Review Article
Volume 12:05, 2023

Irrigation & Drainage Systems Engineering

ISSN:2168-9768

Open Access

Modernisation of Irrigation System for Optimum Utilization of Water with Particular Reference to Harsi Project in Madhya Pradesh

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Abstract

Water is an essential resource for overall development of human settlements. While the demand for water is rising with increase in population and improvement in standard of living, supply of natural water remains more or less constant. As a consequence, the cost of procuring water is increasing fast. Industries and major urban settlements in India and other countries with water shortage have already started taking appropriate measures for conservation of water and optimization of water usage. Currently, the agriculture and irrigation sector has to compete for water with other sectors, an overall irrigation strategy needs to be formulated for ensuring equitable and economic distribution of water in the basin set up.

Various types and formats of irrigation usage have been significantly contributed to development of human civilisation over centuries starting from irrigation by flooding in the Indus Valley civilization to irrigation by canal system in the mauryan period and commercialization of irrigation water in the twentieth century.

This paper presents the state-of-the-art concepts of various issues connected with modernization of canal and water usage system. It is observed that modernization of irrigation needs improvement in all aspects of water usage in agriculture and irrigation. Two most important aspects in this context are Water Productivity and Irrigation Scheduling. Water productivity facilities production of the same quantity of crop by using less water along with more efficient management. In India, excess water accumulates on the field during periods of heavy rain. Such excess water can be utilised either by proper drainage and reutilization of drained water in the same command or in some other command or by allowing the water to recharge the aquifer below the irrigated field and developing a proper system of conjunctive use of surface and ground water.

Accurate irrigation scheduling is a complex issue, depending on both climatic and crop factors. In India, water availability varies widely over space and time. Hence, a long term irrigation scheduling study can be carried out only through stochastic simulation of long term hydrologic water balance data. However, for immediate field decisions, advanced instrumentation system has to be adopted.

Keywords: Water productivity • Irrigation scheduling • Stochastic system • Recirculation, telemetry • SCADA • Participatory management

Introduction

Water, a very important and valuable community resource is essential for existence of life on earth. Increase in population and improvement in standard of living are the demand for water at a very fast rate. However, the supply of fresh usable water is limited and controlled by the natural hydrologic cycle, a part of the overall environment of the mother earth. Thus, water is one of the most important aspects of overall ecological system. Currently demand for water is increasing from various sectors like the urban, agricultural/industrial/power/navigation sector. At the same time, the food requirements of the population have to be met through agriculture and irrigation sectors. The present Water Resources and Irrigation scenario in India is rather complex. India has 16% of human population, 15% of farm animal population, 2% of geographical area and 1% of rainfall, unevenly distributed over space and time. 75% of India's rural population is intimately connected with agriculture and the irrigated agriculture sector has contributed significantly to India's economic development and poverty alleviation. During 1950 to 1970 India was a net importer of food and irrigation was the prime consumer of water. There was not much change in the situation during. However, since 1990, industrial, urban and power sectors are increasing fast leading to larger share of water consumption. It is essential in this context to modernize the irrigation system for optimal use of our water resources by economizing water consumption vis-a-vis yield of agricultural products. This involves not merely improvement of engineering parameters e.g. lining of canals/improvement of structures/providing additional field channels but also application of a complex combination of field disciplines (agronomic/management/field measurement and hydro-sociological aspects) to the irrigated agriculture sector. This process would also include restoration/rehabilitation/detailed diagnostic analysis/ and performance evaluation to identify/quantify design and execute the changes required. The present paper uses the modernization plan scheme of the Harsi project, located in District Gwalior, Yamuna Sub-basin/sindh Sub-sub basin) under Madhya Pradesh water sector restructuring project as an example of irrigation system modernization [1].

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Received: 17 March, 2023, Manuscript No. IDSE-23-92061; **Editor assigned:** 22 March, 2023, PreQC No. IDSE-23-92061 (PQ); **Reviewed:** 05 April, 2023, QC No. IDSE-23-92061; Revised: 18 May, 2023, Manuscript No. IDSE-23-92061 (R); **Published:** 16 June, 2023, DOI: 10.37421/2168-9768.2023.12.388

Literature Review

Modernization of Irrigation system may be defined as (FAO, 1996)

The act of upgrading of improving the system capacity to enable it to respond appropriately to the water service demands of the current times keeping in perspective future needs. OR, a process of technical and managerial upgrading (as opposed to mere revamping and rehabilitation) of irrigation schemes combined with Institutional reforms, with the objective to improve resource utilization (labour, water, economics, environmental) and water delivery services to farms. OR, the transition from supply-oriented to service oriented water delivery [2].

