICT) ready.

Leveraging the existing infrastructure, in 2017, Nava Raipur Smart City introduced a comprehensive supervisory control and data acquisition (SCADA) system for improved water management. The SCADA system is a distributed computer system that is used by operations and management for process monitoring and automation.

SCADA based water management which is a web based application provides actionable data pertaining to water flow, pressure, leakage, consumption and distribution of the city's water supply system. It monitors, operates and control operations of all units/systems and associated devices at intake well, raw water pumping main pipeline, water treatment plant, water gravity main pipeline at various locations across Nava Raipur.

This helps Nava Raipur to provide 24*7 uninterrupted and quality water supply, maintain hydraulic parameters and respond with early restoration of the services in case of an outage event remotely and centrally.

B. How was it implemented?

B.1 SCADA based Water Management

1. **Automation of Water Intake**: At water intake level from the river, the water pumping system has been automated which gives data on the number of charges of pumps, pressure applied, and flow of water. This helps to understand the amount of water pumped from the river every day.

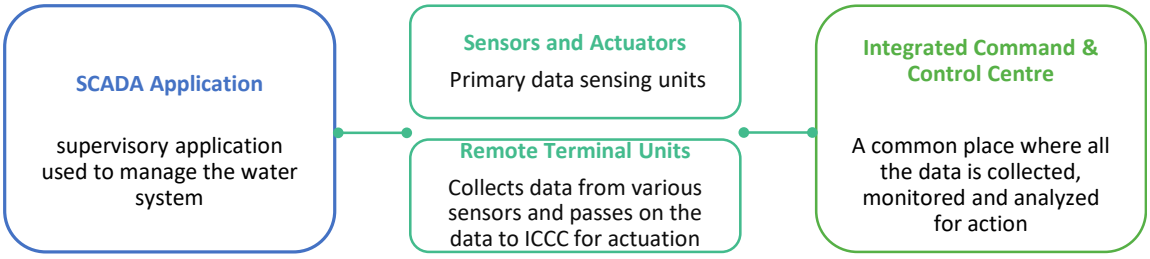

Figure 1: Overview of SCADA System

2. **Water Treatment:** At the water treatment plant (WTP), water goes through a sand filtration process. Water quality analyzers and sensors have been installed to check the quality of data such as hardness, turbidity, chlorine and pH levels. The water quality data generated is verified through SCADA and accordingly the water is chemically dosed and treated with lime and alum by the on field staff. After water is treated, and before it is delivered to the city, water quality is checked again. Losses of water from the intake well to the WTP plants are calculated by using time of operation of each pump set.

3. **Pressure Management:** From the intake well, a 51 km long distribution line has been installed with hydraulic parameter measures at two distinct locations to measure the pressure and flow of the water. The system can manage pressure across the entire network. Pressure at every head of the water pipeline is analyzed to know the pressure at a particular time and take appropriate steps to save water from leakage. Upon detecting the pressure of water, the system can recommend changes in the setting of the pressure regulating devices to the operator at Integrated Command and Control Center (ICCC).

4. **Water Distribution:** From the water treatment plant, water reaches 31 underground water reservoirs through gravity lines installed. From the underground water reservoirs, the water is pumped to the distribution network and to different sectors. The district has been divided into district metered area (DMA).[1] The entire process has been automated. The existing gravity and distributions lines were leveraged for this. With the introduction of SCADA based water management, wall and flow meters were installed in the existing lines. The water

