Management Development Programme
on
Integrated Water Resources Management
for
Karnataka State Water Resource Engineers and Managers

Report submitted to

Advanced Centre for Integrated Water Resources Management
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Contents

1. Introduction

India has more than 18% of the world population but only 4% of the world's renewable water resources with 2.4% of world's land area. Since the available water is limited and requirements varied across sector and geography, there is an urgent need to manage resources in an integrated manner, ensuring equitable access and sustainability. In particular, there is a brewing water crisis in Karnataka with increasing demand from a growing population and accelerating consumption rates.

Integrated Water Resources Management (IWRM) has emerged during the last decade as a potential solution in response to the widespread concern that our freshwater resources are being placed under pressure from population growth and rising demand for water, as well as increasing pollution levels. The Global Water Partnership (GWP) defines IWRM as "a process which promotes the coordinated development and management of water, land and related resources to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partenership, 2010) .

In response to the need to introduce the principles of IWRM in the governance of water resources in Karnataka, a Management Development Programme was organised for entry-level engineers in the Karnataka State Water Resources Department, for them to be able to adopt and advocate for the deployment of these principles in water management across the state.

2. Objectives and Pedagogy

The objective of this Management Development Programme (MDP) was to improve state capacity in the management of water resources by familiarizing the government staff, particularly managers and engineers at state and district levels, with the concepts and methods to understand and address water management issues in Karnataka in an integrated and holistic manner, through the heuristic of Integrated Water Resources Management.

The course outline was drawn to achieve the above objective. The andragogy, or the method used to teach adult learners:

- Consisted of a learning plan designed around the intended learning goals organised into themes, each of which was associated with a lesson plan for a session. Each session was composed of mini lecture followed by a Q&A session to provide clarifications sought by the participants.
- Included several group exercises (including group discussions, case studies and games) and alternate means of communicating information (videos, quizzes and hands-on exercises) to encourage active learning and the clarification of concepts
- Involved instruction in a combination of English and Kannada to ensure that the participants were able to understand the course material. Participants were also invited to actively ask questions and engage in discussion in the language that they were most comfortable using.

Participants learnt the basics of techniques like hydrological monitoring, water quality testing, and remote sensing and GIS. Leading academics and practitioners in the field of water resources management conducted sessions on topics of their expertise. A field visit was also arranged to provide participants with practical exposure to topics that were discussed in the various learning modules.

3. Course Duration and Strength

The course was held for 13 calendar days between 8th and 20th February, 2021. This included 10 days in interactive classroom sessions including group exercises and a day-long field trip. The programme was attended by 32 early career engineers nominated by the Karnataka state Water Resources Department, with the rank of Junior or Assistant Engineer. A complete list of participants is provided in Annexure 8.1 and the course schedule is attached in Annexure 8.1.

4. Inaugural Function

The inaugural function was held on the morning of 8th February 2021. The lamp was lit, followed by an address by Dr. Durba Biswas, Fellow, ATREE, who introduced ATREE as a policy and practice-oriented research organisation.

The Chief Guest, Sri S. B. Siddagangappa, Registrar and Engineer-in-Chief, ACIWRM addressed the participants next. He discussed ACIWRM's efforts to reinvent water management in India, from a previous siloed and project-oriented process to one with an integrated, planned and scientific outlook. Next, the Guest of Honour Dr. P. Somashekhar Rao, Director (Technical), ACIWRM addressed the gathering. Next, Sri M. S. Raviprakash discussed the activities under Phase 1 of the ADB project on IWRM, including the establishment of Karnataka Water Resources Information System, participatory land and water management, Technical Support Group and communications strategy. The efforts also include capacity-building activities through workshops on topics like IWRM, remote sensing and GIS for water resource management, and water accounting. The Guest of Honour Prof. K. N. Ganeshiah, governing board member, ATREE then spoke to the gathering, sharing

a research example of the cultural relevance of water management. Following this was a round of introductions by the participants, followed by a vote of thanks and a group photograph.

5. Session Summary

The sessions in the two-week course brought together water sector experts from academia and practice who engage in water management issues using bio-physical and socio-political lenses.

The initial sessions were taken by ATREE faculty to introduce participants to the key aspects and frameworks of IWRM that they would use as a basis for engagement with the rest of the workshop. The course started with basic sessions on hydrology, the water cycle, systems thinking, normative concerns in water management, water use sectors and environmental flows. These were followed by modules showcasing more applied management systems, covering topics like water resources and irrigation infrastructure modelling, planning and management. Governance aspects of management were covered next, through sessions on water governance, decision-making tools, participatory irrigation management and regulatory authorities. Principles of water law and finance were then covered. The course included sessions to build hands-on skills of remote sensing and GIS, project planning, leadership and personal development. There was also a session on change management to introduce participants to topics on organisational and community leadership. The field trip to Jakkur and Rachenahalli lakes allowed participants to think about the concepts they were learning about in the applied context of urban lakes and watersheds. On the last day of the workshop, participants presented basin management plans that they had prepared in groups, reflecting the rich learning that they had acquired over the previous two weeks.

Throughout the course, an attempt was made to engage participants in critical discussion about the coursework with respect to their roles in the government. Each day, three participants recapped the sessions of the previous day, sharing their key take-aways and thoughts from the modules.

Descriptions of the sessions are provided in Section 6.

Dr Jagdish Krishnaswamy (ecohydrologist), Dr Veena Srinivasan (sociohydrologist), Dr Sharachchandra Lele (Interdisciplinary environmental scientist), Dr Priyanka Jamwal (water quality specialist), Dr Durba Biswas (economist and gender specialist) and Dr Shrinivas Badiger (hydrologist and water policy expert) all ATREE faculty members, took sessions on different topics. In addition, the following external experts were invited to handle other themes.

- M. G. Shivakumar, Chief Engineer, Government of Karnataka (MASSCOTE)
- N. Balakrishnaraj, Consultant
- Ravichandra Masuti, ACIWRM
- Dr Shobha Reddy, Independent expert (Change management)
- Dr. Prakash Kulkarni, Bhageerath (Financing and tariff setting)
- Madhubandti Sadhya and Lianne D'Souza (NLSIU)
- Dr. Sashikumar N (ACIWRM)
- Vijeth Kashyap (ACIWRM)
- Teju Kumar (ACIWRM)
- Dr. Sachin Warghade (TISS, Mumbai)
- Payal Pruthi (ACIWRM)

Bios of the resource persons are include in Annexure 8.9.

6. Session details

6.1. Theme 1: Course Introduction and objectives

Instructor: Dr. Shrinivas Badiger

The course introduction was provided by Dr. Shrinivas Badiger. He gave a brief introduction to Integrated Water Resource Management, shared the objectives of the course along with expectations from the participants.

There was then a short session where COVID safety norms and instructions were shared.

Dr. Badiger then led a rich picturing exercise. The participants were divided into groups of 4-5 persons each, and encouraged to discuss their understanding of the different stakeholders, objectives, activities and elements of water systems. They then prepared a visual representation of this shared understanding and presented it to the rest of the class. The exercise led to a discussion on the need to manage water resources in an integrated manner.

6.2. Theme 2: Introduction to Integrated Water Resource Management
Instructors: Dr. Veena Srinivasan

Under Theme 2, Dr. Veena Srinivasan delivered a lecture which she started with introducing the characteristics of water. She discussed the different sources and sinks of water, and their characteristics. She then discussed the water cycle and led an exercise on developing the water balance of a hypothetical semi-arid watershed. She then moved on to talking about the sectoral uses of water, defining key terms like consumptive use, withdrawal, potential and actual evapotranspiration. She then discussed the Dublin Principles and introduced the concept of systems thinking in IWRM. After lunch, Dr. Srinivasan led a group activity on IWRM scenarios. The participants were divided into groups of stakeholders (rainfed and irrigated (command A, command B, groundwater irrigated) farmers, government, WRD, environmentalists). Each actor would make a decision in every round of the game, which would be fed into a hydrological model along with wildcard outcomes around rainfall, etc. The model would then be run, to produce water balance and payout outcomes.

After the exercise, there was a round of reflection on priorities, allocation, education and cooperation.

