NARAYANPUR LEFT BANK CANAL AUTOMATION PROJECT

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ABSTRACT

In present study, Narayanpur Left Bank Canal (NLBC) Automation System, comprises Supervisory control and data acquisition (SCADA) based automation from Dam to farmer delivery outlets supported by a robust communication system, Geographic Information System (GIS) based Irrigation Network Management Information System (INMIS). Due consideration of Indian economic, social conditions INMIS have been implemented for improving yield in command area by efficiently managing and distributing water judiciously. The system has been pioneering in its design, by the virtue of the farmers at the tail end have received water first time in the history of this canal irrigation project. The system features primarily centralized SCADA system closely integrated to GIS based INMIS for demand aggregation, water allocation and irrigation scheduling with vandalism proof Internet of Things (IoT) based integrated gates comprising of gate actuator, solar power system, level and flow control, wireless communication, security cage and robust design catering to Indian conditions.

Keywords: Farmer focused Canal Automation, Smart Irrigation, GIS, INMIS, SCADA

1. INTRODUCTION

Canal Automation aims at sharing of water judiciously, equally and efficiently among the farmers and other stake holders in command area and reduction of losses (Wahlin and Zimbelman, 2014). By improving the efficiency of the system, it increases the command area by the virtue of saved irrigation water, in turn, increase the crop productivity in the tail end regions. Recently, the Government of India (GOI) has launched National Water Mission (NWM) as a part of national action plan for climate change. The prime objective of NWM is to conserve water, minimizing wastage, ensuring its equitable and judicious distribution across and within the states through integrated water resource development and management. The NWM has been taken into account the provisions of the national water policy, which develops a framework to optimize water use by increasing water use efficiency by 20% through regulatory mechanisms with differential entitlements and pricing. As a sequel to the policy of the GOI, a comprehensive strategy plan was worked out by Krishna Bhagya Jala Nigam Ltd. (KBJNL - http://www.kbjnl.karnataka.gov.in/) to improve water use efficiency by 25% in NLBC system through total system improvement. Phase 1 of the system was launched in 2014 as a pilot project, to be further expanded to entire reaches of the canal. The system was uniquely designed with a specific focus on farmers, and was pioneering to achieve a close integration of GIS, MIS and automation to achieve optimized water use efficiency and distribution with firm focus on farmers, empowering them with a platform which enabled them to plan their cropping, understand demand allocation and also, increase crop productivity within the command area. This system is immensely useful to the farmers in the command area and also, they are empowered with knowledge about the water availability, canal schedule, commodity prices, billing and directly on the system through crop planned and corresponding area details. Keeping in the view of above discussion, the objectives of present study comprises as, (i) to increase the water use efficiency in the network, empowers the management to accurate control on flow through gate operation and accepts the responsibility of automatically control the canal network even in the absence of operators, (ii) to develop the system for catering water demands from the end user and manage available resources efficiently, (iii) to develop the system for mapping of the canal network, beneficiaries to a single platform and to meet their requirement and future expansion, (iv) to develop centralized audit system using water accounting and auditing by establishing flow measurement devices for providing excesses, deficits and corrective measures taken in the canal network, (v) to compare water use in volumetric

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terms per hectare by the distributaries and the defined boundaries, for ensuring optimum water utilization per hectare across the command area. From management and operator perspective, the presented system is a centralized database of canal and sub canals with various nodes, details of farmers, crops individual and zone wise, water bills and soil health, cadastral maps, contour data, updated satellite imagery, water allocation and use etc. The presented study, i.e., INMIS and GIS based SCADA system for canal automation with integrated gates may turn out to be a holistic solution for all stakeholders of the NLBC project.

2. STUDY AREA

The Narayanpur dam with NLBC command area comprises as a study area for the present investigation. Narayanpur Dam is located on Krishna river near Bachihal and Siddapur village of Bijapur District of Karnataka state in India, see Fig. 1. This reservoir caters to the irrigation needs of a very vast area of about 4.5 lakh hectares. The reservoir supplies water to Narayanpur Left Bank canal (NLBC) is the biggest and the main artery of canal network about 77 Kms have designed to discharge of 10,000 cusecs. The length of entire canal network including sub-systems is 6000 km within the project, see Fig. 2. There are six branch canals, i.e. Hunasagi Branch Canal, Indi Branch Canal, Jewargi Branch Canal, Mudbal Branch Canal, Shahpur Branch Canal, and Indi Lift Canal within the network systems.

