COMPENDIUM OF BEST PRACTICES IN

WATER MANAGEMENT 3.0

सत्यमेव जयते

NITI Aayog

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COMPENDIUM OF BEST PRACTICES IN WATER MANAGEMENT – 3.0

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Foreword

Viksit Bharat, meaning "Developed India," envisions a future where India's socio-economic development is balanced with sustainable resource management. In this ambitious pursuit, one of the key pillars is effective water management. Aavailability of safe and reliable water and reducing the risk and impact of water-related disasters are critical for social wellbeing, economic stability and resilient sustainable development. As per World Bank study, water scarcity can erode economic growth to the tune of 6% of India's GDP by 2050. Situation has also been aggravated by changing climatic trends, frequent natural disasters and sudden quake of pandemics. However, sustainable water management practices can add 1% to its GDP.

India is looking forward to an integrated, comprehensive and consensus-driven approach to mitigate the challenges of climate change and water scarcity. Consequently, several successful missions and initiatives taken up by Govt. of India in the last few years are worth mentioning such as Jal Jeevan Mission, Amrit Sarovar, Mission LiFE, Smart cities Mission. While an enormous success has been attained through these missions, much more still needs to be done. Learnings from cities across the world on optimizing water usage and conserving the limited water resources available can bring transformational impacts at the local and national levels and help India achieve its SDG targets.

This Compendium of Best Practices is a repository of unique and effective water management strategies applied nationally as well as internationally. Success stories related to smart infrastructure for efficient irrigation, rejuvenation of lakes and rivers, reuse of wastewater etc are disseminated to stakeholders and practitioners and researchers. The interventions discussed can be replicated under Indian conditions or can be customized to suit the local present conditions to attain best outcomes.

Through this compilation, NITI Aayog has made an effort to highlight the best management techniques, which will serve as motivation and a roadmap for those who want to preserve water for a better future. I am optimistic that the compendium will contribute towards strengthening the water sector of India.

(B.V.R. Subrahmanyam)

Preface

"Under the G20 theme of 'One Earth, One Family, One Future,' collaborative efforts in water management aim to foster global unity and ensure a sustainable future for all. Water conservation in fact is an integral part of the India's cultural history and has become even more relevant in the present day. To ensure long term sustainability of water resources, a combination of demand and supply side interventions have been taken across the world.

Building upon the G20 theme, the "Compendium of Best Practices in Water Management 3.0", aimed to identify and share global and national best water management practices that will help India move towards the goal of becoming water secure 2047. The second edition of this Compendium published in 2021 was well appreciated and thus, encouraged us to prepare the third edition. While the previous compendium was focused on national level interventions, the present edition includes international best practices to increase cross country learning.

In an effort to fill the critical knowledge gaps for efficient water management in India, a number of exemplary good practices from cities across the country as well as globally have been compiled under five themes. Each theme focuses on a specific objective viz. policy led water management, watershed development, smart infrastructure, reuse of treated wastewater and climate resilience. Case studies are examined from the perspective of long-term sustainability and the possibility of replicating their success at other locations.

Crucial to this exercise was the contribution of a number of people. I would like to acknowledge the continuous support and guidance provided by Mr. B.V.R. Subrahmanyam, CEO, NITI Aayog. I appreciate the efforts put in by my team in Water & Land Resources vertical comprising Mr. N. Kumaravel; Deputy Advisor, Mr. Arunlal K., Associate and Dr. Snigdha Goel, Young Professional in conducting extensive research and coordinating with various states, NGOs, and civil society organizations for compiling and designing this document.

I also thank Ms. Madhubanti Dutta; Young professional, NITI Aayog for the valuable inputs and help during preparation of this compendium. The work done by Ms. Jayati Rawal; Intern, NITI Aayog in compiling all the information is duly acknowledged.

The commendable initiatives taken up by various NGOs and organizations also need to be acknowledged. The transformational impacts of such initiatives are tremendous at local levels because of the stakeholder and community involvement throughout the process.

We hope this compendium serves as a useful resource for the practitioners and officials across the country who strive to protect the water resources of India.

(Avinash Mishra)

List of Abbreviations

ACF	Ambuja Cement Foundation
ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AKRSP	Aga Khan Rural Support Program
CRARV	Control Rate Of Annual Runoff Volume
DBI	Diversion Based Irrigation Systems
FFEWS	Flood Forecasting and Early Warning System
GIS	Geographic Information System
JSA	Jalyukt Shivar Abhiyan
JSYS	Jala Samvardhane Yojana Sangha
KMC	Kolkata Municipal Corporation
LIFT	Leaders Innovation Forum for Technology
MNREGA Act	Mahatma Gandhi National Rural Employment Guarantee
MJSA	Mukhyamantri Jal Swavlamban Abhiyan
MRSAC	Maharashtra Remote Sensing Application Centre
NBS	Nature Based Solutions
NLBC	Narayanpur Left Bank Canal
NMC	Nagpur Municipal Corporation
NRW	Non-Revenue Water
O&M	Operation and Maintenance
PHED	Public Health Engineering Department
PRC	Performance Reference Compound
PPP	Public-Private Partnership
RO	Reverse Osmosis
RSSUT	Residential Stormwater Smart grid Utility Technology
TDS	Total Dissolved Solids
TMC	Thousand Million Cubic feet
TUC	Tank Users Groups
VSAT	Very Small Aperture Terminal
VWSC	Village Water and Sanitation Committees
WATCO	Water Corporation of Odisha
WRF	Water Research Foundation

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JAL SAMVARDHAN YOJANA (KARANATAKA)

Place of implementation: Tumakuru District, Karnataka

Organization: Jala Samvardhane Yojana Sangha (JSYS) a society registered under the Societies Act of Karnataka.

Year of implementation: 2002

Background:

Tanks (kere) have been the symbol of water harvesting tradition in Karnataka since time immemorial. Tank systems have contributed to the sustainability of ecology, environment and rural livelihood since centuries. Realizing the pivotal role played by the tank system in supporting rural livelihood and ecology the Government of Karnataka gave priority for restoration of traditional tank systems through community-based tank approach.

Objectives:

- Providing enabling environment for sustainable and decentralized tank management systems
- Reduce poverty by developing and strengthening community-based institutions to take up development and management activities
- Rehabilitate tanks within the district

Intervention:

- Comprehensive tank development was carried out with the participation of Tank Users Groups (TUG).
- Activities involved improvements to tank bund, waste weir, Feeder canal, repairs to the sluice to plug the leakages of water

from the tank and desolation of tank bed to restore its original capacity of the tank and to improve groundwater level, etc

- In 1st phase (from 2002 to 2009) out of 357 tanks proposed, 340 tanks were taken for implementation and in the 2nd phase, (from 2009 to 2012) out of 119 tanks proposed 114 tanks were taken. Out of 357 tanks, in 340 tanks rejuvenation works are completed and are handed over to Tank User Groups for further maintenance.
- Further, in the second phase out of 119 tanks in 114 tanks rejuvenation works were completed and handed over to TUG for further maintenance.

Outcome:

- About 60, 50,716 cum of desolation was done in about 454 tanks in both 1st and 2nd phases, helping in recharge of underground water in the open wells and bore wells in the surrounding area.
- About 1,24,950 local indigenous plant species like Honge, Neem, Bamboo, Tamarind, Neale, Karijali, Jatropha, Accacia, etc planted in the foreshore of tank bed
- 1,52,940 numbers of seedlings supplied to TUG farmers for plantation in the catchments of tanks resulting in minimizing erosion of soil on the catchments and tank bed foreshore.
- Total of 454 tanks rejuvenated as per the 1st and 2nd phase programs.

[1]*For more information please contact: M Madan Gopal, Executive Director, Jal Samvardhan Yojana Sangha. Email: jsys@vsnl.net*

NEERU-CHETTU PROGRAM (ANDHRA PRADESH)

Place of Implementation: Andhra Pradesh

Organization: Government of Andhra Pradesh

Year of Implementation: 2015

Background:

- Groundwater levels are depleted to a depth of 1000 feet below ground level in most of the areas.
- Lack of assured water supply for irrigation, drinking, and industrial purposes.
- Need for scientific management of water resources to ensure more crops per drop of water.
- Neeru-Chettu program was implemented to improve water conservation and management in the State with peoples' participation to make the state droughtproof.

Objective:

- Increase overall green cover in state and ensure 33% forest cover against the current 25%
- Maintain groundwater levels at a safe zone (between 3-8 metres).
- Reduce the gap ayacut under Major, Medium, and Minor irrigation projects by providing assured water up to tail-end areas

Intervention:

- De-silting of minor irrigation tanks and feeder channels.
- Repairs and renovation of existing water harvesting structures.
- Construction of check dams, percolation tanks, farm ponds.
- Arresting the soil erosion by following the ridge to valley approach.
- Development of cascades i.e. chain of tanks to divert water from surplus basin to deficit basin using latest Geographic Information Systems (GIS) and satellite technology.
- Encouraging micro irrigation on large scale and mobile micro irrigation practices in severe water scarce areas.
- Massive afforestation and soil moisture conservation works and rising of nurseries by the Forest Department.
- The silt generated during the de-silting works was allowed to be transported by the local farmers by deploying tractors at their own cost for application of silt to agricultural fields.

Outcomes:

- Improvement in ground water levels in Rayalaseema region due to the works taken up under Neeru–Chettu.
- A total of 126477 structure repaired.
- 86 Lift irrigation schemes revived.
- Block plantation in 3726 ha area, 13.92 lakh nurseries raised and 315 seedlings distributed.
- Quantity of water increased by desilting and taking up construction and repairing structures is 10.38 Thousand Million Cubic feet (TMC).
- Impounding capacity of tanks increased by 4.79 TMC
- Total ayacut stabilized by desilting and repair works is 180791 acres.

[2]https://irrigationap.cgg.gov.in/wrd/neeruchettu

SUJALAM SUFALAM JAL ABHIYAN (GUJARAT)

Place of Implementation: Gujarat

Organization: Government of Gujarat

Year of Implementation: 2018

Background:

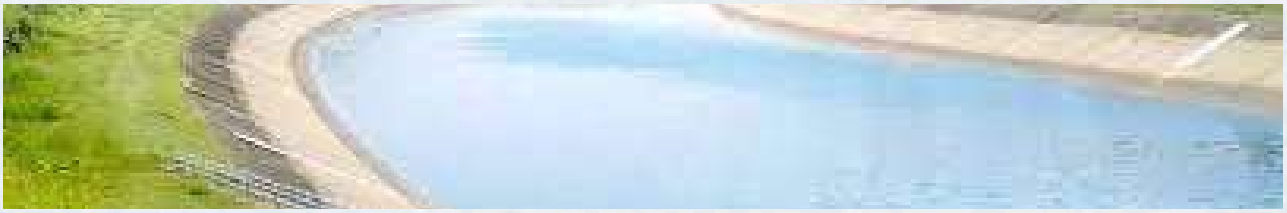
Gujarat has 6% of total geographical area of India but 12.36% of water stressed area of India. 58.6% of total area of Gujarat is subject to water stress due to arid, semi-arid and saline conditions. To address this challenge, Government of Gujarat launched a water conservation scheme Sujalam Sufalam Jal Sanchay Abhiyan which aimed to enhance the capacity of dams, ponds, canals, and contour trenches by desilting and deepening them.