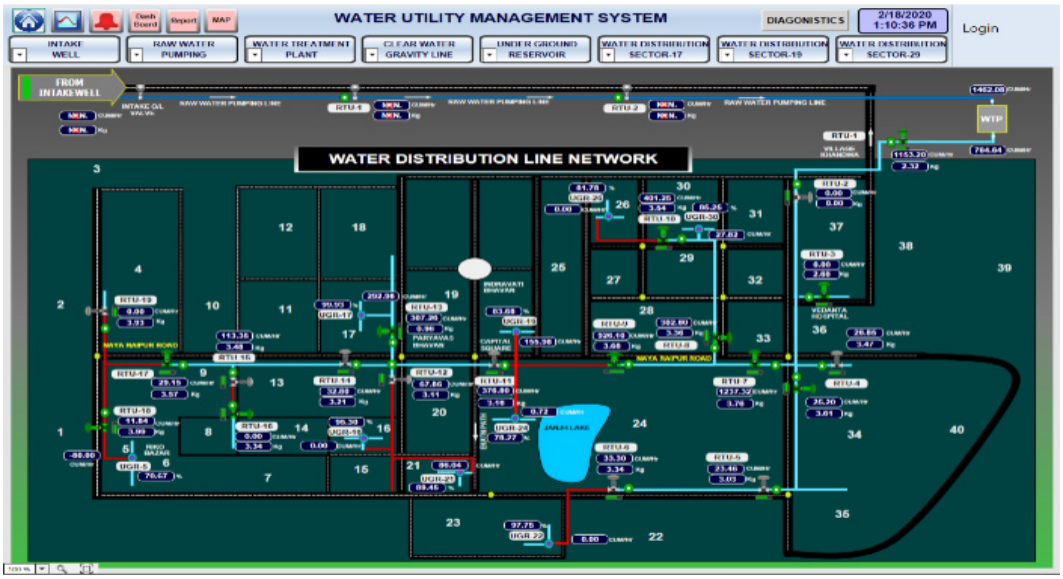

Figure 3: Water Distribution Line Network
(*Source: Screenshot provided by CDO, Nava Raipur)*

distribution lines which have 19 important points where hydraulic parameters such as pressure flow can be measured through remote terminals units (RTUs). By managing the control walls, flow and pressure at a given location can be remotely controlled through ICCC. At underground reservoir, there are parameters for quality to check the quality of water being supplied to the citizens.

5. **Water Consumption:** Water consumption is measured for each sector. Daily MIS report is generated which leverages the flow meter and flow control wall analyzers in the distribution line to determine the consumption of a given area. The data collected provides transparency which allows for improved water allocation. If there are changing trends in the data such as increased consumption in a given month then that is followed up with further research to determine the cause. Many a times this has helped identify points of water leakage. At most places, meters have been installed to measure the water consumption using radio frequency (RF) technology. This also allows for the water bills to be generated for the exact amount of consumption.

6. **Alarm Management:** The system is able to identify any anomalies in the operation of the water network such as: faulting in the meter, unusual water consumption, zone boundary breach, unreported operations, bursts and leakages. The anomalies are reported to the operator at ICCC in real time. Once the alarm is generated at the ICCC, the data is analyzed by the operator and once the anomaly is finalized then the corrective course of action is taken.

   Depending on the nature of the problem, the troubleshooting can be done through ICCC. This would usually include errors related

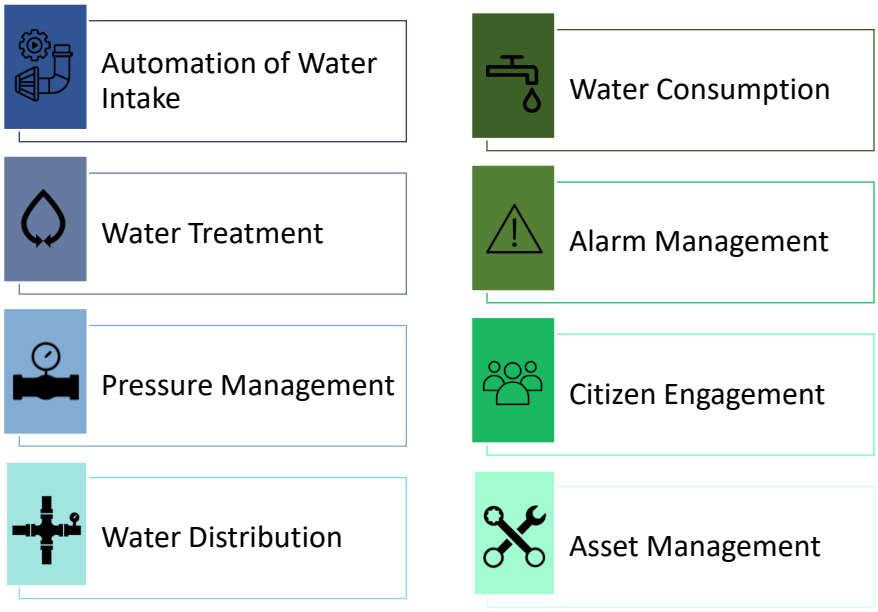

Figure 2: SCADA Based Water Management

to breakage of RTU, pressure and flow. If the anomaly requires on field rectification, operator from ICCC notifies the field engineer through the mobile application.