![Figure 1. Index map of study area](image)

3. EXISTED SCENARIO BEFORE IMPLEMENTATION OF CANAL AUTOMATION SYSTEM

The following points were addressed and existed before implementation of canal automation technology within the study area.

(a). There were suffering atchkut of 1,05,623 Ha where water has not been delivered from the construction of Narayanpur Dam and NLBC network.

(b). The Water Use of Efficiency (WUE) was of 31.75% against design efficiency about 51% within the system.

(c). The infringement of rotational system, i.e., warabandhi was existed within the system.
The proper water regulatory system was not available within the NLBC network.

There was inadequate manpower for canal operation and maintenance in the study area.

The methodology was adopted as fixed flow structure and manual control of the gates, which exhibited wastage of water, inaccuracies and uncertainties in measurement and poor emergency response within the canal network system.

There were inequitable regulations between upstream & tail end water users, hence, tail end users have not been able to receive water.

There were no centralized IT based regulations on water demand aggregation because of area wise water allocation policy were existed rather than actual crops planned within the study area.

The farmers were unable to access information about water availability, plan crops, and commodity prices. Also, there was not any system available for centralized billing and revenue management for this irrigation project.

There is no GIS based information about command area about soil health, crops, water demand and allocation, weather, contours etc.

Establishment of project set up and their implementation

Keeping in view of aforesaid scenario, the following project implementation strategy and solutions were planned to overcome deficiency of the system and become sustainable solution for the concerned stakeholders within the canal network system.

To provide and fix SCADA based “Integrated Automatic Gates” at 30 distributory gates, 335 laterals and DPOs which includes all Distributory Heads on NLBC main canal and entire command network of Hunasgi Branch Canal (HBC);

To implement SCADA software for automatic control and regulation;

To develop the INMIS based on planning of water demands and availability of water before start of the season within the study area;
To set up GIS based data and information generation system such as, mapping of base map, cropping pattern, soil health, weather, water use, water demand, etc. and their continuous updation in every season;

(n). To establish 210 Kiosks tool as part of water allocation management for information collection and dissemination to water user cooperative societies;

(o). To set up AutomationEx of existing 41 Head Regulator (HR)/ Cross Regulator (CR)/Escape gates on NLBC main Canal with Mechanical Refurbishing and electrical retrofitting;

(p). To establish wireless data communication network system;

(q). To set up master control station and training center at Narayanpur and ten other remote monitoring stations within the network system including operation and maintenance of five years,

The step by step establishments of project set up and implementation strategy have been discussed in succeeding paragraph for smooth functioning and execution of centralized GIS based SCADA integrated INMIS within NLBC canal network system.

4.1 Automation of existing HR and CR gates (41 Nos.)

There are existing 41 Nos. of radial gates available at HR and CR locations within the NLBC network system, which were needed to automate for the canal automation and regulations of water demand in the canal network. These radial gates, see Fig. 3, are updated as SCADA based electrical and mechanical retrofitment in the project. Also, the CR control rooms were constructed near to these gates by installing panel instrumentations, for instance, (a) encoders for gate positioning, (b) up & down limit proxy, (c) local control panel for local mode gate operation, (d) u/s and d/s Level Sensor to calculate discharge, (e) gate control panel with touch screen display, (f) network equipment for data transmission and reception.

4.2 Solar powered integrated automated gate

Solar powered integrated gate is specially designed with stainless steel material to avoid erosion and corrosion in the field for combined flow control and metering application within the canal network system of NLBC, see Fig. 4. The integrated gate has built various components, such as, (a) accurate gate control system, (b) accurate gate measurement system, (c) flow measurement device, (d) u/s and d/s water level measurement system, (e) wireless communication system, (f) self sufficient solar based power supply system, and (g) CCTV cameras.

The installed integrated gate can be operated and monitored on field as a standalone gate or operated remotely from master control centre when connected to SCADA communication network. It is a smart device and uses M2M communication to connect to any TCP IP/SCADA/Internet of things network. The integrated gate controls the water discharge by gate operation based on desired set-points, or demand based. The installed integrated gate also has outer vandalism proof cage and it has proven that there is 0% of theft activity happened since last 2.5 years within the canal network system.