Third, it is now well understood that modernization is not limited to the introduction of modern hardware and software techniques, but complies a fundamental transformation of the water resources processes. Such transformation might include, among others, changing rules and institutional structures related to water rights, water delivery services, accountability mechanisms and incentives in addition to physical structures. Hence, the first steps towards modernization would require identification of:

- Technical gaps.
- Financial constraints.
- Social constraints.
- Institutional constraints.

Once the gaps and constraints are identified, the aims and objectives of modernization have to be determined. The objective is to improve yield/ water efficiency/performance of irrigation systems/irrigation services to farmers through, for example, better canal operation/appropriateness of distribution/financial sustainability/elimination of distrust between the employees and the water users/mitigation of environmental degradation as well as reduction of operation and maintenance cost and creation of a sustainable institutional system for management. Thus, the scope of modernization would envisage:

- Operation of the main and distribution system through advanced water control structures and modern operation tools.
- Water application at farm level.
- Introduction of flexibility in water deliveries as opposed to rotational and fixed deliveries.
- Use of modern construction technology such as use of geo-membranes.
- User participation.
- Efficient administration and accounting.

The central water commission of the government of India has formulated guidelines for the modernization of existing projects. These would include, among other, a review of hydrology/land potential/cropping patterns/crop water requirements/physical features of the canal system/ ground water/drainage/water management/environmental management and economic evaluation. Required modifications to existing structures and conveyance system have to be identified and provided for in the modernization projects. In addition, participatory irrigation management and operation plans for improved use of the canal system need to be included. Advances in technology provide many new computer based models and tools to support irrigation managers in taking better decisions to achieve maximum economy in water uses and on issues related to irrigation management (operation, water scheduling, maintenance and other associated activities). Often however, these models or tools are not properly designed to meet the needs of practicing irrigation management staff, leading to a disappointingly low contribution of computer based tools to irrigation management. In this context, the International Irrigation Management Institute, (IIMI, presently named as International Water Management Institute, IWMI) and the french research centre for agriculture and environmental engineering (CEMAGREF) launched a network (named Information techniques for irrigation systems, ITIS) for bringing together irrigation researchers and managers to work on generating and using better information for decision making. In the 5th International meeting of ITIS network on modernization of irrigation system operations held in Aurangabad during 28-30 October, 1998 several authors presented papers on modernization of irrigation systems with case histories from India and Sri Lanka. Some of the interesting findings and observations are presented [3].

Modernization and efficient operation of the irrigation system as well as of drainage systems beyond the outlets serving 40 Ha blocks

- Construction and lining of field channels.
- Land levelling and shopping.
- Field drains.
- Conjunctive use of surface and ground water.
- Suitable cropping pattern.
- Warabandi.
- Supply of credit, seeds, fertilizers, pesticides.
- Extension and training.

It may be noted that the concepts of water optimization, flexibility in water deliveries, accurate measurement of flow-rate, computerization and adoption of information technology, use of GIS and remote sensing data, were not included at that stage. In the same paper Mandavia, 1998 proposed adoption of a comprehensive canal automation system which will promote a flexible, high quality operation of a canal system with the benefits as under:

- Increased crop production.
- Reduced water use.
- Better service to water users.
- Increased power generation.
- Decreased power consumption.
- Labour savings.
- Less water waste.
- Easier management of the water system.
- Improved protection of the conveyance facilities.
- Reduced maintenance requirements.
- More accurate and equitable distribution of water.
- Fish and wildlife enhancement.
- Decreased flood damage.
- Social benefits.
- Environmental protection.

In the paper mandavia has discussed the status of canal automation with case history about the following projects in India:

- The Chambal project of M.P.
- Khadakwasla project of Maharashtra.
- Malegaon project in Maharashtra.
- Rajad project in Rajasthan.
- Sardar Sarovar project in Gujarat.
- Tungabhadra project Karnataka.