7. **Citizen Engagement:** Via e-governance which deploys a mobile application, citizens can directly engage with the authority to check water bills generated, pay bills, request for a new water connection. A helpline number has been established where consumers can call to register complaints related to water distribution, water leakage or water connectivity. Once the problem is identified and authenticated, technicians are assigned for resolution.

   For the purpose of water billing, automatic water reading meter uses a handheld machine at different households for assessing the water consumption. This data is fed into the server, and then, the water bill is generated.

8. **Asset Management:** Asset management for water supply management has been developed using Geographic Information System (GIS). This allows to determine the exact location of water leakage, pipe burst etc., streamlining pipe repair management and monitoring.

B.2 Data Management

1. **Open Connectivity:** The system has Open Platform Communication (OPC) which allows for real time communication of data amongst all control devices- software and hardware. It also has Open Database Connectivity (ODBC) which allows easy access to database management for customized reports and external data control. This includes historical and real time data.

2. **Reports:** The system has the capacity to analyze data collected and generate reports (i) Triggered by SCADA events (ii) On user demand (iii) On timed schedules. It is capable of combining data from multiple databases via ODBC. Historical water management data which was collected prior to SCADA management has also been incorporated into the system.

   Reports have details of water balances and performance indicators for water loss. The reports are accessible across all levels and zonal personnel through dashboards. Daily data analysis is reported and shared with stakeholders. PHED uses daily analysis report

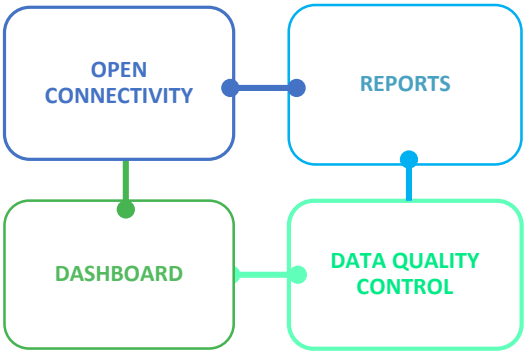

Figure 4: Data Management with SCADA

to identify breakdowns or challenges that need to be addressed.

3. **Dashboard:** The system provides visual and spatial information on maps, GIS layers and network schematics. It includes a web based human machine interface (HMI) where input data and simulation results for the entire network can be visualized, in the form of thematic maps, time series graphs, tables and longitudinal profiles.

4. **Data Quality Control:** Any information entering the data stream undergoes a data validation process through a series of tests such as discrete values, historical values etc. Data is categorized on the basis of its quality. The system is able to recognize anomalies in the data and flag it as erroneous. Such data is not used for any further analysis or any other use. However, the operator at the ICCC has the autonomy to review all data and make the final decision to retain or discard data.

Nava Raipur Atal Nagar Smart City signed a memorandum of understanding with Bharat Sanchar Nigam Limited (BSNL) to install an optical fiber network throughout the city in order to ensure smooth functioning of the water SCADA management system. It is important to have reliable connectivity so that data can be made available without interruptions. The captive fiber optic network of Nava Raipur is maintained by the Electrical department and the Information Technology (IT) team.

Pricewaterhouse Coopers (PwC) has been on boarded as the technical consultant. Jindal is the infrastructure partner. Technical partner is Schneider Electric who installed sensors and actuators at various locations for primary data collection. Schneider Electric and Infrastructure Leasing & Financial Service (IL&FS) are the master system integrators (MSI) for the project. Together, they support the delivery of services and help maintain the services that are available to optimize the system functioning. All the sites where the sensors have been installed were surveyed by the MSI to identify specific requirements, infrastructure gaps etc.

The day-to-day operations are taken care of by Nava Raipur's Public health Engineering Department (PHED).[2] PHED is the main team concerned with water treatment, maintenance and on field management team. Once an error in functioning is identified at ICCC, PHED is notified who deploys the on field maintenance team to correct issues. An Operations & Management (O&M) team has been on boarded to assist PHED. Field staff helps in preventive maintenance, leak detection, leak repair, equipment check and maintenance.

Data which is generated on a daily basis includes: operation of pumps, number of hours for which the pump is functional, data on water quality, and water consumption. Water quality can be tested and managed at every point of water management and distribution.

Data collected at every point is integrated with

ICCC via fiber optics network installed. This allows for real time monitoring In case of disruption in connectivity, there is capacity to restore data, allowing data to be sent to ICCC.

