Modernization of irrigation systems in India: Lessons and opportunities

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Background

- Modernization of irrigation systems in India is a process that aims to improve the use of resources and water delivery to farms. It involves technical and managerial upgrades, institutional reforms, and physical improvements to irrigation schemes. The goal is to make operations more cost-effective and improve service delivery.
- FAO defines Modernization as: ***Irrigation modernization is a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization (labour, water, economic, environmental) and water delivery service to farms.***
- ICID definition states: Modernization is the process of upgrading infrastructure, operations, maintenance, and management of irrigation systems to sustain water delivery services required by farmers to optimize production and water productivity.
- Modernization is not limited to the introduction of modern hardware and/or software techniques but involves fundamental transformation of the way in which the business of irrigated agriculture is done. In most cases, modernization of irrigation infrastructure and services will be a more relevant and cost-effective investment

Modernization areas covered

- **India has an ongoing process of modernization beginning right from the inception of engineered irrigation in the second half of nineteenth century**
- In India, Modernization efforts have covered

- Canal automation
- Modern technologies: Such as Canal Lining, using pipes to distribute water instead of open channels, and using computerized sensors to trigger water applications
- Sprinkler systems: These systems use a perpendicular pipe with rotating nozzles on top to water uneven land
- Drip systems: Another type of modern irrigation system
- Better models for yield forecasting and resource management in a dynamic manner
- Linking multiple sources for increasing supply resilience through unified operation of reservoirs
- Use of telemetry and satellite based communications for informed decision making regarding water deployment
- Development and promotion of water efficient cropping practices

Canal Designs and Prevention of Seepage

- Improvements in Canal designs has been an ongoing effort right since the time of Lacey and Kennedy (1871-1930 and onwards)
- Initially, brick lined channels were brought in at Bhakra Beas projects for main canals.
- Concrete linings have been popular currently
- Geosynthetics especially HDPE is extensively used for Canal Linings.
- Major projects implementing linings are Bhakra-Beas- Rajasthan canal projects, Sardar Sarovar Project, Longest and largest irrigation canals have been lined. Though now there are innumerable projects providing linings
- Geomembranes of various types: Ploymeric (PVC,HDOE,LLDPE, Bituminous and composites) in use with exposed or protected installations
- Linings have been found indispensable for canals serving heavy soils and highly pervious desertic soils.

Pressurized Pipe distribution systems

- Piped Irrigation Networks (PIN) are increasingly popular in India. Many new projects are being attempted with last mile pressurized pipe networks for distribution.
- Major projects are: Sardar Sarovar Command, Mohanpura and Kundalia projects, Ramthal(NLBC) Irrigation project
- PIN are found to have benefits of reduction in land requirements, more robust network and increased water use efficiency leading to increase in service area.
- The requirement of energy for pumping and care for water quality to prevent choking are concerns that need be addressed
- In one case, the increase in the cost of installation had potential to be offset by revenue generated by the excess solar power over the pumping consumption
- Major conveyance in main canals and branches is still energy and cost effective for open canal networks. However, the last mile connectivity through piped networks is effective in reducing many ills of conventional open channel distribution networks.
- Seamless integration with on-farm drip or sprinkler systems is an added advantage.
- Integration with old open channel networks requires some special considerations

CANAL PIPES

A revolution in improving Water efficiency

The Revolution

Advantages of Piped Irrigation:

- No wastage of precious water
- No Land Acquisition Problems
- No Tail End Problems
- Equitable Distribution
- Better Control and Management
- Maintenance Free
- Speedy completion of the Project
- 50% more land can be irrigated with the same water

Micro Irrigation Systems

- Drip and sprinkler systems are largely adopted as modernization measures. Center Pivot systems have not found favour.
- As of February 2024, India's micro irrigation area was 83.46 lakh hectares from 2015–2024 under the Pradhan Mantri Krishi Sinchai Yojana (PMKSY). This represents 18.80% of the country's net irrigated area, which is 68.38 million hectares. Maharashtra and Rajasthan account for 86.2% of the total area under micro irrigation in India
- The penetration of micro irrigation is good for areas with physical water scarcity but the adoption in the water secure areas is lacking. This locks up surplus water resources for trans-basin use or better equity between differently endowed areas in a basin.
- Integration with solar power has proved to be a game changer for energy sustainability. Large experiments in Shah Nahar Project, Punjab and Haryana are promising.
- Scaling down of solar power based micro irrigation is also quite beneficial as witnessed in Alwar district Haryana
- Good progress in automation has been carried out through large players like Jain Irrigation, Netafim and others.