Discussed the canal automation system of khadakwasla and programme of introduction of a computerized management information system for the Maharashtra Krishna valley development corporation of the irrigation department government of Maharashtra. In the course of discussion on improving water delivery performance in the bhakra canal command has indicated development of a model for designing an optimal unit command area incorporating the concepts of equity, efficiency and productivity. Suggested improvement of water delivery system by providing tube-wells at the tail end of the command and relaxing the rigidity of delivery schedule [4].

Presented case histories on modernization of irrigation projects in Sri Lanka. One of the innovative efforts on system operation implemented in gal oya rehabilitation project was the computer aided water scheduling model with a two way communication network for daily monitoring of the water deliveries throughout the system. The model computes the weekly irrigation requirements based on crop water requirements according to growth stages, soil percolation rate, rainfall with application and conveyance losses. The daily diversion requirements at major diversion points and branching off points were monitored and gauge readings were transmitted to the central office through telephones [5].

With reference to the National Irrigation Rehabilitation Project in Sri Lanka Godaliyadda, 1998 proposed typological approach to the modernization of irrigation system operation on the basic assumption that irrigation systems have a heterogeneous behaviour with respect to operation. The goal is to bridge the gap between generic recommendations and site specific recommendations [6].

Mujumdar, 1998 presented information technology based improved management system for the teesta Mahanadi link canal being developed for the teesta multipurpose water resources project in West Bengal by CMC limited as a comprehensive management system. The IT based system covers integrated operation of the barrages, long term and short term plans of operation, scheduling of the operation of the main system and of the distribution network and improved monitoring and control for proper implementation of planned operations. The improved monitoring and control system will also help in effecting required changes in response to changes in river flow availability or the rainfall situation in the command area. The IT based system under development will rely on state-of-the-art technology. This may be customized easily for implementation in any other project with similar components and could be integrated in regional or river basin level management systems [7].

Matsushima shuichi (nichigikuraun), made an attempt to systematize the diversity aspects of irrigation modernization. Focusing on saving of water, he clarified that general movement of modernization was subject to strategic concept concerning integrated water management. “Spontaneity based approach “in which irrigation water demand is reduced by means of motivating water users is superior to “regulation based approach”. Thus, irrigation modernization can be divided into:

- Improving irrigation water delivery.
- Raising management level in quantity of water.
- Raising management level in quality of water.
- Reducing govt. interference/intervention in operation and maintenance.

It is evident that irrigation modernization is a continuously developing process and has to match the prevailing hydro-sociological and environmental set-up. It has to be flexible, user-friendly and needs sincere participation of users. Thus, it needs elaborate training and extension programmes at all levels keeping the stated objectives in view.

Results and Discussion

Water productivity

Producing more crops, livestock, and fish and forest products per unit of agricultural water use holds a key to both food and environmental security. Productivity is a ratio between a unit of output and a unit of input. The term water productivity is used to denote the amount or value of product over a certain amount of water consumption. Crop water productivity is the amount of water required per unit of yield and is an important parameter to assess the performance of irrigated and rainfed agriculture.

Clarified that water productivity is projected to increase through gains in crop yield and reduction in irrigation water and accordingly they identified five formulations for this indicator using different approaches to water input. They observed that hydrological analysis of water productivity posed a number of questions on the choice of the water input expressions. As an example, they pointed out that when adopting a basin wide perspective, irrigation return flows cannot be considered as net water losses.

Crop water productivity will vary greatly according to the specific conditions under which the crop is grown. To optimize the crop production system, one must understand how output increases with increase in water input. Ratios as under need to be evaluated to describe the concept:

Average product of water=(output)/(water input)

Marginal product of water=(change in output)/(change in water input)

In order to improve water productivity at irrigation system and river basin level better land use planning, use of weather forecast data, improved irrigation scheduling and use of various sources of water have to be adopted. FAO has developed a Water Productivity Simple Dynastic Model (WPSDM) on the basis of FAO Irrigation and Drainage Paper 33 on “Yield Response to Water”. This model is based on three major determinations:

- The estimate of actual water consumption by Transpiration (TA) of a crop during its crop cycle, under well watered or water deficit conditions.
- The estimate of above ground Biomass (B) produced by the crop based on the relationship between TA and Biomass water productivity (WPB) so that $B=\Sigma\ TA \times WPB$
- The final commercial yield (Y) of the crop making use of the Harvest Index (HI) obtained as function of B and the occurrence of relevant water stress during sensitive stages of the crop cycle so that:

$Y=B \times HI$

Irrigation scheduling

Irrigation scheduling is very important to achieve optimum water productivity and denotes the decision as to when and how much water is to be applied to a field. The purpose is to maximize irrigation efficiency by applying the exact amount of water needed to replenish the soil moisture to the desired level. Irrigation scheduling saves water and energy. Prof. Broner has prepared a detailed treatise on irrigation scheduling. All irrigation scheduling procedures consist of monitoring indicators that determine the need for irrigation. The purpose of irrigation scheduling is to determine the exact amount of water to apply to the fields and the exact timing for application. Irrigation criteria are the indicators used to determine the need for irrigation. The most common irrigation criteria are soil moisture content and soil moisture tension. Broner, in his paper no. 4.708, presented a comparative statement on different methods of irrigation scheduling (Table 1).

Method	Measured parameters	Equipment	Irrigation criterion	Advantages	Dis-advantages
Hand feel	Soil content moisture	Hand probe	Soil moisture content	Easy and simple	Low accuracy
Gravimetric Soil Moisture Sample	Soil moisture content by taking sample	Auger oven	Soil moisture content	High accuracy	Labour Intensive Field Work
Tensiometer	Soil tension moisture	Tensiometer including Vacuum gage	Soil moisture tension	Good accuracy	Skilled labour breaks at above 0.7 Atm.
Electrical Resistance Blocks	Electrical resistance of soil moisture	Resistance blocks bridge (meter)	Soil tension	Instantaneous reading used	Attested by soil salinity. not sensitive at Low tension.
Water Budget Approach	Temperature, Radiation, Wind, Humidity and Expected Rainfall Depending on Model Used for ET	Weather stn. Or available weather Information	Estimation of moisture content content	No field work required	Needs calibration and periodic adjustment only an estimation
Modified ammeter	Referred ET	Atmoneter gage	Estimation of moisture content	Issues to use	Needs calibration only estimation.

Table 1. Determination of an irrigation schedule is a time consuming and complicated process

Accurate determination of an irrigation schedule is a time consuming and complicated process. The introduction of computer programmes however, has made it easier and it is possible to schedule the irrigation water supply exactly according to the water needs of the crops. Ideally, at the beginning of the growing season, the amount of water given per irrigation application, (also called irrigation depth) is small and given frequently. This is due to the low evapo-transpiration of the young plants and their shallow root depth. In order to improve water productivity Ghosh applied stochastic modeling techniques on irrigation scheduling to take care of the uncertainty factor over a long time period. Knowledge on irrigation schedule and water use optimization can pave the way for supply of the quantity of water required exactly for the proposed cropping pattern in the command area. However, such supply needs design of suitable outlets and measurement of relevant levels and flow.

Advanced concepts of canal regulation

It has already been pointed out that modernization of irrigation system is a continuing process. It is clear that in India we should not attempt to impose a completely modernized structure on our large irrigation canal system existing today throughout India. We have to develop a system to coordinate the existing conventional system with modern process control technology, available in India and used routinely in Indian industries.

Thus the advanced concepts of canal regulation should aim at achieving flexibility, accuracy, simplicity and reliability. Malaterre, pierre-olivier stated that, from a theoretical point of view, regulation of canals can be based on four criteria:

- Considered variables (controlled, measured and control action variables).
- Logic of control.
- Design method (structure and technique).
- Field implementation (configuration and device).

Described the theoretical modelling techniques on canal regulation. The modern modelling system of canal is characterized by time delays, nonlinear features, strong unknown perturbations, and interactions among subsystems. The physical dynamics of such systems can be correctly approximated by Saint-Venant equations on conservation of mass and conservation of momentum combined with nonlinear algebraic cross structure equations. There is no analytical solution of Saint Venant equation except under very simplified condition and hence the equations have to be solved numerically on computer with finite difference numerical schemes. Based on above mathematical background Malaterre Baume enumerated various types of models for control of canal operation as under:

- Complete nonlinear model.
- Complete linearized model.
- Infinite order linear transfer function.
- Finite order nonlinear model.
- Finite order linear model (state space model).
- Finite order linear model (transfer functions).
- Neural network model.
- Fuzzy model.
- Petri net model.