Objectives:

- Deepen 13,000 reservoirs to increase their capacity and store rainwater before monsoon. Other objectives of the scheme were:
- Strengthen irrigation facilities and enhance agricultural productivity
- Revitalise about 32 rivers having length of about 340 kilometres across 30 districts.
- Conduct cleaning drive for canals of 5,400 kilometres.

Intervention:

- Deeping of ponds, tanks, check dams and reservoirs.



- Cleaning of rivers, drains canals, irrigation structures and drinking water sources.
- Construction of check dams, new ponds, Khet Talavadi, and Van Talav.

Outcomes:

- Around 13,000 ponds and check-dams desilted and 32 rivers rejuvenated, creating an additional capacity of 11,000 lakh cubic feet to store water when the rain arrives.
- 6,170 lakes cleaned and deepened.
- 8,107 check-dams and 462 reservoirs cleaned.
- 568 new lakes and 1,079 new check-dams built.
- The water harvesting capacity of the state of Gujarat increased by 42,064 lakh cubic feet in three years (2018-2020)
- About 4000 excavator machines were used to deepen the soil and districts.
- Soil excavated was given to the public free of cost.

[3]*https://gujnwrws.gujarat.gov.in/showpage.aspx?contentid=7359&lang=english*

MUKHYAMANTRI JAL SWAVLAMBAN ABHIYAN (RAJASTHAN)

Place of implementation: Rajasthan

Organization: Government of Rajasthan

Year of Implementation: 2016

Background:

The annual rainfall in Rajasthan is 100 mm in dry hot West to 900 mm in South East. Generally, out of five years, 3 years are drought-affected means untimely, uncertain & varied distribution of rainfall. This leads to unstable crop production. A large part of the rainfall also goes waste due to the high intensity of rainfall in small time. Proper utilization of runoff does not take place due to the lack of Water Harvesting Structures in the watershed area results in a continuous decline in the water level of the wells.

Objectives:

- Making the village self-sufficient in terms of drinking water.
- Increase the level of groundwater table and strengthen watershed.
- Increase the area under irrigation and cultivation through water harvesting & conservation.
- Enhance crop production and productivity.
- People's participation in designing and implementing projects.

Intervention:

- Mukhyamantri Jal Swavlamban Abhiyan

(MJSA) works upon Four Waters Concept. It revolves around the harvesting of available runoff (rainwater, ground water, underground water & in situ soil moisture) in rural areas by treatment of catchment water, proper utilization of available water harvesting structures, renovation of the non-functional water harvesting structures & creation of new water harvesting structures.

- It uses low-cost technology, to increase groundwater recharge by four times and offers thrice the benefit than other any other conventional mode.
- MJSA also adopted the concept of Water Budgeting in Gram Sabhas wherein after determination water use in drinking, irrigation, livestock & other commercial purposes is determined to prepare a water budget. Accordingly, works were identified and approved for the preparation of action plan of the mission.

Outcome:

- This scheme has resulted in an increase of 4% in groundwater level that helped agriculture and irrigation.
- Improved the problem of soil erosion and fertility which resulted in more production.
- Supplied water to 4.1 million people and 4.5 million animals which decreased the death due to water scarcity.

4 https://sarkariyojana.com/mukhyamantri-jal-swavlamban-abhiyan-mjsa-rajasthan

DRINK FROM TAP MISSION (24X7 WATER SUPPLY) – (ODISHA)

Place of implementation: Odisha

Organization: Govt. of Odisha

Year of Implementation: 2020

Background:

Drinking Water Supply in Urban Odisha had been facing severe challenges since decades and the water supply infrastructure could not cope up with the pace of increasing urbanization.

Water supply challenges like poor service coverage, poor water quality, intermittent supply and high-water losses needed to be addressed and solve perennial water woes.

Objectives:

- Drink pure water straight from the Tap: Conversion of intermittent water supply systems to continuous (24x7) water supply systems
- Equitable, sustainable and people-centric service provision with focus on the urban poor.
- Water Supply Management through Community Partnership (Self Help Groups) – "Jalsaathi"
- 100% coverage of households with piped drinking water of good quality as per recommended standards.
- 100% metering of house connections to eliminate non-revenue water (NRW) due to leakages and wastage for full cost recovery.

Intervention:

- Adoption of innovative, state-of-the-art technology & management techniques,

both during construction and operation & maintenance.w

- Quality Assurance through Third Party Quality Monitoring & Public Private Partnership (PPP) Laboratories.
- Government of Odisha implemented enabling policy interventions: 1) Right to water 2) Execution of connections by Public health Engineering Department (PHED) or Water Corporation of Odhisa (WATCO) as public works 3) Household need not bother to obtain road cutting permission for connection 4) Easy instalment on connection charges 5) Explicit component of community participation now with 100% coverage.
- Relaxed house connection norms for the poor which are as below: 1) Water connection with indemnity bond 2) Waiver of connection fee 3) Providing house connection with two taps at Govt. cost under AMRUT for the slums 4) Covering all uncovered slums under Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 5) Shift from hand pump, tube wells to Piped Water Supply.
- Activities for reduction of NRW were taken on a mission mode.
- Awlmost all house connection ferrules replaced with saddle and compression fittings.
- NRW equipments procured and continuous training of staff for carrying out NRW activities

Outcome:

- 100% household level coverage achieved.
- The consumers have water in their taps round the clock directly coming from the public distribution network.
- Absence of the need for personal storage of water (sump).
- Lifting the water to roof level storage tanks as well as need of installation of further treatment/filtration systems at home such as Reverse Osmosis (RO) is eliminated.
- 100% metering and volumetric billing have helped to reduce the leakages and wastages in water supplies.
- Quick resolution of issues and complaints of the consumers enhanced the confidence of the public/communities in WATCO.
- Jalsathis helped in transformation of field situation with enhanced confidence of the people in public water supply system.
- Each Jalsathi's woman is earning between Rs. 10,000/- to Rs. 12,000/- per month as incentives.
- NRW rate was more than 50% which affected the sustainability of 24x7 Water Supply was reduced to 15%.

KAPILDHARA YOJANA (MADHYA PRADESH)

Place of Implementation: Madhya Pradesh

Organization: Government of Madhya Pradesh

Year of Implementation: 2008

Background:

The Kapildhara Yojana by the state of Madhya Pradesh is a unique scheme under the MGNREGA program to develop irrigation facilities on private land of small and marginal farmers, through the construction of dug wells, farms ponds, check dams, etc.

Objectives:

- The program focuses on providing financial support to landholders without access to irrigation facilities and prioritizes marginalized communities to maximize impact.
- The program has contributed to improved productivity, intensity, and diversity of crop production in the region and generated livelihood sources.

Interventions:

- Under Kapildhara Yojana of Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), the wells were constructed to help them irrigate their land.
- Scheme is implemented on the private lands of beneficiaries, Nandan Falodyan for horticulture development, Bhumishilp

for land reform.

- Target of constructing 2.5 lakh Kapildhara wells in the next five years was set to make irrigation facilities available to the poor and needy farmers.

Outcomes:

- More than 3 lakh 57 thousand and 522 Kapildhara wells have so far been constructed on the unirrigated land of poor farmers.
- With this nearly 4 lakh 74 thousand- and 425-hectare unirrigated area has turned into the irrigated area.
- Construction of Kapildhara wells made the lands fertile and different kinds of food grains, fruits, and vegetables were grown.

[6] *https://mohua.gov.in/pdf/624eb41e1f6e6Drink-from-Tap-Mission-A-case-study-of-24x7-Water-Supply-in-Puri-city.pdf*

AUTOMATION OF IRRIGATION SYSTEM: NARAYANPUR LEFT BANK CANAL SYSTEM (KARNATAKA)

Place of Implementation: Narayanpur Dam, Karnataka

Organization: Government of Karnataka

Year of Implementation: 2014

Background:

- Narayanpur Dam is located on Krishna River near Bachihal and Siddapur village of Bijapur District of Karnataka state. 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) which is the biggest and the main artery of canal network about 77 Kms have designed to discharge of 10,000 cusecs.
- Identified issues in the NLBC irrigation system:
- Lack of proper water regulatory system within the NLBC network.
- Inadequate manpower for canal operation and maintenance.
- Fixed flow structure and manual control of the gates resulted in wastage of water, inaccuracies and uncertainties in measurement and poor emergency response within the canal network system.
- Inequitable regulations between upstream & tail end water users, hence, tail end users have not been able to

receive water.

- The farmers were unable to access information about water availability, plan crops, and commodity prices.
- No Geographic Information Systems (GIS) based information about command area about soil health, crops, water demand and allocation, weather, contours etc.

Objective:

- To automate the Narayanpur left canal system and increase water use efficiency.

Interventions:

- More than 4,000 automated control and regulating gates were installed.
- Sophisticated software and communication infrastructure to manage the delivery of water to farmers, located along approximately 1,500km of canals.
- Irrigation scheduled is made available on farmer dashboard.
- Solar powered integrated gates were installed having following components.

(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

(g) CCTV cameras.

- At Narayanpur, there is a master Very Small Aperture Terminal (VSAT) transmitter and receiver equipments and it is connected to all Master Data collection stations by VSAT. It gives bi-directional communication within the system.

Outcome:

- First time in the history of NLBC, water delivered to the tail end users suffering atchkut area.
- Increased and optimized the water use efficiency with in the network and reduce water loss.

- Single room control for canal operation.
- Efficient water distribution among the farmers/stake holders in command area.
- Increased irrigated area and agriculture production till tail end and command Area.
- Online water demand, water billing & revenue generation reduced cost of paperwork and process improvement.
- Instantaneous decision-making system and reduction and elimination of manmade errors.
- Reduction in operational costs and maintenance requirements.

[7] *http://mrsac.maharashtra.gov.in/jalyukt/*

JALYUKT SHIVAR ABHIYAN (MAHARASHTRA)

Place of Implementation: Maharashtra

Organization: Government of Maharashtra

Year of Implementation: 2015-16

Background:

Jalyukt Shivar Abhiyan (JSA) is a flagship program of the Government of Maharashtra launched to provide long-term and sustainable solutions to the water scarcity problem faced by rural communities. The program involved geotagging of water bodies and the use of a mobile application to enable web-based monitoring.