Remote Sensing based performance assessment

- Remote Sensing based assessment of performance of irrigation systems have been beneficially adopted throughout the country with the help of National Remote Sensing Agency.
- Integration with near earth systems of drones provide a quick and reliable means for finding the status of the network and identify the problems over vast areas. They are extensively used for surveying and mapping of command areas
- Multiple products like Cartosat data for accurate topographical mapping provide useful information for planning.
- Nation-wide Geo referenced irrigation data bases, various studies were/are commissioned to generate digital data bases on 1;50,000 scale on the following themes:
  - Command level inventory of waterlogged and salt affected lands mapping.
  - Digitization of all irrigation command area boundaries in the country on 1:50,000 scale.
  - Digitization of river basin, sub-basin jurisdictions, watershed boundaries.
  - Groundwater potential maps in 1:50,000 scale for entire country in a phased manner. Already Phase I and Phase II have been completed and Phase III is in Progress.
  - Satellite remote sensing-based surface water body inventory.

Available geospatial data products

1: Geospatial Data Products for WRD&M by Sh. Saksham Joshi, Scientist/Engineer 'SE', NRSC, Hyderabad https://www.youtube.com/watch?v=iK26dUokdTQ

2: An Overview of Geospatial Technology Applications in the WR Sector by Dr. Praveen Kr. Thakur, Scientist/Engineer 'SG' & Head, WRD, IIRS, Dehradun https://youtu.be/0Qd0fcvt_8o

3: Geospatial Tools for Flood Management by Dr. A V Suresh Babu, Scientist/Engineer SG & Head FM&HAD, DMSG, NRSC, Hyderabad https://youtu.be/KeRd0v6n_Ho

4 : Application of Geospatial Technology in Irrigation Water Management by Dr. Bhaskar R. Nikam, Deputy Director, EDPO, ISRO HQs, Bengaluru https://youtu.be/4MzIy80SEbg

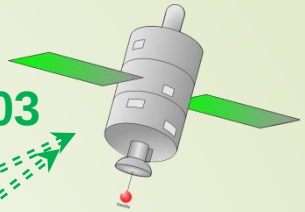
Adaptation related modernization

- Climate change is seriously affecting the water availability and temperature regimes upsetting the evapo-transpiration demands.
- Dynamic policies for such events require micro level data acquisition at farm level and advisories at short intervals.
- Adoption of total weather stations an simplified instrumentation for measurements is being developed- though the efforts require scaling up.
- Mobile based (Android) applications are gaining ground for providing advisory services to the farmers. Lot of private initiatives are being undertaken across the country.
- The services need be made more ubiquitous and provide cost effective advise to the farmers
- ICAR and leading Agricultural universities are providing for tele-consultation and other ITeS based facilities through Krishi Vigyan Kendras.

ISRO – MSSRF Village Resource Centers

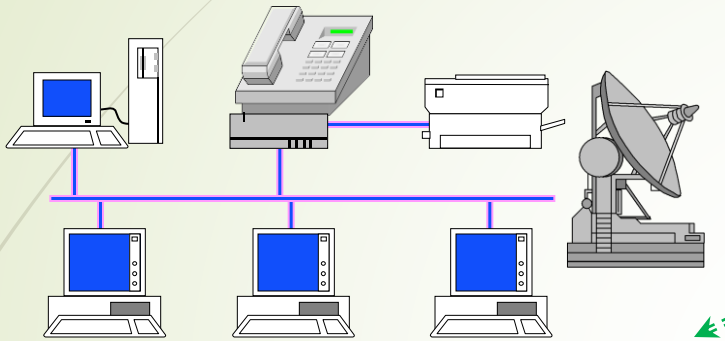
Three – tier Knowledge Network

Lab-to-Lab: Lab-to-Land : Land-to-Lab : Land-to-Land



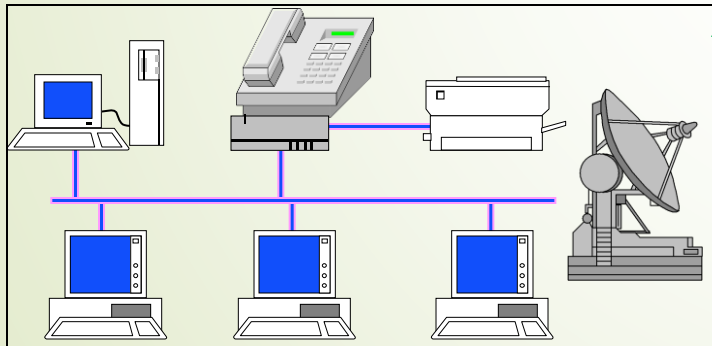
2003

ISRO Uplink/ Downlink Satellite



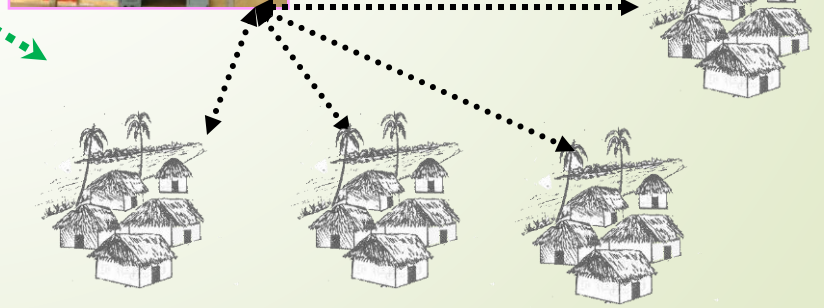
National Level Hub (MSSRF)