6.3. Theme 3: Water Uses and Benefits

Instructors: Dr. Shrinivas Badger, Dr. Sharachchandra Lele

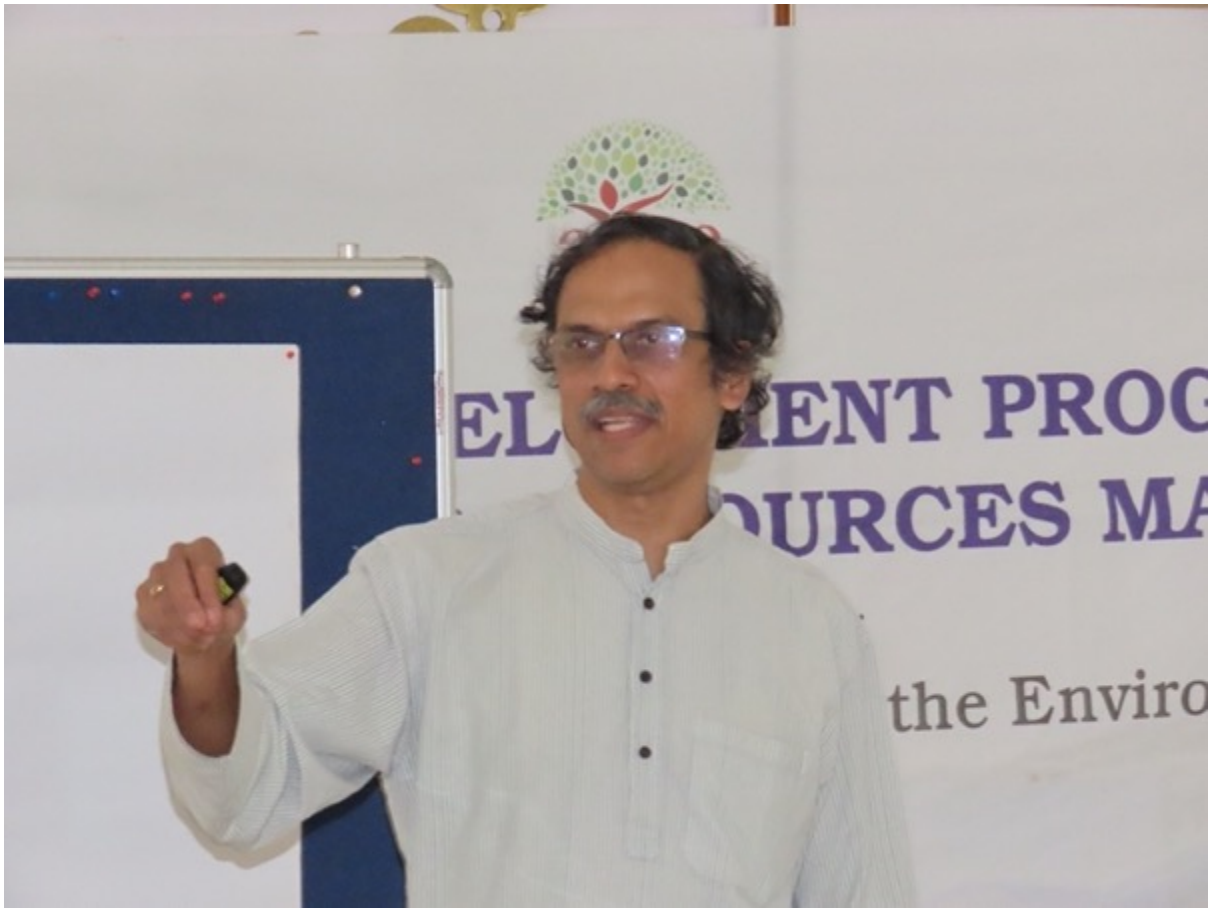
Dr. Shrinivas Badiger started the session by introducing the concepts of watersheds and stream order. He introduced Digital Elevation Models which are satellite-derived maps of elevation, using a DEM of the Malaprabha basin. He described the watershed classification in India, and clarified terms like TMC and Cusec. He next showed the participants a conceptual diagram of the water cycle and explained the partitioning of precipitation water into infiltration, run-off, evaporation and evapo-transpiration. He discussed infiltration to be a function of soil type, soil moisture, vegetation, slope and intensity of rainfall. He also shared that run-off starts after a depth of water on the surface of soil is established.

He explained the water balance equation in a natural system:
$P = Q + ET + R + \Delta S$; $R + \Delta S = I$
P: Precipitation
Q: Surface run-off
ET: Evapotranspiration
R: Recharge
ΔS: Change in storage
I: Infiltration
P, Q and I are measurable parameters while ET can only be estimated as a function of the nature of vegetation, relative humidity, temperature, wind and soil moisture.

He also shared that ET has increased in the recent years due to the spread of irrigated agriculture in India. In human modified systems, the above equation would have to be altered to account for diversion, storage and pumping of blue water.

He also explained the correlation between precipitation rates and vegetation density, sharing that high rainfall levels lead to dense vegetation, rather than high tree cover causing an increase in rainfall. He also discussed the methods of measuring rainfall and the transition of use from ordinary rain gauges through self-recording rain gauge the tipping bucket rain gauges used most widely today. Then then delved into the differences in rainfall and discharge patterns in India and Europe, and linked this to the need for dams in India. He also facilitated a discussion on the ethics surrounding dam construction, and the various associated environmental and social issues. He finally discussed the concept of evapotranspiration, that plants reduce the rate of evaporation that would have naturally occurred if there was only water stagnant in the soil and that actual ET is a function of leaf area index.

Dr. Sharachchandra Lele started the next session by introducing the concept of normative concerns using an exercise of asking ‘why’ of different normative statements until the core normative concern was arrived at. He shared that a normative statement is prescriptive (a ‘should’ statement) rather than descriptive (an ‘is’ statement). He explained that while science is descriptive, policy is descriptive. Normative concerns are universal and concerns ethics. He then discussed the normative concerns underpinning water management and how they are addressed in water policy.



In the next session, Dr. Lele defined key terms like green water, blue water, consumptive use, grey water and black water. He then delved into the issue of urban water management, taking the case study of Bangalore. He led an exercise to estimate the water budget of Bangalore, and then pointed out that since these calculations produce averages, there is a need to further investigate the actual variation in access. He provided an example of a study which revealed that while the mean water usage in Bangalore is 120 LPCD, the median value is only 85 LPCD. Highlighting the issue of inequity, he drew the participants' attention to the need for an IWRM mindset. He finally shared possible starting points for solutions in the form of source integration, sectoral integration, people's integration and normative integration.

Next, Dr. Lele explored the variations in the natural hydrological cycle in the agricultural sector, in the presence of pumping, artificial recharge and irrigation. He spent time on the topic of base flows, river discharge and ground water extraction. He then debunked the 'silver bullet' thinking around watershed management options like check dams, also pointing out that they don't only increase recharge, but also increase evaporation and reduce runoff. He then moved on to sharing examples of other popular solutions that don't always work, like direct artificial recharge, drilling new borewells and desilting tanks. In doing so, he highlighted the importance of systems thinking and the IWRM approach to be able to critically understand the trade-offs associated with any proposed water management intervention.

6.4. Theme 11: Water Resources and Regualation
Instructor: Dr. Priyanka Jamwal

Dr. Priyanka Jamwal started the session by introducing her academic background as an environmental scientist and her work on water resource management, with a focus on water quality. She then discussed the prevalent water quality standards based on water use (as raw water sources with chlorination, for recreation, as drinking water, for fisheries, and for irrigation or controlled disposal). She also introduced concepts of total and faecal coliforms as indicators of contaminants, chlorination, free ammonia and dissolved oxygen. She further shared case studies of ATREE's investigation of fish kills in Ulsoor lake (receiving raw sewage), and Jakkur lake (receiving treated water from an STP but with high levels of algae and a diurnal fluctuation in DO levels resulting from the absence of tertiary treatment to remove nitrates and phosphates).

She then discussed the effects of polluted water on human health (through drinking, contact with irrigation water and ingestion of food crops) and shared the case study of lead contamination in Maggi due to the use of onions irrigated using industrial waste water in tastemaker. She used the water quality regulatory framework and examples of her research on the Vrishabhavathy river to illustrate the need to expand the spectrum of water quality parameters and increase the frequency of sampling. Finally, she showed the participants a video illustrating ATREE's findings on the Vrishabhavathy's pollution problem and shared her thoughts on possible solutions (using real-time monitoring devices, sampling for parameters, engaging with citizens to identify targets and indicators of water quality, using citizen dashboards and establishing decentralised treatment plants). She then discussed her research on the impact of the COVID-19 lockdown on water quality

Then, she moved on to discussing challenges around reducing water pollution. She shared problems associated with wastewater treatment, using findings from a study on the Vrishabhavathy valley STP. The outflows from the STP didn't meet discharge standards for parameters like faecal coliforms and BOD. Ultimately, there was no significant difference in the assessed water quality between areas upstream and downstream of the STP. She also shared the sporadic water quality monitoring was a significant issue. She then shared possible, in the form of establishing centralised wastewater treatment plants (the downsides are that they are expensive, large-scale, often ineffective), treatment system within the drain (example of STRAn-S System), DEWATs systems in a school on Berambadi, Buffer zones in agricultural areas and using constructed wetlands planted with species like typha, canna. She ended the session by introducing innovations around devices for faster, cheaper and more reliable water monitoring.