Objective:

- The Maharashtra government launched the Jalyukt Shivar Abhiyaan in 2015-16 with the mission to make Maharashtra drought-free by 2019, and an aim of making 5000 villages water scarcity free, every year.
- Focus areas under the program include deepening and widening of streams, construction of cement and earthen stop dams, work on nullahs, and digging of farm ponds.
- Increase ground water level in drought areas, and to create, to create new structure of water conservations.
- Sanitize the concept of water budgeting and arrest maximum runoff in the village areas.

- Create awareness and encourage farmers regarding efficient water use in farming.

Intervention:

- Planning-based integrated framework to address both the drinking water and irrigation water demands of communities.
- Building and repairing water harvesting structures such as continuous contour trench, cement Nala bund, earthen Nala bund, loose boulder structures, farm ponds, and agricultural interventions (horticulture plots, terracing, etc.)
- Decentralized water bodies were installed at various locations within villages to enhance the groundwater recharge.
- Mobile application was developed by Maharashtra Remote Sensing Application Centre (MRSAC) for monitoring of the scheme.

Outcome:

- 11,000 villages declared drought-free and agricultural productivity has increased by 30-50%.
- Increase in water storage capacity.
- Recharge of ground water level by 1.5 - 2 m

[8] *https://pmksy-mowr.nic.in/aibp-mis/Manual/SCADA-Narayanapur%20Left%20bank%20Canal,%20Karnataka.pdf*

WATERSHED DEVELOPMENT

Reversing Salinity in Saurashtra - Ambuja Cement Foundation

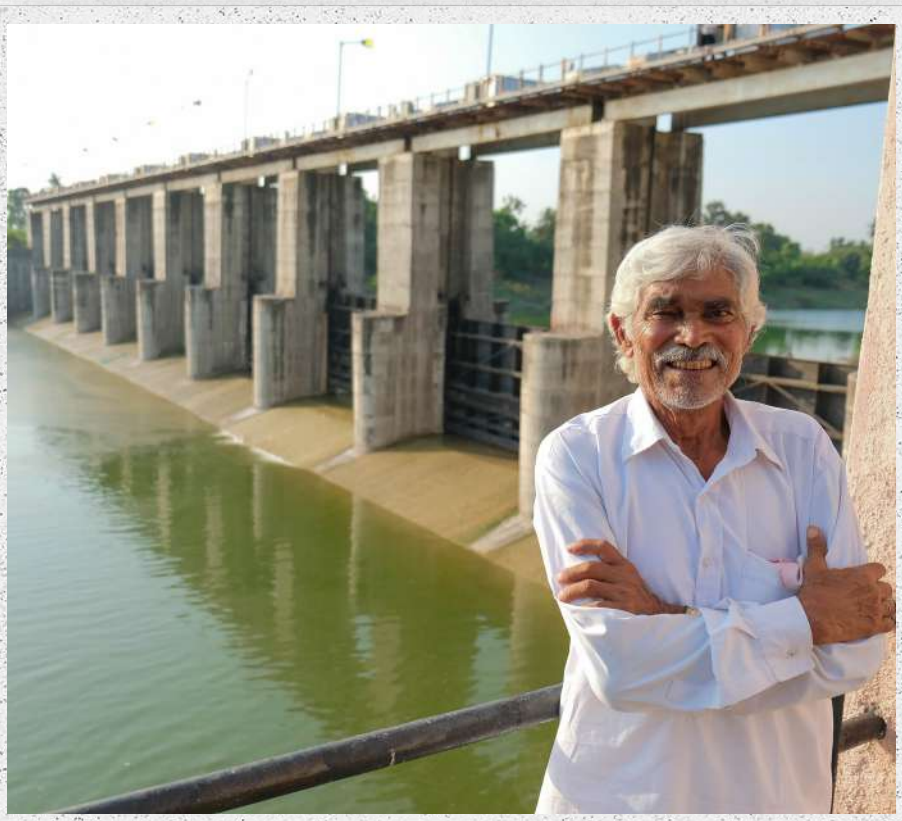
Rejuvenation of Dam for Augmentation of Water Use - Green Thumb supported by Bombay Engineering Group

Diversion Based Irrigation System - Aga Khan Rural Support Programme

Clean and Safe Drinking Water- Govt. of Odhisa

Neknampur Lake Restoration - Dhruvansh organization

REVERSING SALINITY IN SAURASHTRA



Place of Implementation: Kodinar, Saurashtra

Organization: Ambuja Cement Foundation (ACF)

Year of Implementation: Since 1998

Background:

- Increasing pressure from economic activities had caused considerable depletion of groundwater. In particular, the introduction of water pumps in the agricultural industry resulted in a massive exploitation of underground aquifers to extract water for crops.
- Coupled with erratic and reduced rainfall, the natural groundwater table decreased and saline water from the sea seeped in contaminating water and making it unfit for consumption for irrigation.
- Advancing at an unprecedented rate of half a km a year along the 1125 km long coastline of Saurashtra, salinity exposed lakhs of people to risk. The coastline reached 15 km in 1998 and consequently the Total Dissolved Solids (TDS) were more than 400 mg/l. This situation was further aggravated by recurring droughts in 1990's in the area.

Objective: To prevent salinity ingress and ensure sustainable water supply for drinking and irrigation purposes through effective water resource management interventions..

Intervention:

- ACF adopted a holistic approach to address salinity from the supply side as well as demand side.
- The model approach involved the following initiatives to tackle salinity:
  - **Infrastructure development for drinking water supply:** ACF promoted investment in household rain water harvesting systems. they also installed water distribution systems in villages that transported water from centralized well to decentralized taps in the community.
  - **Infrastructure development to increase water harvesting and groundwater recharge:** ACF built check dams, community ponds and constructed long interlinking canals to join streams with village water ponds. ACF converted mined-out pits to artificial lakes and reservoirs by diverting surface water run-off into the pits.
  - **Education and knowledge impartment**: ACF raised the issue of salinity aiming the community, conducted trainings with farmers in micro irrigation and encouuraged growing salinity on the community and resistant crop varieties.
  - **Technology:** ACF promoted modern technologies such as micro irrigation, mulching and use of saline resistant crop varieties (KRL19 wheat) which can be grown in high TDS areas as well.
  - **People's institutions:** Village Watershed Committees, Farmers Producer Companies, Drinking Water & Sanitation Committees were also constituted to drive local solutions.

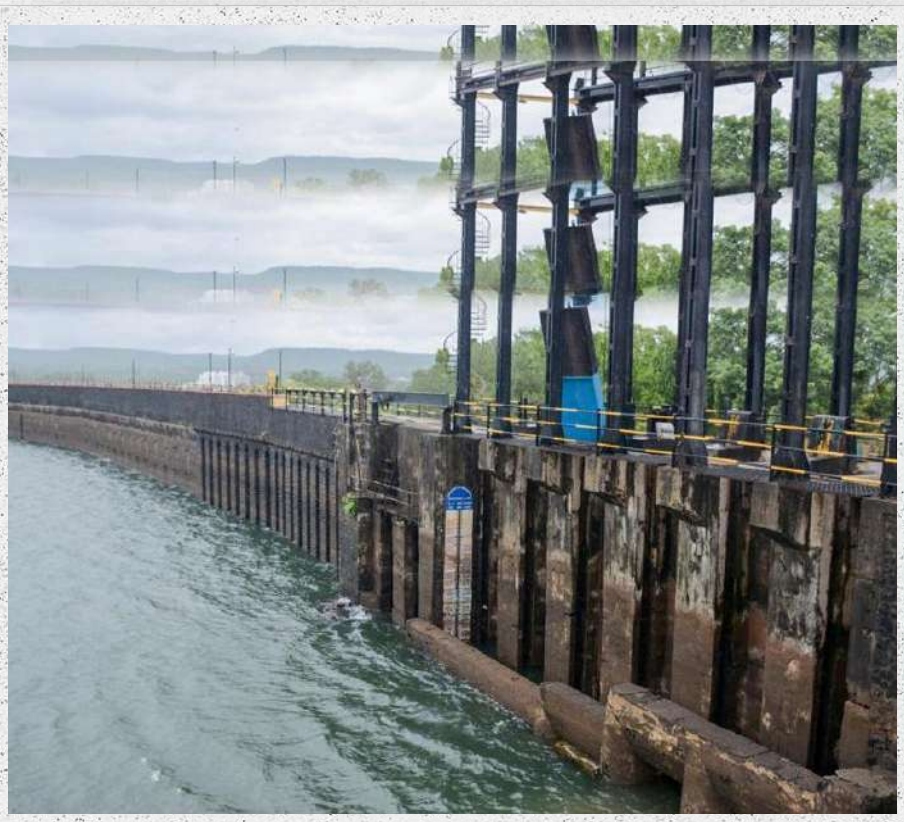
Outcome

The above interventions led to the following macro impacts:

- **38.79 mcm of additional water**
- **22% increase in agricultural productivity**
- **227 check dams**
- **69.26 km interlinking canals**
- **119 ponds rejuvenated**
- **Around 4000 rainwater harvesting systems installed.**
- **70 drinking water distribution systems**

[9] *http://mrsac.maharashtra.gov.in/jalyukt/*

REJUVENATION OF KHADAKWASLA DAM FOR AUGMENTATION OF WATER USE



Place of implementation: Khadakwasla Dam, Pune

Organization: Green Thumb supported by Bombay Engineering Group, Southern Command

Year of implementation: 2014

Background:

The storage capacity of Khadakwasla dam has reduced significantly to 2.90 TMC from 3.75 TMC due to siltation. The silt which ran down from the catchment area formed numerous islands in the lake on which the cattle used to graze. Silt deposit reduced the size of the lake and therefore after the first rains, the lake used to get filled up and during the consequent rains, the dam overflowed downstream causing floods. Dumping of construction material, debris and garbage around and in the reservoir was also another cause of reduction in dam's storage capacity. To increase the water holding capacity there were three options viz. increasing the dam's height, build new dam or rejuvenation of existing dam.

Objective: To rejuvenate the dam and increase its water holding capacity

Intervention:

- The first two options were not feasible from the ecological and economical aspects and thus, desilting was carried out to rejuvenate the dam. Removal of silt from the dam was the only faster and cost-effective way.
- Primitive methods were adopted by using JCBS, dozer, grader, poclain, dumper truck & tippers to remove the silt. The silt

is then pitched & bunded on the periphery of the lake, excess silt is distributed off free to locals & farmers.