In India, development of canal modernization is a continuing process with the assistance of the World Bank. The study and implementation of new techniques no longer target controlling scheme discharges but rather the actual volume delivered to farmers at the correct time to match their requirements. A first series of full scale experiment was successfully implemented in Maharashtra. The attempt was to bring out a merger of traditional float gates, duck bill weirs, baffle distributors with modern industrial technology like centralised process control. Based on the positive result achieved by this pilot project the Maharashtra authorities undertook a much larger operation (Over 200,000 Ha) on an extension zone.

Modernization of harsi irrigation system

The Madhya Pradesh water sector restructuring project seeks to improve water productivity in selected basins of the State and the overall management of water resources including irrigation service delivery through a combination of institutional strengthening/and substantial investment in modernizing about 650 minor, medium and major irrigation schemes covering an area of about 620,000 Ha in the five focus basins.

The Harsi project, started 1928 and completed in 1935, was originally designed to irrigate 7085 ha of kharif, 20243 ha of Rabi and 3036 ha of sugar cane. The harsi dam is situated on the parvathi river which is a tributary to the Sindh River and ultimately the Yamuna River. The catchment area of the reservoir is 777.7 sq.km. The harsi main canal which is a contour canal takes off from Harsi dam. The length of the main canal is about 65 KM. Its entire command is on the right hand side. The harsi dam is located at Latitude 25°45' N and Longitude 77° 58' E and the catchment and command are covered in survey of India topo sheet no. 54G. Harsi Dam is a composite earth dam. The waste weir of the harsi dam is located in a saddle about 3 KM away on the right flank. The spill channel joins natural nallah at about 25 chains. The flood water joins the parvati river at a point 4.10 KM down stream of dam site after a tour of 5.80 KM. The waste weir structure of the dam comprises of a 488 m curve length (chord Length 439 m) with a 3 high masonry weir. This structure is followed by a twin fall structure (4 m each) with straight length of 366 m and 244 m at a distance of 213 m and 235 m respectively from the curved weir.

The catchment of harsi dam is fan leaf shaped with gentle general slope. About 60 % of the area is covered with thick forest. The length of the parvati river up to the dam site is about 48 Km. General slope of the river up to the dam site is 1 in 2000. The independent catchment area of Harsi Dam is 1080 Sq.km. A part of it is intercepted and the intercepted catchment area is 777.5 Sq.km. Harsi command also gets water from various other structures located around the Parvati River (Table 2).

Table 2. The details of these structures are presented in Table.

Sr.no.	Details	Mohini sagar dam/mohini picks up weir.	Harsi dam	Kaketo dam	Phesari dam	Tekanpur tank
1	Catchment area (Sq.km.)	5933	10) Intercepted: 1813.5 11) Independent: 777.5	1036	82.95	64.75
2	F.R.L(M)	267.31	264.93	342.83	334.45	228.49
3	L.S.L.(M)	264.02	252.07	336.89	331.01	221.17
4	Gross storage, m cum	13.44	206.3	130.8	531.85	8.28
5	Dead storage, m.cum	1.698	13.64	6.56	5.15	0.849
6	Live storage, m cum	11.744	192.66	124.24	44.24	7.438

Harsi Canal system comprises 65 KM of main canal with 33 distributaries, 43 minors and 17 subminors having the total length of 418 KM. The project canal system is proposed to be irrigating about 57,728 Ha. For release of water from the dam to the canal three (3) service gates and three emergency gates have been provided. The gates are actuator operated. However, provision for manual operation is also available. The gates are 2.13 m high and 2.10 m wide. The water level noticed on 11th September was 866.8 ft. (264.19 m.). Although the gates are actuator operated type, electric power/generator has not been provided and no cover has been provided over the gate structure. Provision for generator and roof cover for the head regulator structure will have to be made. At the end of head regulator tunnel, there are two regulatory gates. One is for discharging water to the main canal and the other located at the upstream right hand side act as gates of the escape channel. Immediately downstream of head regulator, on the right bank of the Harsi main canal, five escape gates have been provided for emergency release of water. However, the water course on the downstream side of the escape gate is neither well defined not properly maintained. The escape gates need proper maintenance and the escape channels need to be properly defined and maintained.