6.5. Theme 4: Water resources and sustainability
Instructor: Dr. Shrinivas Badiger

Dr. Badiger started the session with a detailed discussion with the participants around their feedback on the programme. He then assigned the participants the group project on Scenario Building and Contextualising IWRM. Participants were required to create an IWRM basin plan in a case study area of their choice, taking into consideration the population, catchment area, rainfall, land use-land cover, etc. In the process, they had to play the roles of policy maker, engineer and contractor. Participants were given time to draft a basin plan and presented their ideas on the last day of the workshop.

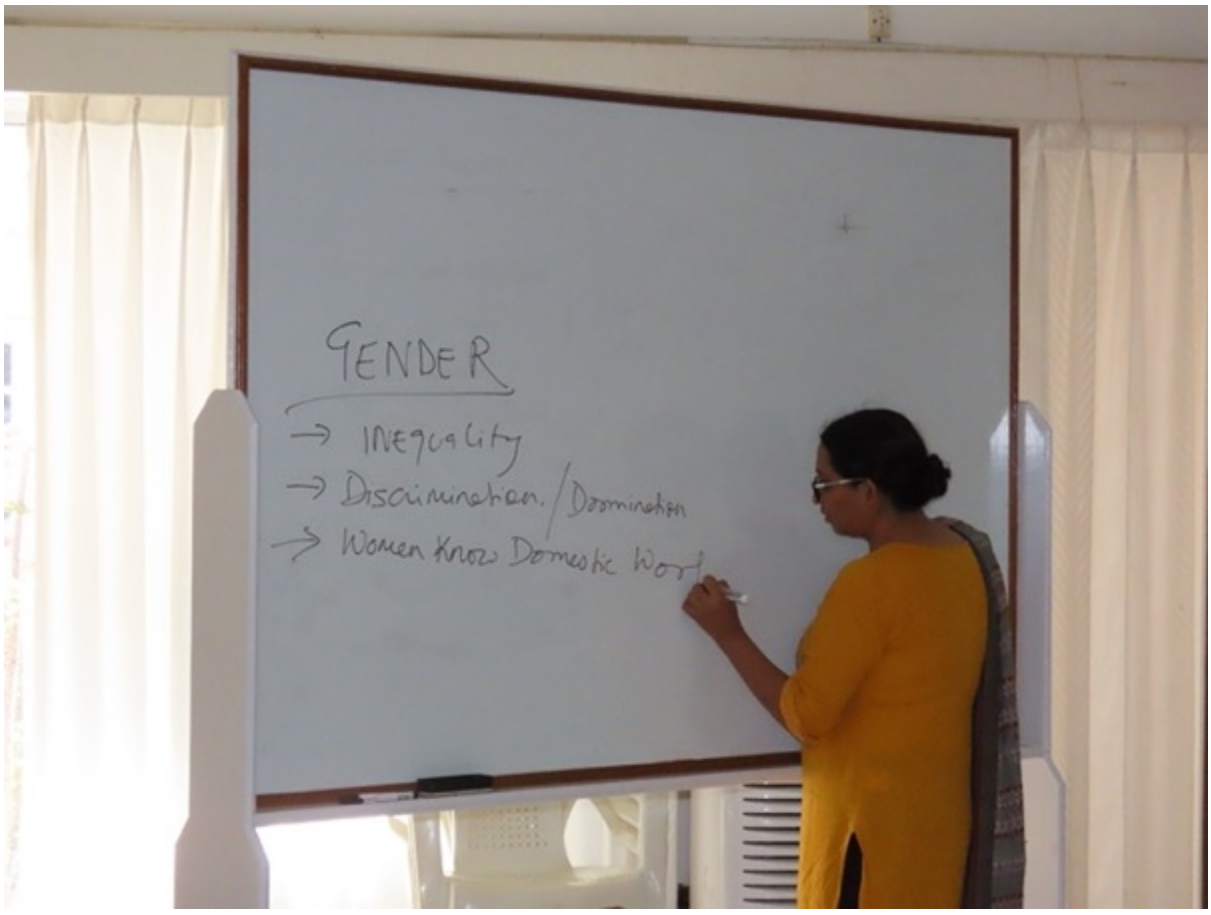
6.6. Theme 5: Water Management at Different Levels
Instructor: Dr. Shrinivas Badiger

Dr. Badiger started the session by introducing the issue of river basin management, and the conflict/cooperation nexus at the international level using examples of the Mekong, Nile and Rhine rivers and the Murray-Darling Basin's experience in implementing IWRM.

He then moved on to discussing water governance in India, sharing the principle of subsidiary in organisation theory, that social and political issues should be dealt with at the most immediate or local level. He also explained the operation of cooperative societies in India. He then discussed India's draft National Water Policy, and its focus on decentralised and collective decision-making. This trends are aligned with emphasis of the 73rd and 74th amendments of the Indian constitution in decentralisation.

He also introduced the concept of regulation and pricing (e.g. telescopic water pricing). He finally provided an overview of the multi-tiered water governance structure in India, and theorised the differences between old and new water governance structures.

6.7. Theme 9: Participation in Water Management
Instructor: Dr. Durba Biswas



Dr. Durba Biswas delved into the gender dimensions of water. She began by asking questions about participants' own experiences with gender, and introduced the concept of gender as a social

construct. She explained that as engineers, participants will most often interact with male stakeholders, which could lead to implementations designed to solely cater to the needs and preference of male and privileged sections of the society. She drew attention to gender-based inequalities in agriculture, particularly with respect to wages and access to equipment. She also used the example of the challenge of women having to collect water on foot and not having access to vehicles to illustrate how gender norms can further exacerbate a situation of water scarcity by inequitably distributing access to resources to cope with these situations. She also discussed the lack of female land ownership (women own only about 2% of land, globally), poor female representation in decision-making, and restricted access to media and information about rights and entitlements. She also shared that India's water laws have only recently begun to incorporate gender, and that gender-sensitive and -transformative policy implementation is still in the nascent stages. She then introduced the concept of Water User Associations and discussed the lack of representation of women and marginalised groups at their grassroot levels. Finally, she conducted a 'Water Privilege' game to illustrate the role of class and geography within gender in deciding water access and control.

6.8. Theme 7: Irrigation Issues and IWRM
Instructor: M. G. Shivakumar

M. G. Shivakumar, Retired Chief Engineer, Visversaraya Jal Nigam Ltd. took a session on the Modernisation of irrigation infrastructure through the MASCOTTE Approach. He started by delving into the question 'why and how are irrigation and IWRM related?' He introduced participants to some key aspects of irrigation – Multiple Use Systems (MUS), Service-Oriented Managememt (SOM),

and planning of irrigation projects. MUSes are large projects that cater to various needs like irrigation, power, fisheries and domestic use. SOM integrates the flow of water, information and money through a system. Mr. Shivakumar stressed that there must be a flow of information between services providers and users; users need logistical information about the timings, volumes and cost of the service, while they relay information about the demand and use to service providers. Irrigation system operations have to take into account multiple (for various purposes) and conjunctive (surface and ground) uses of water. He also mentioned the importance of integration between various dimensions of water services, and of irrigation practitioners being aware of the impacts of their decisions and knowing that allocation decisions can be a source of conflict between competing interests.