- Large scale tree (approx. 10 lakh trees) & grass plantation to avoid soil erosion.
- Proper landscaping to beautify the area.
- Fencing of the entire stretch to protect the water from stray cattle and people.
- Propagation of endemic flora including rare and endangered species by mostly planting indigenous trees & grass.
- Citizen awareness created with the help of print media, radio and television presentation on a large scale.
- In-site conservation of bio-diversity is promoted by taking stock of local flora & fauna.

Outcome:

- Removal of more than 15 lakh truckload of silt till Jan, 2019 leading to enhanced water holding capacity by 0.2 TMC. To build a dam of the same capacity, massive investment of 500-700 crores would have been required.
- The total area desilted was 75 lakhs cubic meter.
- Approx. 5 lakh trees planted to avoid further siltation into the dam, benefitting the overall growth into the 'Green Cover' for the country.
- Encroachments by village goons and cattle sheds removed and replaced by gazebo huts for visitors.
- Additional source of income was generated for farmers through 'fish farming'. Landless farmers were provided with a viable business opportunity by Green Thumb desilting initiative as it enhanced the water capacity of the reservoir giving birth to fishing culture.

[11] *https://greenthumb.in/khadakwasla-dam-rejuvenation/*

DIVERSION BASED IRRIGATION SYSTEM

Place of implementation: Barwani and Khargone districts located in Nimar region of Madhya Pradesh

Organization: Aga Khan Rural Support Programme

Year of Implementation: 2016

Background:

The topography is undulating, hilly and mountainous with abundance of seasonal and perennial streams. Only 36% of the net sown area in Barwani is irrigated, while 56% of net sown area in Khargone district is irrigated. Most agricultural land is rainfed and cultivation is undertaken for Kharif crop only. Migration for the rest of the year for livelihoods to Gujarat and Maharashtra is common. Groundwater extraction was greater than 65%, indicating moderate overextraction. The districts lack natural replenishment of the groundwater, because of low and moderate permeability of the deccan traps. There is a crucial need to shift to surface water and rain-water usage for irrigation purposes.

Intervention

Aga Khan Rural Support Program(I) (AKRSP) initiated work on first Diversion Based Irrigation System (DBI) in 2016, as the undulating topography offered good scope for development of gravity-flow irrigation systems. An expert in DBI systems took up

the initiative to set up the first DBI in Barwani district. Previous DBI systems have been successfully operationalized DBIs in Kalahandi, Odisha and Udaipur, Rajasthan.

Outcome:

- Over the last 6 years, 13 DBI systems have been operationalized bringing 111 ha of land under irrigation coverage and benefitted 93 farmers.
- The cost of implementation comes to Rs.300 per running meter.
- An average DBI system is around 800-1000 metres long and provides irrigation to 5-10 ha of land, thus benefitting 5-8 tribal farmers.

Diversion Based Irrigation Systems (Phad Irrigation System)

Diversion of water from a river or stream through construction of bandharas into a small canal taking off from the upstream side of the bandhara.

The water is then supplied to phads or small blocks of land. Each phad has a number of agricultural plots belonging to different cultivators. To optimize the traditional phad irrigation system, the implementing agencies/NGO have improved upon the ancient practice.

A small storage tank is built across the stream. Water is then transferred via pipelines and valved outlets to beneficiary farmers. This reduces transmission losses of water and increases the life of the system as compared to the traditional earthen channels, which need frequent repair and maintenance.

[1]*https://greenthumb.in/khadakwasla-dam-rejuvenation/*

CLEAN AND SAFE DRINKING WATER IN ODHISA

Place of Implementation: Nuapada district in Odhisa

Organization: Jal Jeevan Mission, Govt. of Odhisa

Year of Implementation: 2019

Background:

Over-extraction of groundwater in Nuapada district of western Odisha has resulted in increased concentrations of natural fluoride in groundwater (as high as 4.95 milligrams per litre). This led to unavailability of clean and safe water in the village. In the absence of alternative sources of drinking water, villagers were forced to drink groundwater, which led to serious health threats like fluorosis and kidney failure. Villagers spent almost 50-60 % of their earnings in health-related issues.

Objectives:

Provide access to clean and safe drinking water in Odhisa.

Interventions:

Source of drinking water was changed from groundwater to surface water. Two major schemes were implemented in the district under the Jal Jeevan Mission. The Lower Indira dam and Jonk river dam have become potential sources of drinking water for the village. Stored water from the dam reservoir was collected in intake wells and transported

to water treatment plants. Water is then purified to drinking standard here and transferred to overhead tanks in different villages.

Outcomes:

- Potable water in villages through functional taps.
- Fall in kidney failure cases by 30 per cent, and no new cases in the last one year.
- Field testing kits provided to villages, where trained women representatives of the Village Water and Sanitation Committees (VWSCs) test the water for potability and report to district water-testing laboratories.
- Village Water and Sanitation Committees (VWSCs) formed in all the villages of the district.
- Series of capacity-building programmes were conducted

[12]*https://www.downtoearth.org.in/news/water/world-water-day-2023-nuapada-switched-to-surface-from-ground-sources-to-solve-its-problems-of-quality-and-quantity-88378*

NEKNAMPUR LAKE RESTORATION – DHRUVANSH ORGANIZATION

Place of Implementation: Neknampur Lake, Hyderabad (Telangana)

Organization: Dhruvansh organization

Year of Implementation: 2016

Background

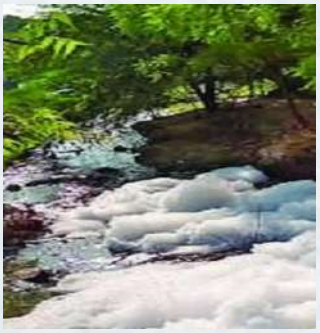
Neknampur lake with area of 25 acres of lake was contaminated with garbage, sewage, water hyacinth, cultural siltation and debris dumping. Encroachment issues plus a legacy garbage dumped place of Manikonda Municipality in Hyderabad became a serious cause of concern.

Objective:

- Restoration of lake and biodiversity
- Increase in water retention capacity
- Create a recreational place
- Biological STP model installation at lake

Intervention:

- Phytoremediation & bioremediation to purify water in lake.
- Desilting of lake.
- Floating treatment wetlands installation & their maintenance at lake.
- Ecological beds establishment at lake.
- Solar Floating Aerators at lake to make lake energy free.
- Floating Bikes at lake to remove floating



garbage at lake.

- Biodiversity register of lake.
- Protection of Pythons, monitor lizards & turtles from poachers.
- Stopping of Invasive species in lake water like catfish & red-eared terrapin.
- Conducting Cultural programs at lake for Cultural rejuvenation of lake.
- Immersion pond at lake for separate festival celebrations at lake.
- More than one lakh plantation at lake which includes native species & medicinal plants

Outcome:

- 90% reduction in BOD of the lake due to constant maintenance of treatment system. Neknampur lake water analysis parameters are available on TSPCB webite for every month.
- Beautiful lake with no smell or odor though sewage is still coming into lake.
- Water hyacinth still in lake but never covered the lake.
- Recreational place for Community.
- Lake rejuvenation & Community rejuvenation going parallelly.

[13] *https://www.equatorinitiative.org/2020/04/24/solution11006/.*

SMART WATER **INFRASTRUCTURE**

Improving water services through smart metering in The Republic of Korea - Korea Water Resources Corporation

Using satellites for better irrigation - Australia

Sponge city initiative - People's Republic of China

Community-based Stormwater Smartgrids: Distributed AI/IoT Rain Harvesting Networks for Flood and Drought Resilience- Raingrid

IMPROVING WATER SERVICES THROUGH SMART METERING IN THE REPUBLIC OF KOREA

Place of Implementation: Cha – ri Village, Seosan City, Republic of Korea

Organization: Seosan city government, K-water (Korea Water Resources Corporation)

Year of Implementation: 2016

Background:

Cha- ri a small village operated by two district metered areas located in Seosan City of South Korea faced several water losses due to deterioration of water pipes. Seosan city has relatively low rate of non-revenue water, except one of its village Cha-ri which has high rate of non-revenue water at 32% in 2015. Due to drought situation in 2015, it was difficult to identify and reduce water loss in a wide supply area. To detect and reduce water leak Kapilage, Sesoan City and K-Water installed smart metering system to understand and cope with drought situation.

Objective

- To detect water loss and reduce rate of non-revenue water, leakage from burst pipes and improve customer satisfaction in Cha-ri village.

Interventions:

- Seosan city and K- Water Installed Smart water meters in region.
- Created nine sub district metered area systems withing two district metered areas.

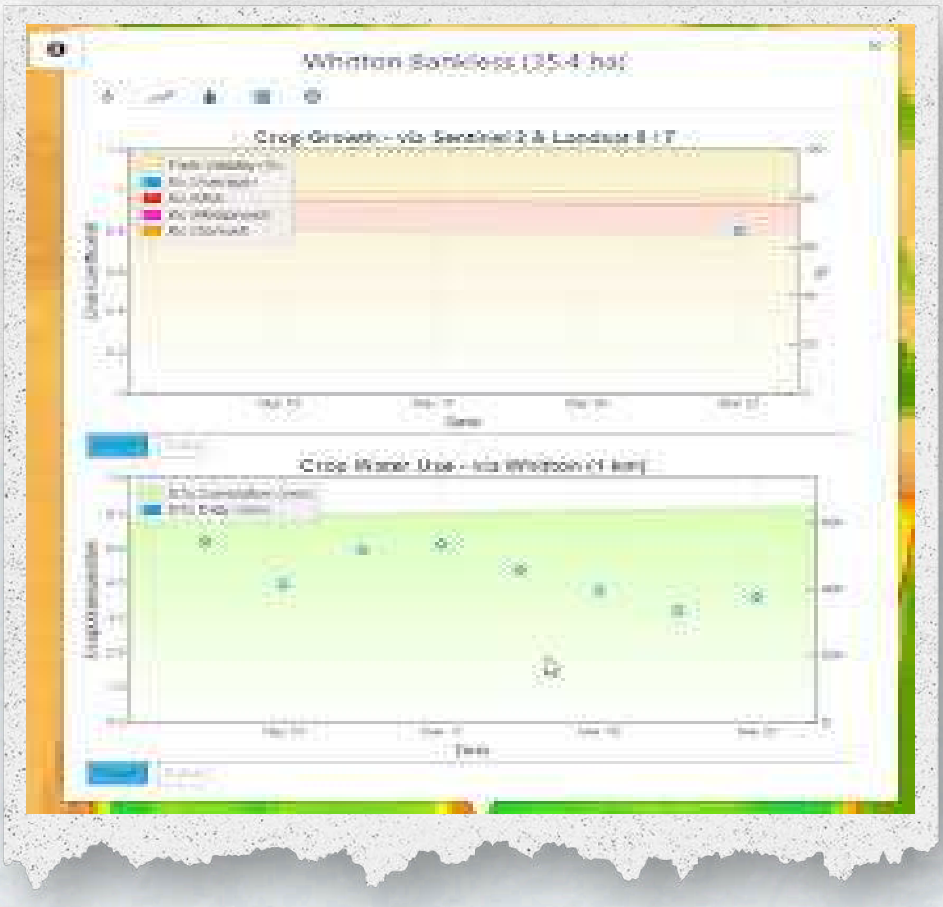
- Non-revenue water analysis was conducted on daily basis to understand and detect leakage.
- Water monitoring systems was expanded to 12 branches.
- Customer satisfaction evaluated by smart phones.