4.3 Hybrid Wireless Data Communication Network

The communication network is designed as a hybrid network considering the large area of operation. Since the parameters and conditions of each locations, the changes are made considering geography, terrain, climatic conditions, distance and future expandability at that particular location within the canal network system. The three components, i.e., main SCADA centre, data concentrator station, and slave stations are installed for establishing the hybrid wireless data communication network within the system, see Fig. 5.
Figure 3. Integrated gates installed within canal network of NLBC

Figure 4. Typical installation of solar powered integrated gate within the system

Figure 5. Hybrid Wireless Network Typical Architecture
(i) Main SCADA centre
At Narayanpur, there is a master VSAT transmitter and receiver equipments and it is connected to all Master Data collection stations by VSAT. VSAT gives bi-directional communication within the system.

(ii) Data concentrator station
Master data collection station has control of HR and CR gates which are polling the slave radios through UHF radios and concentrate the data. It is sending the concentrated data to Main SCADA Centre by VSAT.

(iii) Slave stations
Slave stations are integrated with gates at various HR and CR locations which are polling by master station and data are collected at master station. Some Stations act as repeater, and connect the farther station to the master. All stations at various locations at HR and CR gates have GSM/GPRS backup communication system.

4.4 Soil Collection, Testing and Preparation & Distribution of Soil Health Card
(2.78Lakh soil samples)
As a National Mission for Sustainable Agriculture (NMSA) during 12th Plan of Niti Ayog, Govt. of India, the objectives have been formulated to make agriculture sector more productive, sustainable and climate resilient; to conserve natural resources; to adopt comprehensive soil health management practices; to optimize utilization of water resources. “Soil Health Management” (SHM) is one of the most important interventions for this mission of Govt. of India. There were about 0.278 millions soil samples collected from the command area and tested in the laboratory. These soil health cards, see portal in Fig. 6, were distributed to the farmers through INMIS, Information Kiosk and specially developed smart phone application for successfully execution and implementation of this project objective. These soil map data were transformed into layers for mapping through GIS based visualization within the canal network system.

Figure 6. Soil health card portal for collection of farmer, soil, crop, other details

4.5 Irrigation Network Management Information System (INMIS) for entire command area (0.54 million ha) of NLBC
To manage the entire canal network spread among three zones and several other sub juridical systems, it was necessary to implement Irrigation Network Management Information System (INMIS). It comprises of office process automated and providing single click information about all the canal details with the end users and beneficiaries of the system. The entire system regulates and controls the information related to user management, canal structure with all the design details, data of all the stakeholders at each section of canal network, water user co-operative society implementation, handling of crop water requirement collected from end user and WUCS, updating the
analytics of collected water demand integrated with SCADA software for canal automatic operation and canal monitored data incorporated for revenue generation through crop water billing from WUCS and farmers.

4.6 Geographical Information System (GIS) for entire command area (0.54 million ha) of NLBC

When working with wide spread command area of 0.54 million ha, it is necessary to have GIS based system for mapping and existing activity working within the command area. The GIS based mapping of canal structures with respect to revenue and cadastral maps were made to simplify the powerful tool for catering the need of end user requirement. The user can simply get the details for canal network to farmer information. GIS based mapping also cater base map generation for day to day routine decision making perspective. These were included more than 42nos. of informative data layers, such as, soil health layer, land use land cover, contours, Digital Elevation Model (DEM) and other related details. Currently, the system is performing well and helping to take decisions by authorities of NLBC system. Also, this system has exceptional capability to analyze season wise cropping pattern and crop yield within the command area which is very useful to stakeholders, for planning the water use requirement intended for next season from last two and half years. The sample data layers and GIS framework of NLBC network system, is included in Fig. 7.

![GIS framework of NLBC network system](image)

**Figure 7** Sample of data layers in GIS framework for NLBC network system

4.7 Information Kiosk with farmer dashboard

Information Kiosk with farmer dashboard has become powerful tool for e-governance and all information at one place intended for farmer focused and their growth. The following information were collected and stored for the usefulness of farmer.

(a). Details of farmer details with canal command jurisdiction offices for solving grievances

(b). Information about irrigation schedule for better planning of crop water releases

(c). Farmer can raise their water demand depending upon cropping pattern and area for irrigation within command area.

(d). Revenue collection being made easy and accessible through crop - Water Billing

(e). Weather observed and forecast details on one single click

(f). State wide commodity rates are accessible right from the kiosk
(a). Soil health card viewing facility is also provided to the farmers within command area
(b). Important portal links and accessibility of all the central and state government facility provided to the farmer.
(c). Enormous knowledge base in terms of books are added to the system
(d). The farmer dashboard is multilingual which can be accessed in Kannada, Hindi and English.