Strategic Partners



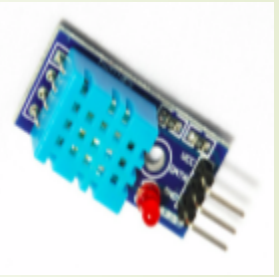
Block level hubs
Village Resource Centre (VRC)

Village Knowledge Centre (Village Level)



Solar Power

Arduino, SIM 900, Battery, Temp and Relative Humidity sensor



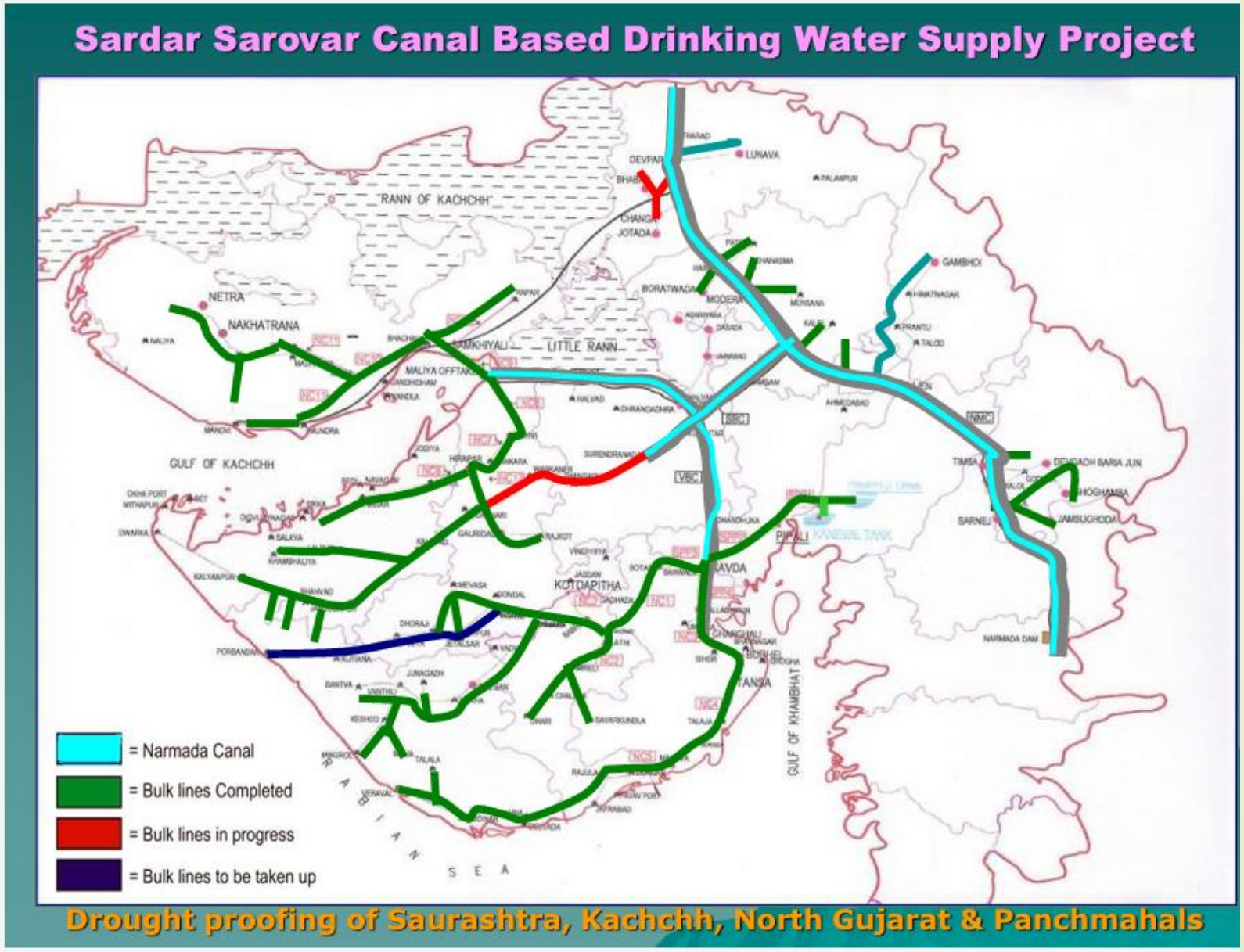
Bowman Water Tube with ultrasonic sensor