Outcome:

- Difference of 430 cubic meters per day was found between the flow rate in the district metered areas and the total flow rate of the water supply area in the Cha-ri.
- Increase in flexibility in managing response time to address complaints of failure in service.
- Rate of non-revenue water decreased from 32% to 10% after installation of smart water systems.
- Control system allowed for the analysis of customer usage patterns, which resulted in 55% reduction in customers water usage and 70% reduction in cost to the customer.

[15] *https://development.asia/case-study/improving-water-service-through-smart-metering*

USING SATELLITES FOR BETTER IRRIGATION



Place of Implementation: Australia

Organization:

IrriSAT app was created by Mr. John Hornbuckle, Jamie Vleeshouwer and Dr. Janelle Montgomery.The app was awarded as 'Best technology' in the WatSave Annual Awards 2018 in Australia.

Year of Implementation: 2019

Background:

Traditional methods of collecting data such as manual measurements or ground-based surveys can be time-consuming and labor-intensive. Moreover, these irrigation systems often rely on fixed schedules or manual observation, which may lead to overwatering or under watering of crops. Without accurate information on crop water requirements and environmental conditions, farmers struggle to determine the optimal timing and duration of irrigation. Drought conditions and limited water availability pose additional challenges to agricultural productivity. Weather-based irrigation management systems can help mitigate the impact of drought by adjusting irrigation schedules based on forecasted weather conditions.

Objective: Use of remote sensing to increase irrigation efficiency and crop productivity

Intervention:

- IrriSAT is a weather-based irrigation management app developed in Australia.

It uses remote sensing to provide site specific crop water management information across large spatial scales at fine resolution.

- Developed using Google Earth Engine, this app delivers crop water use and information to assist in irrigation scheduling and crop productivity benchmarking.

Outcome:

- IrriSAT users reported water savings from using tool in several ways:
  - Modifying irrigation timing to better match crop water demands.
  - Better predicting coming climate events and modifying irrigation schedules / deficits to minimize impacts on crop.
  - Identifying poorer performing areas within irrigated crops and changing management i.e. laser levelling.
  - Benchmarking performance of irrigated fields across farms and regions and using limited water resources on better performing fields.

[16] *https://www.adb.org/sites/default/files/publication/838386/adb-brief-222-sponge-cities-prc.pdf*

SPONGE CITY INITIATIVE: SUSTAINABLE URBAN WATER MANAGEMENT

Place of Implementation: China

Organization: People's Republic of China

Year of Implementation: 2014

Background:

Urbanization and industrialization along with opening-up policies since 1978 led to rapid economic and urban growth in the Performance Reference Compound (PRC), with an urbanization rate of 64.7% (2021). The PRC faced significant flooding across the country that killed 397 people, affected 14.3 million people, and caused $21.8 billion in economic losses. Building vast concrete barriers and covering all permeable surfaces is not sustainable and instead cities should adopt nature-based solutions to flooding. Sponge cities is one such solution that allows urban areas to absorb water in times of high rainfall and release it in times of drought.

Objectives:

- To adopt low impact developments concept which improve effective control of urban peak runoff, and temporarily store, recycle and purify stormwater.
- To integrate systems of Blue-Green-Grey infrastructure.
- It also focuses on upgrading traditional drainage systems by constructing underground water storage tanks and tunnels, and integrating natural water

bodies.

Interventions:

- China has implemented a comprehensive solution. They have combined low impact development methods with grey infrastructures, large scale flood control projects and rehabilitation.
- Indicators like control rate of annual runoff volume (CRARV), wastewater reuse rate, rainwater reuse rate, groundwater table, pluvial flood control and prevention ability were used to identify performance assessment on flood control, aquatic environments, water resources, water security and other aspects.
- Greenways development for controlling the volume of stormwater runoff.
- Reconstruction of pervious pavement and pipelines
- Artificial wetlands, artificial ponds and artificial soil infiltration are all used to purify and retain rainwater runoff at the end of catchments.
- Restored riverside wetlands and gentle green slopes along the river to reduce flood risk.
- Sponge city infrastructure like rain gardens and bioswales integrated with drainage pipe network improvements

Outcome:

- After implementing Sponge city program Shenzhen now has a high-density greenway network that totals over 2,300 kilometers in length, including green transport corridors, forests, and parks varying in width from under 3 m to over 100 m.
- Sponge city program eliminated flooding in six areas, eliminated pollution in seven river branches, and reduced the urban heat island effect.

COMMUNITY-BASED STORMWATER SMARTGRIDS: DISTRIBUTED AI/IOT RAIN HARVESTING NETWORKS FOR FLOOD AND DROUGHT RESILIENCE

Place of Implementation: Canada

Organization: Raingrid

Year of Implementation: 2015

Background:

- Canada is committed to sustainable storm water management as by increasing permeable surfaces through water sensitive urban design like bioswales, raingardens and permeable paving, they also invest in collecting storm water. At the individual and property level rain tanks are promoted to collect and measure rain water runoff.
- But there are various problems at property-based rain harvesting and land-based infiltration systems, where it is difficult to measure storing capacity, if system is already storing past storm water.
- To address this issue Raingrid stormwater Smart grid was developed using Artificial Intelligence and IoT system. The purpose of AI is to determine how much rain fall will runoff from roof of the household given predicted rainfall wherease IoT system is used to capture, filter and stores it in suitably sized cistern. on-board sensors calculate temperature, barometric pressure and rooftop runoff retained in the cistern.
- AI also predicts property by property

basis when the next rainfall is likely to come, and to consequently empty cisterns to provide appropriate storage to ensure practically zero stormwater runoff from the rooftops that constitute the majority of urban impermeable area.

Objective:

- Flood Prevention
- Weather prediction through AI and IoT
- Reducing need for piped stormwater management

Intervention:

- RainGrid's Residential Stormwater Smartgrid Utility Technology (RSSUT) is a smart water management technology designed to capture rain runoff from rooftops.
- The RainGrid system consists of: individual property cisterns, an artificial intelligent cloudbased weather algorithm, localized sensors, and electrically actuated drainage for harvested water reuse either within or exterior to the building envelope. A basic RainGrid System offers two stage primary filtration and storage in either above or below ground cisterns.
- Primary goal of taking rooftops offline from the storm sewer system, with a secondary goal of providing harvested water for groundwater recharge, potable or non-potable uses.
- RainGrid offers real-time rainfall/diversion data visualisation and micro-climate analytics on an individual property and network wide aggregation.
- IoT system has sensors for temperature, barometric pressure, and cistern level, and an electrically actuated valve for drainage.

Outcomes:

- Stormwater Smartgrid system successfully reduces 90% rain water runoff size of the cistern serving the roof area.
- Stormwater Smartgrid system is capable of retaining roughly 60% of all urban runoff as system penetration rises from 20-80%.
- Because of the smart grid innovation, RainGrid was designated by the Water Research Foundation (WRF) Leaders Innovation Forum for Technology (LIFT) as an Intelligent Water System for demonstration adoption and implementation by municipalities and utilities in 2015.

[18] *https://www.iwra.org/wp-content/uploads/2018/11/9-SWM-Canada-Final.pdf*

WASTEWATER
TREATMENT & REUSE

Growing tomatoes without soil using vertical farming in hydroponics- Sundrop Farms

Waterless dyeing technology in textile processing - DELFT University, DyeCoo, Tong Siang Co.

Reuse of treated water in Arequipa, Peru - Cerro Verde

Making Namakkal District of Tamil Nadu Water secure - District Administration of Tamil Nadu

Reuse of treated wastewater in thermal power plant in Nagpur - Nagpur Municipal Corporation

Watershed development in Hyderabad to address water scarcity

GROWING TOMATOES WITHOUT SOIL USING VERTICAL FARMING IN HYDROPONICS

Place of Implementation: Port Augusta, South Australia

Organization: Sundrop Farms

Year of Implementation: 2016

Background:

- The UN's Food and Agricultural Organization estimates that food production levels need to be increased by 70% from 2007 levels by 2050 to feed a projected world population of 9.7 billion.
- Due to reduced availability of land for agriculture, efficient farming methods have become a necessity.
- Sun Drop farms established in 2016, is one of the leading tomato producers in barren regions of Australia that grow tomatoes with the help of sea water and sunlight.

Objectives:

- To produce crop with the help of sea water, without soil in arid regions.
- To increase water usage efficiency in farms and conserve more water.
- Use of vertical farming to achieve food security

Interventions:

- Port Augusta farm is a 4.5-hectare greenhouse, powered by a 51,500 m2 concentrated solar power plant consisting of 23,000 mirrors directing the sun at a 127-metre-high tower weighing 234 tons.

- The heat generated is used for three processes: to keep 20 ha of greenhouses at optimum temperature; to generate electricity via a turbine to power farm systems; and to desalinate seawater drawn from the nearby Spencer Gulf.
- A vertical farming hydroponics facility is established to grow tomatoes without soil.
- The desalination unit produces pure water to irrigate the crops. The heat and carbon dioxide keep the tomatoes in the optimum atmosphere to facilitate year-round photosynthesis.

Outcome:

- The farm produces one million liters of fresh water every day by desalinating seawater drawn from 3 km away.
- 7,000 tonnes of tomatoes a year i.e.15% of Australia's total crop was grown in arid land.
- 1,80,000 of tomatoes were grown hydroponically in stacks without soil.
- Saving of 2 million liters of diesel and 15,000 tons of CO2 when compared to traditional farms.

[19] *https://gca.org/the-australian-farm-producing-tomatoes-with-seawater-and-sunlight-but-no-soil/*

WATERLESS DYEING TECHNOLOGY IN TEXTILE PROCESSING

Place of Implementation: Taiwan

Organization: DELFT University, DyeCoo and Tong Siang Co.