4.8 SCADA system software for controlling and monitoring

SCADA system software (see Fig. 9) is implemented for the monitoring and controlling of integrated gates and HR/CR gates of canal network system through wireless data communication network. The water demand data has been feed to SCADA software to monitor and control automatically canal regulation points and to make them proper analytical reports which enable decision maker to understand situation in whole command area of NLBC network system.
4.9 Development of smart phone application for farmer

It is a miniature version of Information Kiosk on a smart phone which can be downloaded to smart phone and can be used as Information Kiosk by the stakeholders within the command area. The sample screen shot of the application is shown in Fig. 10.

![Smart phone application for farmer](image)

**Figure 10.** Smart phone application for farmer

4.10 Master control station

Master control station is located at Narayanpur (see Fig. 11), which cater all command area related information and control as well as regulate the information. Master control station has equipped following equipments:

- SCADA Application Server
- INMIS Application Server
- GIS Application Server
- Engineering Station
- Wireless Data Communication Master Station Equipment
- 10 Mbps Lease line for Web Connectivity
- UPS and Generator set for Power backup

4.11 Remote monitoring station

Remote monitoring station is meant for monitoring of canal command area and not for any control. The total ten numbers of monitoring stations have been established for monitoring the flow and other canal related activity at Sub-division & Division level within the NLBC network system.
4.12 Training Center

This project comprises of various components and technology, henceforth, capacity building among all the stakeholders, i.e., from farmers, WUCS presidents and KBJNL office staff of the system were necessary to have training center, see Fig. 11. The center facilitates the regular training to all stakeholders at Narayanpur. Training center is equipped with state of art classroom in which 35 numbers of people attend trainings at a time, and also, have hands on sessions for all the application software.

![Figure 11 Master Control Station and Training Center](image)

4.13 Operation and Maintainance of the project

The five years of project operation and maintenance were conditioned as per project contract, out of which two and half years has been completed successfully. Also, the project is functioning well in current scenario.

5. OVERALL SYSTEM ARCHITECTURE

Overall canal automation system is comprises of various components, the system architecture and data flow is depicted in Fig. 12.

![Figure 12 NLBC Canal Automation Architecture](image)

(a). Farmer / WUCS list their crop and Area which they are willing to cultivate for the particular crop season.

(b). All the water demand goes to the respective office and complete canal command area water report is generated and analyzed through INMIS & GIS.

(c). Irrigation Scheduled is prepared as per the demand collected.
(d). Irrigation Schedule is published in farmer dashboard.
(e). Analyzed and approved irrigation schedule is feed to canal control & SCADA Software.
(f). All the necessary commands and set points is generated by the software and transmitted to the HR/CR & Integrated Gates
(g). All the feedback is taken into SCADA is also given to the INMIS and Crop - Water Use analyzed into INMIS & GIS.
(h). Water bills are generated through INMIS.
(i). Crop Pattern and Crop Yield report is generated through Remote Sensing data for particular crop season.

CONCLUSIONS

As this was the first and one of its kind of project happened in India, various laboratories and field tests have been conducted and witnessed by various scientists from renowned institutions of Govt. of India, such as, Central Water and Power Research Station(CWPRS), Pune, FCRI, WAPCOS, Indian Institute of Science (IISc) Bangalore and KBJNL. They have passed and verified all the tests for specified performance in the Indian Eco-Sociological condition and project got sanctioned certificate for the same. The conclusions derived from the present study are as follows:

(a). First time in the history of NLBC, water delivered to the tail end users suffering atchkut area,
(b). Increased and optimized the water use efficiency within the network and reduce water loss,
(c). Single room control for canal operation,
(d). Water distribution has been done judiciously, equally and efficiently among the farmers/stake holders in command area,
(e). Increased irrigated area and agriculture production till tail end and command Area
(f). Smooth function of water auditing and accounting,
(g). Online water demand, water billing & Revenue generation that reduced cost of paperwork and process improvement,
(h). Instantaneous decision making system and reduction and elimination of man-made errors,
(i). Reduction in operational costs and maintenance requirements,
(j). Better services to the water users and responses to emergencies,
(k). Easy water management system for enhancing collaboration and knowledge sharing within government and stake holders.

REFERENCES


KBJNL website portal: http://www.kbjnl.karnataka.gov.in/