He then introduced the IWRM spiral, a heuristic to assess the progress of an IWRM process. He also mentioned that the end of the spiral is aspirational – IWRM is always a work in progress and a project is never 'complete'. He highlighted the 4 steps in planning an IWRM process,

1. Recognising and identifying the issues in the basin and the need for IWRM.
2. Assessment, conceptualisation, and the preparation of a draft plan
3. Coordination and detailed planning
4. Implementation, monitoring and evaluation

The then discussed the impact of irrigation in the environment and possible mitigation measures. Irrigation can cause water-logging and salinization, water-borne diseases, agricultural runoff and pollution of groundwater. Measures to minimise these impacts can be divided into policy, engineering, management and agronomic practice interventions. Under policy interventions, he

listed water or electricity pricing to incentivise water conservation, transferable water rights (cap and trade system), setting enforceable limits on water extraction (command and control), incentives for land-reclamation, and requiring environmental impact assessments prior to projects. Within engineering measures, he discussed the integration of environmental considerations into plans, reduction of canal seepage by lining, and the construction of drainage facilities. Possible management interventions include improving the efficiency of existing infrastructure, improving information provision and increasing farmers' involvement. He shared an example from the Bhadra right bank canal where telemetry has been used to measure the discharge in the canal and alter discharge levels as needed. Among agronomic interventions, he listed land levelling, on-farm water course improvement, drip irrigation, crop rotation, management of fertiliser levels, and applying soil reclamation practices. He then facilitated an activity where different groups were asked to discuss how the environment uses water, the importance of the environment to water management, the interaction of the environment with other water use sectors and the environmental benefits of IWRM.

He next introduced the terms MASCOTTE (Mapping systems for services in canal operation technique), cross-regulator (a check structure to maintain water level in the upstream part of the canal, offtake (to allow discharge from a main canal to a distributary), SCADA (Supervisory Control and Data Acquisition), upstream control (the use of cross regulators to maintain a particular water level), and downstream control (the maintenance of a particular water level downstream of a cross-regulator). He then explained the normative characters of water delivery services (equity, reliability and flexibility) and described the different kinds of delivery schedules (rotation, arranged, on-demand).

He then delved into irrigation structures from the modernisation point of view. He described storage structures and shared how farmers raise water levels in canals by themselves in the absence of infrastructure or planning to serve their irrigation needs. He next introduced the topic of modernisation to improve irrigation performance using the MASCOTTE approach. He distinguished between the processes of operation and maintenance. In the MASCOTTE approach, the users are both the payers and decision-makers. He described the steps of the MASCOTTE approach, and elaborated on 'Rapid Appraisal Procedure', the first step of the methodology, which is conducted to gain initial information regarding the potential for water conservation.

He shared insights from workshops conducted in various irrigation projects in Karnataka. The findings included budget limitations, absence of participatory irrigation management and insufficient capacity for operation and maintenance. He discussed the topics like 'Payment for Water Services' that were explored in the workshops, including. He also explained the implementation strategy for modernisation that emerged from the workshops and showed photographs of follow-up action. He then facilitated an activity for participants to discuss their conceptions of development, rehabilitation and modernisation, their constituents and the differences between the terms. They were also encouraged to reflect on the changes in irrigation systems, the drivers of change and their expectations of future changes.

6.9. Theme 9: Participation in Water Management
Instructor: N. Balakrishnaraj

N. Balakrishnaraj led a session on participation and involvement in water management. He shared an overview of the different stakeholders of water resources and services, and Water users Cooperative Societies.

He shared a case study of Gondi Irrigation Modernisation Project to explain the consideration of Environmental and Social Safeguards in Water Resources Planning. He described the objectives of safeguards monitoring, and environmental and social safeguard indicators. He then described the identified environmental and social issues, and the ADB Safeguard Policy. He explained the process and findings of the initial environmental examination of the Gondi project and the safety measures undertaken.

He provided a historical overview of water development and management, from an infrastructure development focus post-independence, through a social approach, to one that is socio-technical, managerial and political. He also shared that irrigation projects currently have an efficiency of below 50% and, as a result, are becoming a burden on state exchequer.

He next defined the term ‘stakeholder’ and provided a classification of the types of stakeholders. He showed a diagram of the stakeholders in a river basin. He also shared that stakeholder participation helps ensure that citizens and organisations respect rules and guidelines. He described the steps involved in stakeholder consultation. He next discussed policy Initiatives in Karnataka around Participatory Irrigation Management (PIM), formally adopted by the government by amending the

Irrigation Act of 1995 in 2000. He also shared the functions of the Water Users Cooperative Society, a statutory body formed by the government, which include making water use and cropping pattern decisions. He also shared the functions of the Project Level Federations. He asked the participants on their opinions around the need for PIM/WUCS and their ideas on how WUCs and sustainable engagement should be designed.

He next explained that irrigation requires both sociological and technical expertise. There is a need for the involvement of NGOs with social experience and skills in water management. NGOs can help reduce the burden on the department to plan and execute department in planning and executing projects. He ended by sharing that there is a dearth of engineers in Karnataka who are engaged in PIM and that there is a need and opportunity for involvement in participatory efforts.

6.10. Theme 3: Water uses and Benefits
Instructor: Dr. Jagdish Krishnaswamy

Dr. Krishnaswamy introduced the concept of ecological water flows and highlighted the importance of river water flowing to the sea. He started by discussing the livelihood options of fisheries and navigation that are directly dependent on flowing rivers. He discussed a definition of 'ecologically sustainable water management' and its components of ecological sustainability and human needs.

Next, he delved into the nature of water flow and levels, and human and ecological uses of river water along its course. During this time, he also drew attention to the differences between hydropower and irrigation dams, the importance of sediments and nutrients brought by rivers till coastal areas, importance of natural fluctuations in water flow including flooding during peak and overbank flow, and the concepts of lateral, longitudinal and vertical connectivity in rivers.

He then introduced the concept of Environmental Flow Assessment and its objectives, and delved into the steps involved in regulating river water flow, through designing and implementing Adaptive Water Management Plans. Finally, he introduced the concept of routing, the process of estimating the effect (hydrograph and depth profile) of releasing water from a dam at some point downstream.

6.11. Theme 8: Planning and Objectives
Instructor: Ravichandra Masuti

Mr. Masuti started the session with a definition of IWRM, and stating that IWRM and Integrated River Basin Management are synonymous with each other. He shared that a river basin is an area drained by the river and its tributaries, and that river basin planning involves asking the questions: Where are we now? Where do want to go? How do we get there? How will we check that we are getting there? He shared the differences between traditional (development planning) and modern ways of planning (management planning). He then delved into the different stages in the historical development of river basins, and different kinds of planning (single sector planning, multi-purpose planning, management planning). Next, he moved to talking about national planning and explained the meaning of India being a federal state with a unitary bias. Water is currently a state subject, but it may enter the concurrent list (under both states and the centre), based on recommendations of the Ashok Chawla committee. While this may help in resolving inter-state disputes, it might also entail planning becoming more centralised.

He listed out the tributaries of the Krishna and Cauvery basins, and delved into a case study on the preparation of the river basin profile for Tungabhadra. In such an exercise, results need to be modelling for present and future demand.

Mr. Masuti ended the session by sharing the ten golden rules of basin planning:

- Comprehensive understanding of the entire system (river basin profile)
- Plan and act, even without full knowledge
- Prioritise issues, develop a phased approach to achieve long term goals
- Be flexible to changing circumstances
- RBP is an iterative and chaotic process
- Develop relevant and consistent thematic plans
- Address issues at appropriate scale by nesting local plans under the basin plan
- Engage stakeholders
- Focus on implementation of the basin plan throughout
- Select planning approach and methods to suit the basin needs

6.12. Theme 6: Introduction to Water Policy and Legislation

Instructors: Ms. Madhubanti Sadhya, Ms. Lianne D'Souza, NLSIU

Ms. Sadhya started the session by sharing the highlights of the 2012 National Water Policy. She then shared the water allocation priorities of the policy and its consideration of irrigation planning. She then introduced the Karnataka State Water Policy, 2012 and its allocation of 55 LPCD for domestic water use in rural areas, 70 LPCD in towns and 135 LPCD in major cities.

She then moved on to describing state laws like the Karnataka Ground Water (Regulation for protection of sources of drinking water) Act, 1999; Karnataka Groundwater (Regulation and Control of Development and Management) Act, 2011; Karnataka Irrigation Act, 1965 (emphasising participatory irrigation management); Bangalore Water Supply and Sewerage Act, 1964 (making rain water harvesting compulsory).

She then delved into the topic of IWRM. She spoke about the Dublin Principles, and the Guidelines for Integrated Water Resources Development & Management, 2016 which provided a framework for its implementation in India, with a focus on river basin-level implementation. She then shared the functions of river basin organisations. She then shared that the implementation of IWRM has not yet been very successful because the draft River Basin Management bill hasn't yet been passed, the legal framework is inadequate, etc. She ended by introducing the principles of international Environmental Law - Principle of precaution, Polluter's Pay Principle and Doctrine of Public Trust.