Year of Implementation: 2012

Background:

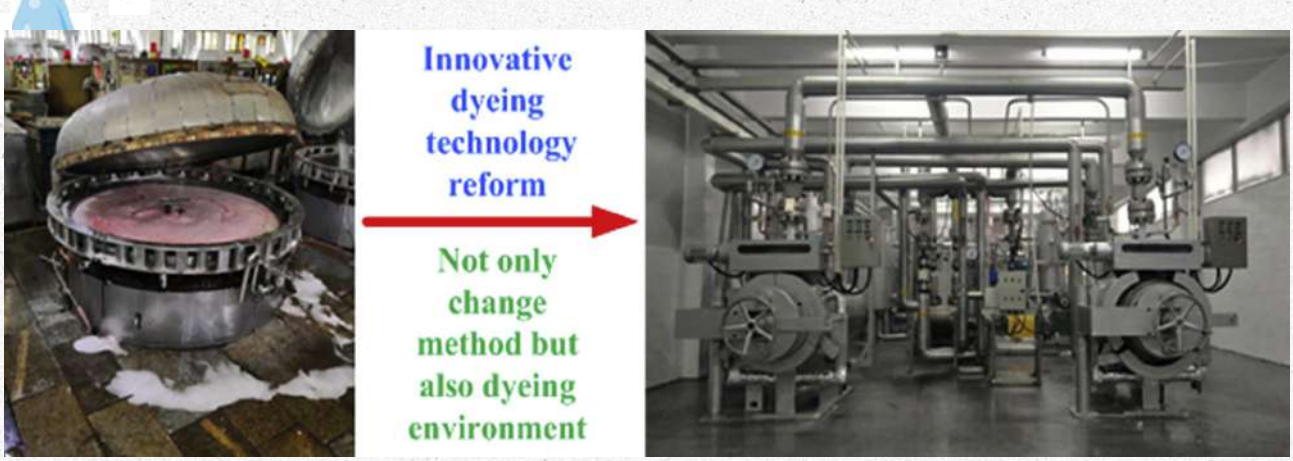
- Conventional textile dyeing is highly water intensive. It uses fresh water as solvent generates highly polluted water that must be treated extensively prior to discharge into rivers.
- A new commercial scale technology for dyeing synthetic fabric, DyeOx, was implemented in Taiwan that utilizes carbon dioxide (CO2) instead of water in the dyeing process. This technology does not require water or chemicals, and uses lesser energy than in conventional processes.
- The technology was conceived at DELFT University and commercialized by the start-up DyeCoo and Tong Siang Co., a dyehouse in Thailand.

Objective:

- To reduce withdrawal of waste water and reduce consumption of freshwater in textile industry.
- To improve water quality and increase net basin benefit.

Intervention:

- Waterless dyeing technology utilizes recycled CO2 in a semi closed loop dyeing



process for polyester fabrics. Nike Inc. partnered with DyeCoo in 2012 to implement waterless dyeing technology in four factories in Taiwan.

- Two machines were installed that produce 9,20,000 kg of fabric per annum and consumed less water.

Outcome:

- Elimination of chemical solvents
- Reduction in energy usage by 49%.
- Reduction in water withdrawals of 8256000 m3 when compared with conventional dyeing methods.
- Waste water treatment resulted in zero effluent discharge.

[20] *https://2030wrg.org/wpcontent/uploads/2022/01/72-D-Waterless-dying-technology-in-textile-processing.pdf*

REUSE OF TREATED WATER IN AREQUIPA, PERU

Place of Implementation: Arequipa, Peru

Organization: CerroVerde

Year of Implementation: 2016

Background:

- In 2008, more than 90 % of municipal sewage and waste water from Arequipa city in Peru was discharged directly into the Chili River. Largest copper mine in Peru Cerro Verde required access to additional water supply to expand its operations.
- To meet the water needs a water resource recovery facility called La Enlozada was designed, financed, built, and operated by Cerro Verde under a public-private partnership (PPP) agreement.

Objective:

- To treat waste water and to improve Chili water river quality.
- To reduce waterborne disease and advance sustainable solutions to region's water supply and sanitation sector.

Intervention:

- La Enlozada was built on the grounds of the Cerro Verde mining complex which contains the wastewater collection system, pumping station, and wastewater treatment plant. Land was provided by municipal authorities.

- Cerro Verde committed to finance in exchange of providing water resource recovery facilities. Cerro Verde would receive a percentage of the treated water to be used for mining processes. The rest of the treated wastewater would be returned to the river, to be used by farmers downstream.

Outcomes:

- The city of Arequipa is benefitting from wastewater treatment at no cost to the taxpayer. Wastewater treatment coverage has increased. More than 95 percent of the city's wastewater is treated.
- Enhanced water quality of Chili River boosted biodiversity in river.
- The Chili River was rehabilitated, and incidents of waterborne illness reduced.
- Farmers use improved quality of treated water for irrigation for crops.

[21] *https://documents1.worldbank.org/curated/fr/919231576609000366/pdf/Wastewater-From-Waste-to-Resource-The-Case-of-Arequipa-Peru.pdf*

NAMAKKAL DISTRICT OF TAMIL NADU BECAME WATER SECURED

Place of Implementation: Namakkal District of Tamil Nadu

Organization: District administration in five municipalities, 19 town panchayats and 322 village Panchayats across the district

Year of Implementation: 2022

Objective: Address water scarcity in Namakkal district and make it water secure.

Background:

Before 2022, Namakkal district of Tamil Nadu was facing severe water scarcity. To deal with water scarcity five municipalities of district administration, 19 town panchayats and 322 panchayats across the district implemented several water conservation activities, rain water harvesting, lakes, rivers, springs protection and reconstruction works

Interventions:

- To capture rainwater and replenish the groundwater table rooftop collection systems, percolation tanks and check dams were constructed.
- Artificial recharge structures were constructed for recharging groundwater.
- Around 685 individual farm ponds, 530 community farm ponds, 113 recharge shafts and 105 check dams were constructed across the district.
- Encroachments spread along the

Before desilting of pond at Namakkal

After desilting

waterbodies were removed across the district.

- Data acquisition systems were implemented to effectively monitor and control water supply networks.

Outcome:

- 49 tanks and 1400 kms of minor streams, rivers were rejuvenated.
- Encroachments spread over 110 acres along waterbodies across the district were removed.
- Sewerage network of around 24.72 km was created.
- Sewerage cleaning over a length of 500 km was undertaken.
- Recharge of aquifer significantly reduced reliance on unsustainable sources.
- Advanced technologies enable the administration to detect leaks, reduce system losses, optimise water distribution.
- With implemented strategies Namakkal became second best district in India in terms of groundwater availability.
- In Union Jal Shakti Ministry's annual ranking, Namakkal achieved second place in the conservation and management category for the year 2022.

[22] *https://www.indiawaterportal.org/articles/namakkal-district-tamil-nadu-sets-example-becoming-water-secure pdf*

REUSE OF TREATED WATER IN THERMAL POWER PLANT IN NAGPUR

Place of Implementation: Nagpur

Organization: MahaGenCo, Nagpur Municipal Corporation (NMC)

Year of Implementation: 2015

Background:

The city generated around 425 million liters a day of wastewater with a capacity of just 100 million liters a day, increasing population and large volume used in thermal power plants, makes city water stressed. MahaGenCo partnered with NMC to explore the use of wastewater from treatment plant for its operation.

Objective:

- Address water scarcity in Nagpur.
- To increase water demand for power plant.
- To diversify water supply sources by incorporating alternative sources (treated wastewater) and invest in sanitation and wastewater infrastructure for the city.

Intervention:

- Project included a raw wastewater intake facility with a pumping station of 130 million liters per day.
- Wastewater treatment plant with secondary and tertiary treatment to meet MahaGenCo's water quality requirements.
- A 16.2 km pipeline from the wastewater treatment plant to the power plant.

- A one-day reservoir of treated wastewater at the Thermal Power Plant for back-up.
- End user was MahaGenCo of waste water for that they paid NMC INR 2.03 per cubic meter of raw wastewater.

Outcomes :

- The city of Nagpur is on its way to becoming the first Indian city to reuse more than 90 percent of its wastewater.
- The proximity of the power plant to the wastewater treatment plant lowered water transport costs.
- Treated waste water is less expensive for a power plant and has consistent quality and quantity more than freshwater.

[23] *https://documents1.worldbank.org/curated/en/847531576610020104/pdf/Wastewater-From-Waste-to-Resource-The-Case-of-Nagpur-India.pdf*

WATERSHED DEVELOPMENT IN HYDERABAD TO ADDRESS WATER SCARCITY

Place of Implementation: Five villages near Hyderabad, Telangana.

Organization, National Agro Foundation

Year of Implementation: 2021

Background:

- There are two primary sources of water in Hyderabad — the Nagarjuna Sagar reservoir (River Krishna) and the Yellampalli reservoir (River Godavari). Water levels at both these reservoirs were dangerously low in 2019 affecting the drinking water supply for its 6.8 million residents.
- In year 2021, Novartis in collaboration with non-profit organization National Agro Foundation launched watershed development program to solve problem of water scarcity in 5 villages Near Hyderabad, Telangana region.

Objectives:

- Improving drinking water availability and quality, and sanitation facilities to maximize economic and social welfare without compromising vital ecosystems.
- Install drinking water and sanitation facilities at local schools, provide livelihood support (e.g., backyard poultry, livestock for milk) to landless families through women self-help groups, and plant 3,000 trees.

Interventions:

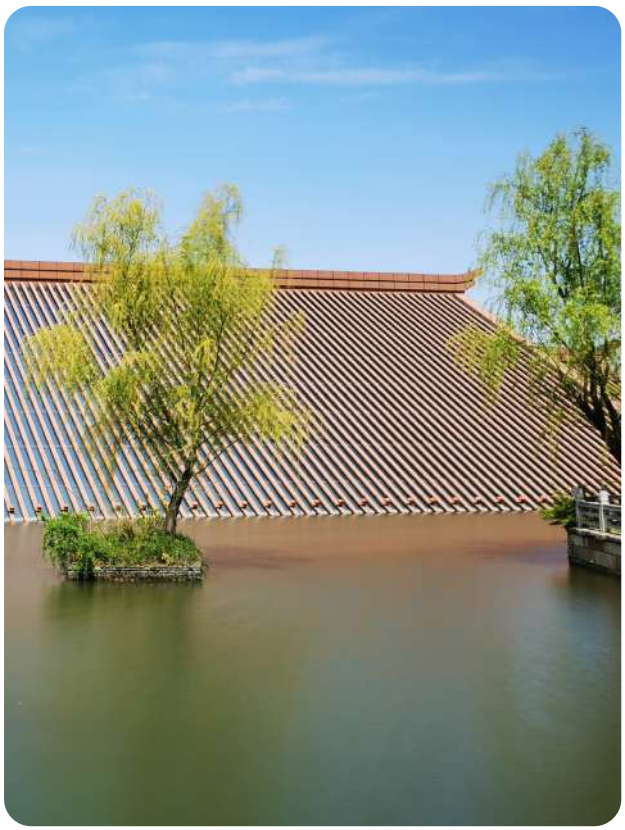
- Implied integrated model to rejuvenate vital eco system.
- Promotion of inclusive development.
- Capacity-building to farmers, in particular training on advanced water-saving techniques and methods to increase agricultural productivity sustainably.