One very interesting feature of harsi command is the reuse of drainage water for irrigation through salwai pick up weir with thirty two gates for controlling the reuse of drainage water for irrigation. During the irrigation periods, the appreciable recharge in the ground water finds its way to the local nallahs of the command areas. Besides, substantial quantity of waste water is also collected in seepage drains. Most of these local nallahs and seepage drains join the river Noon which flows from the centre of the command and forms the central drainage for the hardi command. The waste water is picked up in the Salwai Pick Up weir constructed across the noon river for irrigating the fields in the tail of the command through salwai channel having the discharge capacity of 2.83 Cumec. The quantum of water re-utilized is about 36.67 MCM.

The Harsi command is has twenty six water users associations for promoting effective participatory management program since 2000-01. Elections, under the Madhya Pradesh sinchai prabandhan main krishkon ki bhagidari adhiniyam 1999, were conducted in 2006. Rupees 48.00 lacs have been provided for construction of farmer's information cum contact centers. Most of the 28011 members of the associations are small land holders. 208 members of the executive committees are elected as territorial constituency members and the presidents of the associations. There are 26 co-opted women T.C. members. Women in general do not take active part in the Participatory Irrigation Management (PIM), however due to the efforts of the executive engineers; some of them have started taking part in PIM.

WUAs held five annual general meetings will an average attendance of 90% PIM awareness among the farmers is gradually increasing and hence problems of farmers belonging to scheduled castes and scheduled tribes are getting more attention leading to relatively more availability of irrigation water for the deprived classes and marginal farmers (Table 3).

Table 3. Every wua has the following sub committees.

S No.	Name of the sub committee	Responsibility entrusted	Remarks
1	Responsibility entrusted	Works committee Checking the works	
2	Works committee	Checking financial expenditure and auditing	

Departmental officers have transferred the relevant records to the wua through its secretary, who is a sub-engineer in the state water resources department including records relating to distribution of irrigation water, maintenance of distribution system etc. WUAs take up various operation and maintenance works by engaging casual labourers for construction of small structures, and other petty works are awarded to local contractors. The irrigation systems are not in good physical condition. In general, canals are silted up, full of weeds, sections are out of shape in different reaches and the banks have tendencies to settle. Some reaches are showing excessive seepage and have breached in past. An unsatisfactory, canal system, wastage of irrigation water by farmers, and application of water to fields using inferior application methods, result in unsatisfactory delivery of water in the middle reaches of the canal system and complete lack of supply at tail ends of canals. Under these, circumstances, the area actually irrigated through canal system is only 74% of the designed area. This asked improve significantly after implementation of the modernization programme.

The constraints as under would be addressed by the modernization programme

- Waste weir would be revamped and converted to an ogee shaped weir for improvement in water discharge capacity.
- Complete lining of main canal and leaky portions of the distributories to reduce seepage loss.
- Provision of control systems at the outlets to maintain even distribution of water at the tail end of various distributories.
- Introduction of suitable measuring instruments and control system including Telemetry and SCADA.

Taking into account the vast potential of the harsi irrigation command and the harsi composite catchment area, an advanced telemetry, SCADA and instrumentation and control system is proposed to be implemented during the ongoing modernization programme.

Five important components of the Harsi irrigation system are

- **Harsi catchments:** With harsi dam on the river parvati and associated kaketo dam and phesari dam.
- Madikhera dam and mohini pick up weir with feeder channel for augmentation of supply to harsi catchments.
- Harsi canal with its distributaries in harsi command.
- Salwai pick up weir for augmentation of return water to harsi command.
- Tekanpur tank system with supply of water to BSF camp.

The term, “control”, in the context of canal operation means creating and achieving the hydraulic results required for achieving proper agricultural production and supply of appropriate quantity of water to the consumers within the canal command area. It involves operating persons, equipment, instruments and structures to follow a unified system covering supply, storage and distribution. Local manual control and local automatic control use more human power but lose control when the flow of information is blocked due to various reasons and the decision making body delays the supply of water at proper time and appropriate place. Naturally the ultimate users fail to get the services necessary to maximize their production. Hence, the need for a central control centers for monitoring/control/and delivery of decisions in conjunction with the necessity of the users. A solution to this critical issue needs a Supervisory Control and Data Acquisition System (SCADA) for optimization of water resources, usually linked with the appropriate computer system to facilitate online calculations and report making can be performed within a short span of time.