Ms. D'Souza then led a session on Indian and International water laws. She listed key water laws in India and the division of legislative powers between the centre and state. Next, she delved into the concept of 'Right to Water' and its coverage in the constitution.

Next, she moved on to discussing International Law on Water, and the two types of laws – treaty law and customary law. She then spoke about the development of international law on water and its applicability in India. She ended by discussing the Doctrines of International water law and shared some case studies to illustrate these concepts.

After lunch, there Shashank Palur demonstrated the tipping bucket rain gauge and water level sensors, and Dr. Shrinivas Badiger conducted an exercise called the 'Tipping Point' game to introduce participants to the concept of resilience and tipping points in social-ecological systems. This was followed by a visit to Rachenahalli and Jakkur lakes.

6.13. Theme 11: Water Resources and regulation

Instructor: Dr. Priyanka Jamwal

Dr. Jamwal started the session with describing different kinds of water pollutants like pathogens, oxygen demanding wastes, nutrients, salts, heavy metals, pesticides and emerging pollutants like superbugs. She shared the anthropogenic (point and non-point) and geogenic sources of pollutants, and their types based on fate and transport (conservative and non-conservative). She led an exercise to model the the fate and transport of pollutants, based on the equation:
input rate = output rate + reaction rate

She discussed the different ecosystem services provided by lakes in Bangalore, like groundwater recharge, fisheries, recreation, irrigation and biodiversity conservation. The main problem associated with water pollution is due to increasing population and inadequate STP capacity. She shared a comparative case study between the water quality of Jakkur and Bellandur lakes; Jakkur has a lower BOD and higher DO due to the presence of an STP just upstream of the lake. She then provided an overview of different kinds of STPs (centralised, lake-side, decentralised, in-stream waste water treatment plants), along with their advantages and disadvantages.

She concluded the session by sharing that current water quality criteria are insufficient in terms of parameters monitored. Also, more clarity on goals would be essential to improving ambient water quality.

6.14. Theme 10: Water Resources Information and Data

Instructor: Dr. Shashikumar N., Mr. Vijeth Kashyap, Mr. Teju Kumar

Dr. Shashikumar started the session with a definition of data, and primary and secondary data sources. He then introduced the terms ‘data management’ and ‘data science’. Next, he illustrated the importance of data management for sectoral management, planning, disaster response, decision support, reporting and governance. He provided an overview of data management for IWRM as a collection of tasks to collect, store, process, describe, and model the data. He finally discussed Karnataka Water Resources Information System (KWRIS).

Next, Vijeth Kashyap led a discussion on Water Accounting+ (WA+), a tool developed by IWMI, FAO, WWAP and UESCO-IHS for water accounting at the river basin scale. He spoke about the need for WA+ given that water is a finite resource, its demand is increasing and decision-making is challenging. WA+ provides information on beneficial and non-beneficial use, and utilised and utilisable water. WA+ works on the basic principle of the water balance approach (inflow, use, outflow measurement using open access satellite measurement). He shared information on major datasets used in WA+, the methodology used and the nature of the various output sheets.

Next, Mr. Teju Kumar conducted a session on river basin modelling using 'Source'. He started by introducing the concept of a model, and the eWater Source model. Source is a node and link model, where nodes represent a hydrologic process, a water control structure, convergence/divergence of tributary or river, or a management rule, and link move or route of water and constituents through the system. He then explained the schematic and geographic constructions of Source. Geographic scenario building blocks are made of watersheds and functional units, and used to construct rainfall runoff models, constituent generation model, constituent filter model. Source can be adapted to model catchments, rivers and urban water. He then shared case studies of using Source to model the Murray Darling basin, urban water in Melbourne. It was used be IIT-Delhi, the government of Maharashtra, and the Government of Karnataka.

Next, he provided the example of the river basin modelling exercise of Tungabhadra sub-basin, with the data collection, processing and preparation processes. He described the process of calibrating the rainfall runoff model starting with the Shivamogga catchment. He also explained the scenario analysis using the model and present model-building activities.

6.15. Theme 11: Water Resources and Regulation

Instructor Dr. Sachin Warghade

Dr. Warghade started the session by sharing the concepts and tools of water regulation. He shared that water policies are not enforceable, but regulations are mandatory. He described different kinds of regulation systems like physical, social/economic, monetary systems. He discussed tools like command and control, market-based tools, community-based initiatives and citizen action.

In order to illustrate water regulation, he conducted an exercise using the analogy of cutting a resource cake. He then discussed possibilities like doing a demand analysis, and dividing division and selection opportunities among stakeholders. He then shared resource-level, user-level and utility-level regulation. He finally provided the case study of a vicious cycle in the agricultural sector based on a World Bank report and conducted an exercise for participants to brainstorm on ways to break the vicious cycle.

Next, he delved into tariffs as regulatory instruments, and ended with a case study of MWRRA in the upper Godavari basin.

6.16. Theme 13: Water resources and financing

Instructor: Dr. Prakash Kulkarni

Dr. Kulkarni started by explaining that water services (supply, sanitation, irrigation) are infrastructuralised and have significant associated costs, although infrastructure construction costs are usually subsidised by the government. The main cost components in O&M are water input costs, distribution costs and management costs. He explained that a cost-benefit analysis is one of the

main bases for sanctioning of irrigation projects. He also discussed the basis of financing irrigation projects during the British era and the post-independence, and the high experienced capital and operational costs throughout. He mentioned that the question of irrigation water pricing is sensitive in India and based on a mix of social, economic and political factors. He discussed the main criteria governing water price (ability to pay, volume of water used, quality of service and recovery). He then elaborated on the importance of an Asset Management Plan listing the physical assets of the scheme.

He also discussed catchment protection or development levies charged for a limited time to fund a scheme, and the contentious issues of distributing charges among various users. He next spoke about pollution charges based on the 'polluter pays principle', which can either provide a 'right to pollute' or reflect downstream costs. He also discussed financial penalties for breach of water licences by taking more water than authorised, for unauthorised activity on a river bed or bank, or for damaging public works. He finally elaborated on the financial and operational challenges of the sector in Karnataka and suggested the changes needed to reform the system.

On the topic of fixing water tariffs, Dr. Kulkarni started by explaining that tariffs are important to operate projects and to some extent recover capital expenditure. He described the competing factors impacting tariffs, and forcing prices up or down. He mentioned that the National Water Policy (2002) prioritises drinking water, calls upon states to formulate State Water Policies and emphasises the physical and financial sustainability of existing facilities. The 2012 amendment recognises water as an economic good, directs the establishment of state water user authorities and emphasises participatory approaches. The National Water Framework law is not backed by a legal

framework and is powerless despite being progressive. He shared that a common objective is to shift the funding responsibility from the government to water users, and that a volumetric charge is the preferred but difficult to implement strategy to charge users accurately and incentivise conservation.

He then moved to the topic of financing of infrastructure and operations, and mentioned that it is difficult to generate competition in the water market because of a natural monopoly of the service provider. He elaborated on various water pricing systems, the reasons behind declining recovery rates due to slow increase in tariffs and the questions on dropping recovery rates, increasing O&M costs. He finally discussed the policy options for improving financial efficiency and ending with sharing his thoughts on the importance of safeguarding farmer interests while increasing irrigation efficiency.

He shared information on the tools and techniques in economic assessment, like sustainability analysis, risk and sensitivity analysis, distribution analysis, and cash flow analysis. He finally discussed the procedure for implementing a water project.

6.17. Theme 12: Leading change

Instructor: Dr. Shobha Reddy, Payal Pruthi

Dr. Shobha Reddy started the session by discussing the differences between Rachenahalli and Jakkur lakes, explaining that while Rachenahalli may seem more aesthetically appealing due to better vegetation and water quality, Jakkur lake is better from an environmental science perspective since its storage area has not been encroached upon and due to the presence of an STP. She spoke about the conservation challenges for water bodies, with a greater focus on 'engineering' perspectives at the cost of environmental and social perspectives and a lack of clear objectives for lake protection.

She also discussed reasons for public apathy around and lack of involvement in the management of ecological commons. She then shared her experiences in rejuvenating the Rachenahalli lake through the establishment of Jalmitras, a citizens group.