Outcomes:

- Increase in water availability by 50%-60%.
- Ground water table augmented by 10 feet (3 meters)
- Benefited around 2000 families.
- Created an additional 50,000 m3 water storage capacity.
- Harvested 60,000m3 volume of rainwater
- Increased farmer income to INR 8100 per acre.

[24] *https://www.novartis.com/in-en/the-road-water-neutrality-a-race-we-can-wipdf*

CLIMATE RESILIENT **WATER MANAGEMENT**



Temporary flood water storage in agricultural areas in the Middle Tisza river basin - Govt. of Hungary

Sihlanzimvelo Stream Cleaning Project - eThekwini municipality, South Africa

Metropolitan Area Outer Underground Discharge Channel (MAOUDC)- Tokyo City Administration

Making Namakkal District of Tamil Nadu Water secure - District Administration of Tamil Nadu

Flood Forecasting and Early Warning System - Govt. of Kolkata and Asian Development Bank

TEMPORARY FLOOD WATER STORAGE IN AGRICULTURAL AREAS IN THE MIDDLE TISZA RIVER BASIN

Place of Implementation: Middle Tisza river basin, Hungary

Organization: Government of Hungary

Year of Implementation: 2009

Background:

River straightening, combined with other factors (sediment accumulation in some river sections, deforestation, land use change) caused continuous increase in peak flood water levels. Peak water levels were 753 cm in 1876, 909 cm in 1970 and 1040 cm in 2000. From the period 1998-2001 four serious flood events took place on the Tisza river with peak water levels, as neither the height of the dikes, nor their strength were adequate. In one flood event dikes were ruptured and protected areas were flooded.

Objective:

- Cost effective measures for flood protection strategy for the middle Tisza river basin
- To cope with the changing condition of river basin and strengthen weak points of existing dike system.

Intervention:

- Six temporary reservoirs were used for agricultural purposes in normal periods and utilized for temporary water retention

during flood. An additional water retention area along the Tisza river was created in 2022. The water retention areas were planned to have a lifetime of over 100 years.

- A mechanism of economic compensation implemented by the government for remunerating farmers in case of damage to the agricultural soil and yield losses during flood events
- Cost-benefit analysis of the selected strategy performed

Outcome:

- Area utilized for agricultural purposes in normal conditions, is eventually flooded (intentionally and under controlled conditions) and utilized for flood water retention in case of emergency.
- This system supplemented the dikes to cope with floods with a return period of 100 years or higher.
- Allowed buffering during extreme precipitation events and reducing flood wave propagation, with consistent beneficial implications for flood risk mitigation.
- First polder was inaugurated in 2009 and other five temporary planned reservoirs were completed during 2010-2015.
- One of these polders was successfully used in 2010 flood event which showed that flood mitigation system proved effective for the purposes of disaster risk reduction.
- Cost benefit analysis presented a trade-off between efficiency in risk reduction and relatively low initial investment costs.

[25] *https://climateadapt.eea.europa.eu/en/metadata/case-studies/temporary-flood-water-storage-in-agricultural-areas-in-the-middle-tisza-river-basin-hungary/#adapt_options_anchor*

SIHLANZIMVELO STREAM CLEANING PROJECT

Place of Implementation: Durban, South Africa

Organization: eThekwini municipality in partnership with Roads and Stormwater Maintenance Unit

Year of Implementation: 2011

Background:

Durban (eThekwini) is the third most populous city in South Africa. The coastline along eThekwini is vulnerable to flooding and erosion as culverts designed in earlier times did not factor in the debris carried by rivers during storm events. The streams are located in high density, low-income settlements with poor water quality. This poses human health risks and flood associated impacts. Alien and invasive vegetation, accumulation of solid waste increased the amount of silt in rivers causing stormwater blockages. This project is located within the uMhlangane River Catchment to help the city manage flooding and stormwater blockages.

Objective:

- To remove solid waste, alien and invasive vegetation along 295 km of streams.
- To control flood and clean stormwater blockages.
- To create employment.

- To educate communities about flood management.

Intervention:

Community co-operatives of 8-10 local people involved in :

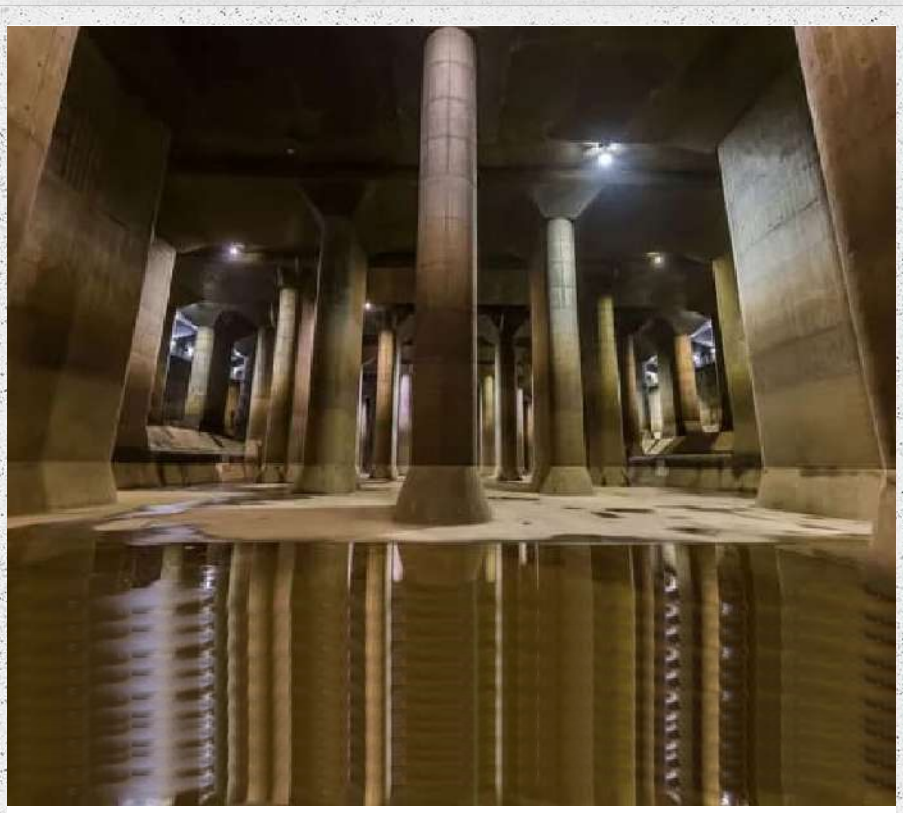
- Clearing 5 km of river along with 3 m corridors on either side of water.
- Re-planting indigenous plants in riparian zones.
- Reporting sewer leaks and blocked manholes.
- Circulating knowledge about species and vegetation within the community.

Outcome:

- Sihlanzimvelo expanded its reach from 295 km to 525 km, creating clean public spaces for recreation.
- Around 800 jobs were created, saving millions of rand by preventing damage to road culverts and infrastructure in the city.
- The maintenance program removed solid waste and alien vegetation in KwaMashu under the Sihlanzimvelo Stream Cleaning Project.

[26] *https://issuu.com/glen.t/docs/imiesa_october_2022/s/17157119*

METROPOLITAN AREA OUTER UNDERGROUND DISCHARGE CHANNEL (MAOUDC)



Place of Implementation: Tokyo, Japan

Organization: City Administration

Year of Implementation: 2005

Background:

Tokyo experiences severe floods during the monsoon as the rivers swell during that time. The stormwater drainage system does not have the capacity to accommodate runoff during extreme rainfall. To mitigate risk of flooding City administration developed Metropolitan Area Outer Underground Discharge Channel (MAOUDC) system.

Objective:

- To build flood defense system using advanced infrastructure.
- To mitigate risk of flooding and associated impacts.

Intervention:

- Underground tunnels works as a function to divert and manage flood water.
- Five contaminant silos which are connected to 6.3 km long central tunnel located 50 meters beneath the surface collects excess water from rivers in and around the city.
- System contains pumps and water tanks to divert overflowing flood water into the

underground silos and tunnels.

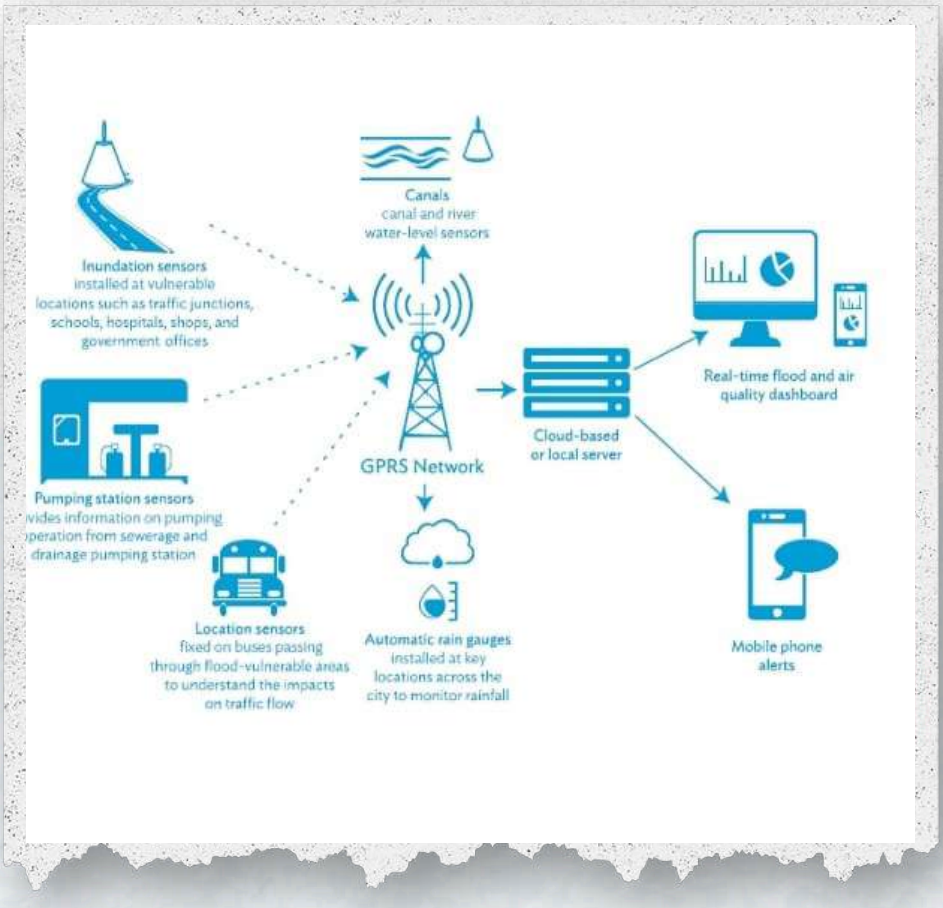
- When the flow within the river system becomes normal, stored water is pumped back into the Edo river that is connected to the Tokyo Bay.