The system starts from collection of water in the Harsi dam from various sources and is accomplished by opening and closing of gates or variation of level in various structures, which contribute water to the harsi catchment. Distribution of water in harsi command is accomplished by opening and closing of gates in harsi dam head regulator, head regulators of various distributaries, minors and outlets and cross regulators at each measurement site. The basic duty parameters to be considered are:

Types of crops and their water requirement within the canal command.

- Upstream water level.
- Downstream water level.
- Gate positions.
- Gate opening.
- Gate width.
- Flow status.
- Flow data.
- Collection of data of each station.
- Transfer of data to master station.
- Storage/retrieval/analysis of data.
- Decision making at master station to arrive at optimal solution.
- Transfer of decisions from master station to substations and remote stations.
- Final implementation status.

The following field stations are proposed as a part of the overall control system:

- Field station to measure water level at Harsi Dam.
- Field station to measure water level at Kaketo Dam.
- Field station to measure water level at Pehsari Dam.
- Field station to measure water level at mohini pick up weir. Field station to measure water level at tekanpur tank.
- Field Station to measure water level at salwai pick up weir.
- Field Station to measure water flow at mohini feeder canal head. Field station to measure water flow into doab canal.
- Field station to measure water flow D/S doab canal at Ch.4050 of feeder canal. Field station to measure water flow at river sluice of mohini pick up weir.
- Field station to measure water flow at river sluice of harsi dam. Field station to measure water flow at river sluice of pehsari dam. Field station to measure water flow at kaketo dam.
- Field station to measure water flow at tekanpur canal head.
- Field station to measure water flow at waste weir (spill way) of harsi dam. Field station to measure water flow at spillway of kaketo dam.
- Field station to measure water flow at spillway of pehsari dam.
- Field station to measure water flow at Spillway of Mohini Pick up Weir. Field station to measure water flow at harsi canal head.
- Field station to measure water flow at escape.
- Field station to measure water level at upstream and downstream sides of cross regulators near D3A, D8, D15A
- Field station to measure water flow into distributary D 3A
- Field station to measure water flow downstream of distributary D3A field station to measure water flow into distributary D8
- Field Station to measure water flow downstream of distributary D8 field station to measure water flow into distributary D 10A

- Field station to measure water flow downstream of distributary D10 A
- Field station to measure water flow into distributary D 15A
- Field station to measure water flow downstream of distributary D15A field station to measure water flow into distributary D 16
- Field Station to measure water flow downstream of distributary D16 field station to measure water flow into distributary D 17
- Field station to measure water flow downstream of distributary D17 Hence, there will be 38 field stations.

The distribution of water is accomplished by opening and closing of gates at the head and cross regulators at each of measurement sites. Non contact optical encoder type electronic sensors have been installed at each gate of the dam and at all off-taking canal distributaries to measure gate opening of each individual gate. Ultrasonic water level sensors working on Sonar principles will be installed upstream and downstream locations to convey water levels in real time to a local control room.

The hydro-measurement of surface water discharge is a complex task depending on a number of boundary conditions. The software for calculating this discharge must therefore use algorithm to take care of all possible conditions. In general the discharge algorithm depends on three measurable variables i.e. Upstream Water Level, gate opening and downstream water level. In addition certain site dependent constants are also important e.g. gate width and coefficient of discharge which in turn depends on crest width and slope.

The computer based SCADA system requires following subsystems:

- Data acquisition subsystem.
- Data processing subsystem.
- Software subsystem.

Human-machine-interface subsystem the whole system can be divided into:

- Catchments and canal system.
- Sensors, local area network and data acquisition units.
- Data acquisition server.
- Operator work station.
- Communication server.
- Data processing server.
- Web server.
- Remote terminal unit.

The supervisory control method requires equipment for data collection, communication/transfer and control/analysis/management. Each remote site requires a Remote Terminal Unit (RTU). The RTU collects data, communicates with control centre and controls the remote site based on the information received from the control centre. A communication system is required between each RTU and the control centre to allow two way communication and for monitoring and control. In addition to communication instruments and accessories, the control centre will need facilities for monitoring, computing and controlling.