C. Solution Enablers

Centralization of Data Collection

- Centralization of all data collected at ICCC acts as an enabler for regular reporting, monitoring and controlling actions.

Collection of Real Time and Geographic Data

- GIS mapping of all existing infrastructures/ assets allows for easy management and planning of new infrastructure elements.
- The SCADA operator notifies the alerts to network managers and field technicians to take immediate actions to prevent or minimize service disruptions.

Predictive Analysis

- The system is able to predict the operations of hydraulic and water quality parameters for the next 48 hours and raise alarms based on the future state of these parameters, when required.
- The system allows the operator to create operational what if scenarios and visualize the results of these scenarios for easy comparison and decision making.
- The water bills generated allow to determine the consumption in a given neighborhood.

Historical Data Analysis

- Online historical data is available in SCADA system, which is used to analyse water quality, water supply & demand, water wastage, pipeline pressure, etc. This allows to monitor and minimise water loss in supply network.

D. Challenges

Revenue Generation

- The population of Nava Raipur is little over 5 lakhs. This reduces the scope for revenue generation. The SCADA project was approved keeping in mind that the city will grow over the years which will improve the viability of the project.

Availability of Personnel

- Availability of trained resources who can work with specialized datasets and data system is a challenge.
- When there is disruption in SCADA operations due to lost connectivity, availability of a greater number of human resource on

ground becomes a challenge. The number of individuals employed on ground has reduced since the implementation of SCADA based management.

Coordination amongst Various Stakeholders

- There are several stakeholders involved in the project. Coordination amongst all the stakeholders becomes difficult at times resulting in lack of accountability.

Electrical Lines

- The electrical lines were installed before the advent of SCADA based water management. Although there is GIS data available on the location of underground lines, it is not always accurate, resulting in installation and management delays.

The Impact

Automation of Water Management System

- SCADA water management system has resulted in complete automation of data collected, replacing manual data collection.

Better Water Allocation

- Through the analyzers in the distribution line, it is possible to measure the water consumption. Increased transparency of water usage has resulted in better water allocation. It has also resulted in water conservation by about 20%.

Improved Management

- Regular monitoring has resulted in preventive maintenance improving overall water quality.
- Improved accountability within the city administration through real-time assessment, planning & management of water.
- Enhanced decision making through business analytics, reporting and tools.
- Underground reservoirs operate in an auto mode. If the water level in the reservoirs becomes too high, the water inlet valve automatically closes resulting in prevention of water wastage.

Inter Department Coordination

- Coordination amongst urban local body departments such as electricity, PHED etc. has improved as a result of this implementation.

Conclusion

By collecting real time data on water pressure, it's been possible for the city to manage the water flow- this coupled with analysis of water consumption in different sectors has resulted in water conservation. For any citizen related service, it is imperative for the city to engage its citizens and encourage their participation. The e-governance component allows the citizens to access information related to water services, raise complaints, and pay bills from a mobile application.

Nava Raipur has taken into the account the population growth that city is expected to experience in the future and has already developed infrastructure that will allow the city to better serve in the present and be resilient in the face of future. It must be noted that the true potential of water SCADA management will only be known with time; some of its immediate results can already be seen.

While planning for the present improves the quality of living, if it does not take into account the future growth of the city which is often accompanied by influx of people, the quality of life can be disrupted going ahead. Nava Raipur has illustrated well how a city can leverage data not only to improve its existing services and administration but also to be prepared for the future needs of the city.

Endnotes

1. District metered areas are small clusters of water users with a provision to individually monitor the water supplied and consumed.
2. Public health Engineering Department (PHED) is responsible for water supply and management.

Abbreviations

BSNL	Bharat Sanchar Nigam Limited
DDG	Data Driven Governance (Tata Trusts)
DMA	District Metered Area
GIS	Geographic Information System
HMI	Human Machine Interface
ICCC	Integrated Command and Control Center
ICT	Information and Communications Technology
IL&FS	Infrastructure Leasing & Financial Service
LEDs	light emitting diode
MSI	master system integrators
MoHUA	Ministry of Urban and Housing Affairs
O&M	Operations & Management
ODBC	Open Database Connectivity
OPC	Open Platform Communication
PWC	Pricewaterhouse Coopers
PHE	Public health Engineering Department
RTU	Remote Terminals Units
RF	Radio Frequency
SCADA	Supervisory Control and Data Acquisition
WTP	Water Treatment Plant

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