Outcome:

- Flood water is successfully stored during extreme rainfall and reduced the risk of water stagnation around the city.
- The damages resulting from floods have been reduced (halved) in comparison to losses before establishing the defense system.
- The tunnels are open to tourists and visitors to spread awareness about the importance of disaster management during inactivity.

[27] *file:///E:/A%20Catalogue%20of%20Best%20Practices%20for%20Building%20Flood%20Resilience_compressed%20(1)%20(1).pdf*

FLOOD FORECASTING AND EARLY WARNING SYSTEM IN KOLKATA



Place of Implementation: Kolkata, West Bengal

Organization: Kolkata Municipal Corporation (KMC) with technical assistance from Asian Development Bank (ADB)

Year of Implementation: 2018

Background: Kolkata is highly prone to recurring flooding:

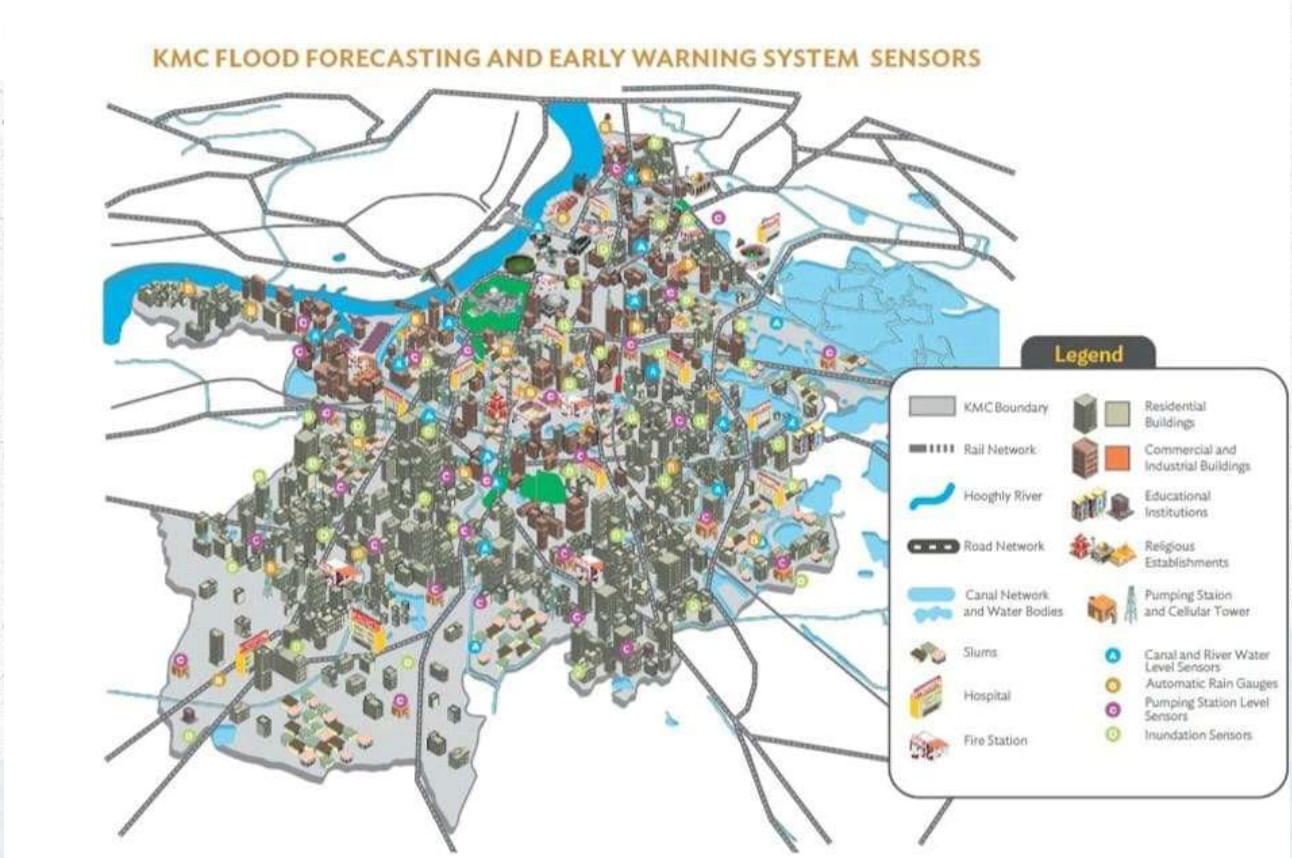
- Urbanization challenges like encroachment of water bodies, inadequate storm water drainage systems, inadequate solid waste management block the tidal channels
- Deltaic topography and extreme rainfall
- Lack of flood preparedness.
- Flood Forecasting and Early Warning System (FFEWS) is the first comprehensive city level early warning system in India implemented by KMC with the help of ADB.

Objective:

- To improve flood resilience of the city
- Monitor and disseminate flood risk data

Interventions:

- Establishing a city level FFEWS designed to visualize the real time information on temperature, air quality and water



stagnation and other climate related data using 400 sensor nodes.

- Installation of ultrasonic sensors across vulnerable hotspots and critical junctions like canals, water pumping stations, traffic junctions and schools
- Community involvement through installation of shopfront sensors in commercial areas.
- Capturing real time information on
- Flood and air quality and upload on a centralised cloud server for processing. This data collected can be visualized in a Geographic Information Systems (GIS) platform.
- Disseminate warnings to the public through mobile notifications, radio and television broadcasts.

Outcome:

- Flooding reduced about 4,800 hectares, and KMC expects further flood reduction in over 6,000 hectares
- Reduced impacts from flood-induced traffic congestions
- Flood-informed urban planning
- Reduced economic loss and impacts on livelihoods
- Improved flood awareness and safety at community level
- Access to environmental and inundation data at the shop or building-level.

[28] *https://www.adb.org/publications/toward-resilient-kolkata*

Key Learnings from **Compendium**

Water conservation practices are being carried out across the globe that have immensely benefitted the farmers and society resulted in optimal allocation of water resources. Studies demonstrating significant changes in the system were selected for this compendium and grouped under five themes viz. Policy-led interventions, Watershed development, Smart water infrastructure, Wastewater treatment and its reuse and Climate resilient water management. Overall, these interventions have immensely benefitted the farmers, optimized the consumption of water resources and developed climate resilience in the respective area. Specific learnings observed from the studies in this compendium are described below:

Policy-led Interventions

1) Policy led interventions are instrumental in effective water management at village or district level.

2) Tanks, check dams, farm ponds are conventional methods of water conservation with which local communities strongly associate. Hence, community participiation will lead to ownership and help in long term sustainability of the intervention.

3) Deeping of ponds and tanks is an effective way to restore groundwater levels and address water scarcity. Silt resulted from soil excavation during deeping is an important resource for the farmers and thus they are ready to participate in the whole process.

4) Water budgeting as adopted in Mukhyamantri Jal Swavlamban Abhiyan of Rajasthan proved to an effective measure of optimizng water consumption.

5) Suucessful model of Drink From Tap Mission in PURI city can be replicated in other cities as well. The main features of this mission are Right to Water policy, relaxed house connection norms, reduced non revenue water through 100% metering and volumetric metering.

6) Use of information technology with smart metring helps in data capturing which can be used by the operators as a tool for decision making.

7) Construction of wells in water scarce regions will aid in impriving the fertility of land and consequently the agricutral economy of the area.

8) Automation of canal systems will help in decision making process.

Watershed Development

1) Building robust and sustainable structures positively impact year long availability of water

2) Employing modern techniques like microirrigation , mulching raise the irrigation efficiency.

3) Community awareness about quality and qauntity of water can help in averting risk of water stress.

4) Precautions must be taken to avoid accumulation of silt in dams as it lowers the water holding capacity.

5) Shift from rain dependent farming to harvesting and storing rain water through diversion-based farming is required.

6) Over extraction of ground water can lead to Fluoride contamination creating health issues.

7) Shift in source of water from ground water to surface water in areas which are contaminated with heavy metals is recommended.

8) The implementation of Phytoremediation and Bioremediation techniques are effective in biological rejuvenation of lakes.

9) The biological restoration of lake can integrate renewable energy options such as solar power within the process.

Smart Water Infrastructure

1) The implementation of IoT and AI devices for monitoring water consumption and losses can effectively predict weather patterns, leading to a reduction in non-revenue water and better flood management.

2) In order to adapt to climate change, irrigation system needs to be conjugated with remote sensing and satellite imagery techniques.

3) The timely prediction, and subsequent modification of irrigation schedules can enhance the irrigation efficiency and crop productivity.

4) The implementation of Nature-Based Solutions (NBS) is a viable approach to mitigate the impact of floods.

5) Upgradation in traditional drainage systems is required.

6) The integration of blue, green, and gray infrastructure is a viable approach to effectively manage floods.

Wastewater Treatment And Reuse

1) Hydroponics in combination with desalination is efficient method of growing crops with reduced fresh water consumption.

2) Waterless drying technology in textile industries results in enormous amount of water and energy savings.

3) Tertiary treatment of wastewater and its reuse in mining operations presents a financially and environmentally beneficial model.

4) Nagpur model of reuse of tertiary treated water to generate steam in thermal power plant is an excellent demonstration of how circular economy can result in lowering the volume of freshwater withdrawal. This model can be adopted by other cities as well.

5) Community-driven initiatives are better maintained and demonstrate longevity in terms of resource management.

6) In large urban water supply systems, comprehensive monitoring and real-time data procurement ensures control, decision support and sustainable use of water resources.

Climate Resilient Water Management

1) In the wake of rising flood events all across India, sustainable flood protection initiatives are required.

2) Hungary introduced a cost-effective practice for flood protection in which agricultural land is used as temporary reservoir during flooding for water retention.

3) Constructing underground tunnels as practiced in Japan is an innovative measure to divert and manage flood water. The water stored in the storage may be used for domestic supply or can be pumped back into the river when the river water recedes.

4) Flood Forecasting and Early Warning System (FFEWS) model implemented in Kolkata can be replicated in other cities.

5) Real time monitoring through smart technology is effective in building city's flood resilience.

सत्यमेव जयते

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