Sensors are employed at various catchments/canal sites to measure water levels, flow rate and gate operations. Sensors will be properly selected to be compatible to software and computer of the overall system. Different types of sensors consist of water level sensors, floats, bubblers, ultrasonic sensors, pressure sensors, flow rate sensors, ultrasonic flow meters, flumes and weirs, gate openings. Data collected are transmitted to catchment/canal control centre through communication link.

The communication system may be:

- Single channel VHF radio.
- Single channel UHF radio.
- Metallic cable (4 to 100 pair).
- Fibber optic cable (2 to 8 pair).

Data processing both at Harsi catchments/dam/canal head control and mohini pick up weir will have two pentium IV computers at each of the two locations. Two PCs from the RTU's *via* data concentrator telemetry interface unit will receive the incoming data. A watchdog monitor will be provided to check the status of each computer and to control the changeover switch between the two PCs. If one PC fails to operate, another one will automatically take over. The master scada station will be located at dabra office. If necessary, data transmission system can be provided to transmit important data to bhopal wrd office at a later date.

This unit will display all important canal process parameters and will comprise:

- Catchments/canal process single line diagram showing mohini pick up weir, kaketo dam, pehsari dam, harsi dam, harsi canal head regulator, all cross and major head regulators.
- Tabular data display.
- Graphs.
- Bar charts.
- Data entry forms.
- Billing.

Telemetry, SCADA and measurement system for harsi canal project will function through collection of data through field stations as well as transmittal and storage of the data in data acquisition system telemetry unit. It will display collected and calculated data on 40 × 4 alphanumeric LCD display and collected/calculated/stored data will be regularly transmitted to SCADA stations to help the decision making process.

Conclusion

Water is an essential resource for overall development of human settlements. A densely populated country like India has a large population dependent for their livelihood on agriculture. The canal irrigation system has played a significant role in shaping the rural economy and rural development over the year. However, economy of water usage for agriculture is yet to get adequate attention in the agricultural and irrigation sectors and no concerted attempt has been made so far charge user charges to for water at source particularly for agriculture and irrigation. However changes are coming with the execution of modernization programmes, with the help of international agencies for better water productivity. Harsi, a very old and important irrigation project in the state of M.P, still follows conventional management concepts and methodology. This refer suggests that introduction of modernization programmes comprising participatory management in operation/maintenance work introduction of up to-date control systems along with extensive training of the users and the management/operational personnel can bring about rapid improvement and optimize water usage.

References

1. Sinha, Ranu, Edoardo Borgomeo, Christian Fischer, and Robert Hope, et al. "Do rehabilitated canals influence irrigation technology choices? Evidence from smallholders in Madhya Pradesh, India." *Water Econ Policy* 7 (2021): 2150017.
2. Jain, Sharad K, Pushpendra K Agarwal, Vijay P Singh, and Sharad K Jain, et al. "Ganga basin." *Hydrol Water Resour India* (2007): 333-418.

3. Mistry, JF. “Irrigation in Gujarat Glimpses of the Horizon of Works to be Handled by the Engineers in the Near Future.” *Water Energy Int* 38 (1981): 27-26.
4. Jadhav, SP. “Modernisation of canal command areas through adoption of piped networks and/or micro irrigation systems.” *Water Energy Int* 66 (2009): 33-36.
5. Azoury, PH, M Baasiri, and H Najm. “On the optimum utilization of water hammer.” *Proc Inst Mech Eng Power Process Eng* 202 (1988): 249-256.
6. Durugkar, Santosh, and Ramesh C Poonia. “Optimum utilization of natural resources for home garden using wireless sensor networks.” *J Inform Optim Sci* 38 (2017): 1077-1085.
7. Elgendy, E, and J Schmidt. “Optimum utilization of recovered heat of a gas engine heat pump used for water heating at low air temperature.” *Energy Build* 80 (2014): 375-383.

How to cite this article: Ghosh, Asok, and PK Chatterjee. "Modernisation of Irrigation System for Optimum Utilization of Water with Particular Reference to Harsi Project in Madhya PradeshModernisation of Irrigation System for Optimum Utilization of Water with Particular Reference to Harsi Project in Madhya Pradesh." *Irrigat Drainage Sys Eng* 12 (2023) : 388.