RBC Flume with ultrasonic sensor

ClimaAdapt

Basin level agricultural water management

- Storage based irrigation systems are becoming the norm due to variability of water yields during the monsoon and ever-increasing demands over lean season flows (base flows)
- Interconnection of co-basin reservoirs with a large reservoir acting as a mother source has been adopted in many commands like Sardar Sarovar and Godavari river based systems in Telengana.
- Trans-basin transfers for sustainability of irrigation services in adjoining basins is also being carried out through pressure pipelines and lift schemes.
- Financial sustainability for such systems are difficult to achieve due to poor revenue accruals from the beneficiary areas.
- Surpluses in mother source are utilized to a large extent through such measures and off-line carryover storages are also sustained in such cases.
- For arid areas with very unreliable yields, such schemes hold potential.


Sardar Sarovar Canal Based Drinking Water Supply Project
RANN OF KACHCHH
LITTLE RANN
GULF OF KACHCHH
GULF OF KHAMBHAT
ARABIAN SEA
NETRA
NAKHATRANA
LUNAVA
GAMBHOI
PIPLI
NAVDA
KOTDAPITHA
TANSA
= Narmada Canal
= Bulk lines Completed
= Bulk lines in progress
= Bulk lines to be taken up
Drought proofing of Saurashtra, Kachchh, North Gujarat & Panchmahals

Better Data Acquisition and Management

- Resource assessment from the catchment areas is very important for real time success in irrigation management
- Deployment of Satellite based data acquisition platforms in various basins have commenced since 1999. Presently, CWC manages about 900 stations with telemetry. Upgradation to 1678 sites is under way. Apart from these, individual states also operate their own networks.
- Due to unreliability of land based communication platforms, geostationary satellite based networks are preferred.
- National Hydrology Project in various phases have provided newer technologies and tools for data acquisition
- In the era of climate change, real time data acquisition and forecasting over shorter time periods is increasingly sought for by reservoir operators.
- Remote sensing based assessment of snow packs in glaciers and yields is being carried out at major projects like Bhakra system.
- Satellite based rainfall assessment and yield assessment is also being attempted on experimental basis.

Socio-economic sector reforms

- Participatory Irrigation Management practices are being encouraged since 1985 onwards.
- The aims are to create a sense of ownership, improve equity amongst local stakeholders, improve efficiencies of use and act as a bridge between service managers and stakeholders
- Various states have created legal instruments in form of acts for improving PIM activities. So far, most of the states with substantial irrigated areas have enacted the legislation and have implemented measures for promoting in new irrigation projects.
- As per estimates, about 55500 Water Users Associations have been created and 10.23 Mha irrigated area is covered by such entities.
- The adoption of PIM measures is inversely proportional to the water availability in the area. Better endowed areas lack the drive.
- Societal structures and political structures at the grassroot level play an important part in PIM activities adoption.

Challenges of Modernization

- While greenfield projects are more amenable for implementation, existing projects pose challenges of implementation.
- Many of the instances referred are greenfield projects. In real life, very few projects are these types in India.
- Existing water application and management traditions have to be handled carefully to avoid rejection.
- Technologies chosen should be robust and well-proven else the success remains limited to initial operations only.
- For existing projects, rehabilitation is a vital requirement else the success of integration suffers considerably.
- In data acquisition components, the existing data captures and newly acquired data should be compatible for efficient utilization. Change of basis can derail the project.
- Post installation servicing and troubleshooting are the most important components. The project should pay careful attention to the same.

Challenges of Modernization

- Present revenue models and water allocation methods pose a challenge to efficient cost recovery mechanisms for the projects.
- Purchase of the concepts by the stakeholders is a vital requirement- else the measures provided do not yield results irrespective of careful designs.
- Absorbing the new technologies and approaches depend heavily on the capacities of the management personnel. Initial period of intensive trainings, retention of personnel in their roles and gradual withdrawal of handholding is a very important requirement.
- Changes in cropping patterns and agricultural practices require making sufficient extension services available for significant periods.

Conclusions

- Modernization is a continuous process with multiple dimensions and is multi-disciplinary in nature. Interacting technologies should be capable of working in harmony with each other.
- Choice of approaches depend upon the prevailing conditions in the beneficial area.
- Sociological setups and prevailing practices should be accounted for to evolve a change management strategy at managerial and beneficiary levels.
- In the era of increasing effects of climate change, the modernization is necessary for efficient utilization of water and equitable distribution.

Thank you