She discussed the tools they used, including social media, engagement with fisher-folk, volunteer activities, involving school students, involving the MLA, etc., and the challenges they face in generating public interest, achieving a greater mix of local vegetation and more scientifically sound lake management. She then described a case study of watershed protection in New York as a lesson in sharing responsibility, and ended with an exercise for participants to brainstorm on ways to revive the Cauvery river.

6.18. Theme: Communicating Water Beyond Statistics
Instructor: Payal Pruthi

Payal Pruthi started the session by driving home the importance of talking about water, and the necessity of communicating with generalists (beyond statistics and numbers). She then described the 3p approach to communication, which includes consideration of presentation, people and place. She showed several pictures to communicate how they are able to convey more than facts to a wide range of stakeholders. She also shared examples of government officials who are leveraging social media to share positive stories of change. Next, she shared ideas of the diversity of places where water communication can take place like in agricultural fields, through folk music, community radio, graffiti, etc. She finally ended the session by inviting participants to come up with ideas to communicate the importance of water management through social media.

6.19. Theme 16: RS-GS in water resources management
Instructors: ATREE Eco-informatics lab

Ganesh Shinde from the ATREE Eco-informatics lab led a session on the introduction to remote sensing and GIS. She started by providing an introduction to what GIS and remote sensing are. He drew parallels between the GIS software and AutoCad and explained the terms ‘latitude’ and ‘longitude’. He then described the basic characteristics of maps (location, legend, scale, projection, signs, symbols and marks), their classification and elements. Maps can be classed on the basis of scale (small, medium and large), function (general reference/topographic, thematic/special purpose,

charts) and subject matter (cadastral, plans, soil/vegetation/etc.). The elements of a map include title, author, legend, date, orientation, grid and scale.

He next explained that in 'GIS', 'Geographic' stands for location, 'Information' for database and 'system' for a collection of hardware, software, people, plans, etc. GIS is composed of location (where is it) and attribute (what is it) information. Data can be represented through either the Geographic Coordinate System or the Projected Coordinate System (used to convert a point on a sphere to a flat surface). He then explained the different kinds of map projections, their uses and the distortions associated with each. Next, he described the layer types – raster (rows and columns of pixels) and vector (points, lines and polygons), and the process of converting a vector to a raster.

Then, he introduced the term 'remote sensing' as the acquisition of information about an object or phenomenon without making physical contact with it. There are two kinds of remote sensing: active remote sensing when the sensor sends a signal that is reflected, and passive remote sensing which senses reflections of radiation emanating from a natural source of illumination. He also mentioned that the types of resolutions in remote sensing are spatial (cell size), spectral (number of colour-bands), temporal (unit of time) and radiometric (colour depth), and that all these types of resolutions are sensor-specific.

He then explained that a scanned image is a raster since it is composed of pixels. Georeferencing is the process of assigning latitude (y coordinate) and longitude (x coordinate) coordinates to an image. She mentioned that while georeferencing, a minimum of four points should be fixed, with additional points fixed for greater accuracy. Finally, he led a hands-on exercise of the participants to

identify the coordinates on a toposheet and georeferenced the scanned image of a topo-sheet on the Quantum GIS software.

7. Valedictory Function

The valedictory function took place on Saturday, 20th February 2021. It started with a welcome address by Dr. Durba Biswas, Fellow, ATREE and the lighting of the lamp by the guests and some students. Next, two workshop participants shared their feedback of the workshop and mentioned their key take-aways from the workshop. They appreciated the interactive sessions, the campus and the cultural programme organised.

Following this, the Chief Guest, Sri S. B. Siddagangappa, Registrar and Engineer-in-Chief, ACIWRM addressed the gathering. He was impressed by the participants' openness towards IWRM. He also stressed on the importance of implementing IWRM in the most practical way under ambient conditions on the field. The guest of Honour, Mr. Vamsidhar Pothula spoke next. He congratulated participants for their enthusiastic participation, and encouraged them to use their learnings in the course of their careers. Guest of Honour Dr. P. Somashekhar Rao, Director (Technical), ACIWRM addressed the gathering next, and shared that they had only had an overview on IWRM and encouraged them to remain curious and open to learning. He pointed out that the involvement of political leaders in water management should be viewed as political engagement and not political interference. Similarly, he stressed the importance of regarding the population of the country as a strength and not a liability. Finally, Dr. Siddappa Setty addressed the gathering on the importance of learning from traditional knowledge, different stakeholders, nature. Trade-offs involved in

development interventions. Certificates were then distributed to the participants, followed by a vote of thanks by Dr. Priyanka Jamwal, Fellow, ATREE. The workshop ended with a group photograph of the participants, organisers and guests.

8. Annexures

8.1. Lists of participants

SN No	Name	Designation	Email ID	Phone Number
1	Akhila V	AE	akhilavram@gmail.com	8050603480
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32	Veena D N	JE	veenanagaraju1997@gmail.com	7795166984

8.2. Course Schedule

Management Development Programme on Integrated Water Resources Management Training Programme Schedule			
Monday , February 08, 2021 (Day 1)			
Theme 1: Course Introduction and Objectives			
6:00 to 8:00am		Participants Check-in	
8:00 to 9:30am		Breakfast	
9:30 to 10:30am		Participant Registration	
10:30 to 11:00am		Tea/Coffee Breaker	
11:00 to 01:00pm		Inaugural Ceremony Participant Introductions Group Photo	
		Lunch	
2:00 to 2.30pm		Pre-Training Quiz-0	
2:30 to 3:00pm	1.1, 1.2	Course Introduction Course Objectives and Expectations	Shrinivas Badiger, ATREE
3:00 to 3:30 pm		COVID Safety Norms and House Rules	ATREE and SoAW
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm		Rich Pictures-Exploring Ideas on need for IWRM	ATREE and Participants
5:15 to 5:30pm		Feedback for the day	
Tuesday, February 09, 2021 (Day 2)			
Theme 2: Introduction to IWRM			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	2.1 2.2, 2.3	Characteristics of Water: Why is Water Special Water Sources-Where Does Water Come from?	Veena Srinivasan, Director, Centre for Social and Environmental Innovation, ATREE
10:30 to 10:45am		Tea Break	
10:45 to11:45am	2.4	Water Demand and Water Scarcity	Veena Srinivasan
11:45 to 12:45pm	2.5	IWRM- Definitions, Principles and Methods	Veena Srinivasan
		Lunch	
2:00 to 4:00pm		IWRM Scenarios (Group Activity)	ATREE-Water Group
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm		IWRM Scenarios (Group Activity)	Participants
5:15 to 5:30pm		Feedback for the day	

Wednesday, February 10, 2021 (Day 3)			
Theme 3: Water Uses and Benefits			
9:15 to 9:30am		Recap of the previous day	
9:30 to 11:00am	0.1	Hydrologic Cycle and Components of Water Balance Surface Water Hydrology	Shrinivas Badiger
11:00 to11:15am		Tea Break	
11:15 to 12:00pm	0.2	Groundwater Hydrology	Shrinivas Badiger
12:00 to 01:00	3.0	Normative Concerns in Water Management and Governance	Sharachchandra Lele, ATREE
		Lunch	
2:00 to 3:00pm	3.1	Beneficial use of water- for people (Domestic use)	Sharachchandra Lele
3:00 to 4:00 pm	3.2	Beneficial use of water- for people (Agriculture)	Sharachchandra Lele
4:00 to 4:15 pm		Tea	
4:15 to 5:15pm	3.21	Sustainable Management of Water	Sharachchandra Lele
5:15 to 5:30pm		Feedback for the day	
Thursday, February 11, 2021 (Day 4)			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	11.31	Water Quality – Framework for IWRM	Priyanka Jamwal, ATREE
10:30 to 10:45am		Tea Break	
10:45 to11:45am	11.32	Surface and Groundwater Pollution	Priyanka Jamwal
11:45 to 12:45pm	11.33	Water Quality Regulation and Management	Priyanka Jamwal
		LUNCH	
Theme 4: Water Resources and Sustainability			
2:00 to 3:00pm	4.1	Group Project Assignments: Scenario Building and Contextualizing IWRM	Shrinivas Badiger
Theme 5: Water Management at Different Levels			
3:00 to 4:00 pm		Group Project Activities	Shrinivas Badiger
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm		Group Project Activities	Shrinivas Badiger
5:15 to 5:30pm		Feedback for the day	

Friday, February 12, 2021 (Day 5)			
Theme 5: Water Management at Different Levels			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	5.1 5.2	IWRM at various levels: International water organisations	Shrinivas Badiger
10:30 to 10:45am		Tea Break	
10:45 to 1:00pm	5.3 5.4 5.5 5.6	National level water organisations State level Water organisations River Basin Water Organisations Integrated River Basin Management	Shrinivas Badiger
		Lunch	
Theme 9: Participation in Water Management			
2:00 to 04:00	9.41	Gender and Water	Durba Biswas, ATREE
04:00 to 04:15		Tea Break	
4:00 to 05.00	9.42	Mainstreaming Gender in IWRM	Durba Biswas
5:00 to 5:15		Gender Game	Durba Biswas
5:15 to 5:30pm		Feedback for the day	
Saturday, February 13, 2021 (Day 6)			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	7.3	MASSCOTE approach to IWRM and Irrigation Modernization	M. G. Shivakumar, CE, GoK
10:30 to 10:45am		Tea Break	
10:45 to11:45am	7.3	MASSCOTTE Case discussions	M. G. Shivakumar
11:45 to 12:45pm	7.4	Water Productivity – Estimation at Farm and Basin scale	M. G. Shivakumar
		Lunch	
Theme 9: Participation in Water Management			
2:00 to 3:00pm	9.1	Participation and Involvement in Water Management	N. Balakrishnaraj, Consultant
3:00 to 4:00 pm	9.2	Stakeholders of water Resources and services	N. Balakrishnaraj
4:00 to 4:15 pm		Tea break	
4:15 to 5:15pm	9.3	Water Users Cooperative Societies (WUCS)	N. Balakrishnaraj
5:15 to 5:30pm		Feedback for the day	

Sunday, February 16, 2021 (Day 9)			
Day Off –Project Preparations			
Monday , February 15, 2021 (Day 8)			
Theme 3: Water Uses and Benefits			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	3.3, 4.2, 4.3	Beneficial use of Water-Environment: Environmental Flows	Jagdish Krishnaswamy, ATREE
10:30 to 10:45am		Tea Break	
10:45 to11:45am	3.4	Beneficial use of water-other interests (Fisheries and Inland Navigation)	Jagdish Krishnaswamy
11:45 to 12:45	2.6	Introduction to Climate Change and its Impacts on Water	Jagdish Krishnaswamy
		Lunch	
Theme 8: Planning and its Objectives			
2:00 to 3:00pm	8.1 8.2	Introduction to Basin Planning National and Sectoral planning	Ravichandra Masuti, ACIWRM
3:00 to 4:00 pm	8.3	Development Planning and Management planning	Ravichandra Masuti
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm	8.4	River Basin and Sub- Basin planning	Ravichandra Masuti
5:15 to 5:20pm		Field visit Goals and Instructions	Shrinivas Badiger
5:20 to 5:30pm		Feedback for the day	
Tuesday, February 16, 2021 (Day 9)			
Full day session at **ATREE** and Field – start from SoAW at 08.30am			
Theme 6: Introduction to Water Policy and Legislation			
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am	6.1	National and State Water Resources Policy	Madhubanti Sadhya, NLSIU
10:30 to 10:45am		Tea Break	
10:45 to11:45am	6.2	Water Laws	Ms. Lianne D'Souza, NLSIU
11:45 to 12:45pm	6.3 6.4	IWRM and National Policy Goals International Water Laws	Madhubanti Sadhya
		Lunch	
2:00 to 3:00pm		Water Monitoring and Measurement Tipping Point Game (Activity)	Shrinivas Badiger
3:00 to 3:30pm		Quick Tour of ATREE Labs	
3:30 to 3:45 pm		Tea	
4:00 to 5.00pm		Field Visit to Rachenahalli Lake	Led by Dr. Shobha Reddy, MGIRD, Jalamitra
5:15 to 6:00pm		Field Visit to Jakkur Lake	Led by Dr. Annapurna S Kamath, JaLaPoshan Trust

Wednesday, February 17, 2021 (Day 10)			
Themes 9.5 and 12: Role of Negotiation and Leading Change			
9:15 to 9:30am		Recap of the previous day	
9:30 to 11:00am	7.1 7.2	Irrigation and IWRM Impact of Irrigation on the Environment (WEF Nexus)	Shrinivas Badiger
11:00 – 11:15am		Tea Break	
11:15 to 12:00pm		Progress Checks and Clarifications on Participants IWRM Final Project Presentations	Shrinivas Badiger
12:00 to 01:00pm		WW Treatment and its Implications on Surface Water Quality	Priyanka Jamwal
		Lunch	
Theme 10: Water Resources Information and Data			
2:00 to 3:00pm	10.1	Data Management KWRIS	Dr. Sashikumar N, ACIWRM
3:00 to 4:00 pm	10.2	Water Accounting	Mr Vijeth Kashyap, ACIWRM
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm		Water Accounting-Plus	Mr Vijeth Kashyap
5:15 to 06:30pm	10.3	Basics of Hydrological Modeling River Basin Modelling: Tungabhadra Case Study using SOURCE	Mr Teju Kumar, ACIWRM
Thursday, February 18, 2021 (Day 11)			
9:15 to 9:30am		Recap of the previous day	
Theme 11: Water Resources and Regulation			
9:30 to 10:30am	11.1	Water Allocation and water rights	Dr. Sachin Warghade, TISS
10:30 to 10:45am		Tea Break	
10:45 to11:45am	11.2	Regulatory Activities in Water Management	Sachin Warghade
11:45 to 12:45pm	11.4	Regulation of Water Utilities	Sachin Warghade
		Lunch	
Theme 13: Water Resources and Financing			
2:00 to 3:00pm	13.1	Water Resources and Finances	Dr. Prakash Kulkarni, Bhagirathi
3:00 to 4:00 pm	13.2	Fixing of tariffs, methods and issues with specific reference to India	Prakash Kulkarni
4:00 to 4:15 pm		Tea Break	
4:15 to 5:00pm	13.3	Economic perspectives of IWRM	Prakash Kulkarni
5:00 to 5:10pm		Feedback for the day	
05:10 to 05:30pm		Post-Training Quiz	

Friday, February 19, 2021 (Day 12)			
Theme 7: Irrigation Issues and IWRM			
9:15 to 9:30am		Recap of the previous day	
9:30 to 11:00am	19.5	Role of Negotiation in Water Planning	Dr. Shobha Reddy, Formerly Additional Director, Mahatma Gandhi Institute for Rural Energy and Development (MGRED) Managing Trustee, Jalamitra
11:00 to 11:15am		Tea Break	
11:15 to 12:00pm	12	Leading Change	Dr. Shobha Reddy
12:00 to 01:00pm		Communicating Water Beyond Statistics	Payal Pruthi, ACIWRM
Lunch			
Theme 16: RS-GIS in Water Resources Management			
2:00 to 3:00pm	16	Introduction to Map Reading	ATREE GIS Team
3:00 to 4:00 pm		Basics of Geographic Information Systems and Remote Sensing	ATREE GIS Team
4:00 to 4:15 pm		Tea Break	
4:15 to 5:15pm		Hands on Map Creation and Geo-referencing	ATREE GIS Team
5:15 to 5:30pm		Feedback for the day	
Saturday, February 20, 2021(Day 13)			
		Closing Day	
9:15 to 9:30am		Recap of the previous day	
9:30 to 10:30am		IWRM Project Presentation by Teams	
10:30 to 10:45am		Tea Break	
10:45 to12:45am		IWRM project Presentation by Teams	
12:45 to 01:30pm		Valedictory Ceremony and Certificate Presentation	
01.30 to 2.30pm		Lunch	
02:30pm		Participants Check out	

8.3. Group projects

The 32 participants divided themselves into groups of 4-6 members and were tasked with making a hypothetical IWRM basin plan for surface water. They could select a case study area of their choice, taking into consideration the population, catchment area, rainfall, land use-land cover, etc. In the process, they had to play the roles of policy maker, engineer and contractor. Participants were given time to draft a basin plan and presented their ideas on the last day of the workshop.

The presentations were well thought-through and reflected the insights that they had acquired from the workshop. Participants included various normative concerns into their planning and included

considerations on environmental sustainability like planning a reduction in cultivation area of water-intensive crops like rice and sugarcane, irrigation tank rejuvenation, and an increase in ragi planting and water-efficient irrigation methods like drip and sprinkler irrigation in rural areas, and demand-side management, increase in lake buffer zone area and rainwater harvesting in urban areas. They also reflected on issues of water allocation equity between urban and rural areas and whether borewell ownership can be made public in cities.

They also delved into governance issues and planned for participatory irrigation management through water user associations, allowing them to collect taxes from the users and use them for infrastructure maintenance. In urban areas, they planned for volumetric and differential pricing to incentivise water conservation, and waste water management through the reuse of grey water, installation of DEWATS systems and more stringent treatment of industrial affluents.

8.4. Field Trip

On 16th February, 2021, the participants were taken on a field trip. They first visited ATREE, where they had a lecture on environmental law. After lunch, Shashank Palur, Research Assistant at ATREE provided a demonstration of the tipping bucket rain gauge and water level sensor, and Dr. Shrinivas Badiger facilitated the Tipping Point game.

Participants then visited the insect lab where they saw some specimens in the insect museum, and the water quality lab where they saw the apparatus for preparing bacterial cultures and carrying out atomic absorption spectrometry for identification of heavy metals in water sample.

They were then taken to Rachenahalli lake, where Dr. Shobha Reddy from Jalamithra gave them an overview of Bangalore's system of cascading lakes and Jakkur lake's situation in the Hebbal lake system. Bangalore lake water was earlier used for domestic and irrigation purposes but the lakes today have mainly ecological, aesthetic and recreational utility, with a limited amount of fishing activity. She also narrated the story of the revival of the lake. They then visited Jakkur lake. Here, Teertha Ravindran, Lake Manager, Jalaposhan. She then explained that Jakkur lake used to be a eutrophied body receiving raw sewage, but citizen efforts since 2009 have led to its rejuvenation. The lake was dredged, a sewage treatment plant with a capacity of 30 MLD installed and a wetland was constructed to stabilise the nitrate and phosphate levels, and increase the BOD.

8.5. Recreational activities

Recreational activities were conducted throughout the training programme for the participants to enjoy the verdant campus of the School of Ancient Wisdom and enjoy their time at the workshop. An outing to Nandi Hills, yoga sessions by a trained instructor were organised.

The participants also had access to books and sports equipment at the venue. The ATREE organising team participated in these activities along with the participants, which helped create cohesion between the ATREE team and participants.

8.6. Cultural programme

On the evening of 19th February 2021, a cultural programme was organised for the participants. The group Bhoomi Thayi Balaga was invited to perform earth-related the music. The event was enjoyed by the participants who broke into impromptu song and dance at the end of the evening.

8.7. Materials provided to participants

Participants were given a laptop bag, course handbook, notepad and pen, water bottle and flash drive with course material and additional materials, include links to online training videos, readings, open source GIS software and datasets (particularly GIS layers).

8.8. Course assessment and feedback

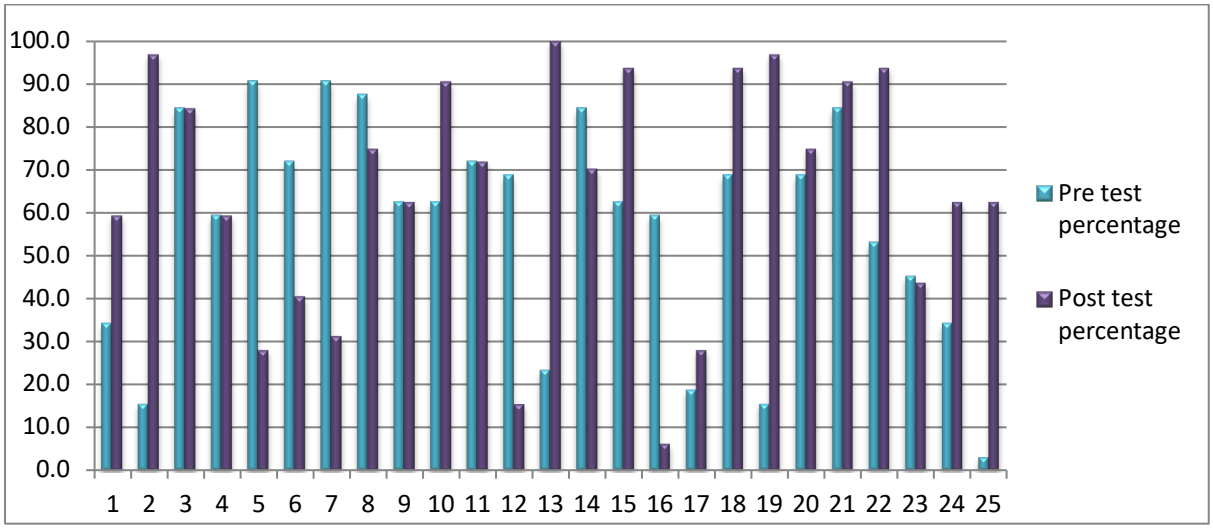
Participants were administered multiple-choice tests containing 25 questions before and after the programme to assess their level of familiarity at the start of the workshop and their degree of understanding at the end of the training.

The participants were administered a test before the workshop to assess their understanding of water-related concepts and an assessment on the final day of the workshop to understand how they had absorbed the discussed topics.

While using this method to objectively gauge the effect of the workshop is a bit tricky because the questions in both the tests were different, an effort was made to keep the difficulty level of both the tests comparable. This allows for a rough assessment of the impact of the workshops in increasing participant understanding of IWRM concepts.

20 of the 32 students scored more in the post workshop-test than in the pre-workshop assessment. The mean and median scores of the post-workshop test were 14.2 and 14, and those of the pre-workshop test were 16.3 and 16.5. These summary statistics show that by and large, participants performed better in the post-workshop test than in the pre-workshop assessment.

A comparative chart showing anonymised individual pre- and post- workshop assessment scores is presented below:



8.6.1 Course assessment-1

Question Number	Number of people wrote the correct answer	percentage of people who wrote the correct answer
1	11	34.4
2	5	15.6
3	27	84.4
4	19	59.4
5	29	90.6
6	23	71.9
7	29	90.6
8	28	87.5
9	20	62.5
10	20	62.5
11	23	71.9
12	22	68.8
13	7.5	23.4
14	27	84.4
15	20	62.5
16	19	59.4
17	6	18.8
18	22	68.8
19	5	15.6
20	22	68.8
21	27	84.4
22	17	53.1
23	14.5	45.3
24	11	34.4
25	1	3.1

8.6.2 Course assessment-2

Question Number	Number of people wrote the correct answer	percentage of people who wrote the correct answer
1	19	59.4
2	31	96.9
3	27	84.4
4	19	59.4
5	9	28.1
6	13	40.6
7	10	31.3
8	24	75.0
9	20	62.5
10	29	90.6
11	23	71.9
12	5	15.6
13	32	100.0
14	22.5	70.3
15	30	93.8
16	2	6.3
17	9	28.1
18	30	93.8
19	31	96.9
20	24	75.0
21	29	90.6
22	30	93.8
23	14	43.8
24	20	62.5
25	20	62.5

8.8. Course feedback

A feedback form was also provided to the participants in the beginning of the workshop, for them to fill after each session. Additionally, verbal feedback was sought from the workshop at the end of every day of the training programme. From the feedback received, it appears that participants particularly appreciated the subject matter knowledge of the resource persons, the interactive nature of the sessions and the use of both Kannada and English in the sessions. They also enjoyed the recreational activities like yoga sessions and sports and appreciated the campus setting of the School of Ancient Wisdom.

8.9. Brief Bios of Resource Persons

Shrinivas Badiger

Dr. Shrinivas Badiger is a Fellow with the Centre for Environment and Development at ATREE. He uses systems approaches linking climate, agro-ecological and socio-economic processes to understand the context of changing waterscapes within a larger framework of sustainable

environments and human wellbeing. This includes understanding land-use change and cropping system choices, surface and ground water interactions in natural and anthropogenized hydrologic systems; inter and intra sectoral water allocations, water management practices and policies in changing socio-economic, institutional and climate conditions. Dr. Badiger holds a Ph.D in Soil and Water Resources Engineering from University of Illinois at Urbana-Champaign, USA, 2001 and a M.Eng, Water Engineering and Management from the Asian Institute of Technology, Bangkok, Thailand. Prior to joining ATREE, Dr. Badiger held positions as a post-doctoral scientist at International Water Management Institute, Colombo, Sri Lanka and a Project Manager and Water Resources Engineer at Green Engineering Company Limited, Bangkok, Thailand.

Veena Srinivasan

Dr. Veena Srinivasan is a Senior Fellow and leads the Water, Land and Society programme at the Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore. Her research interests include inter-sectoral water allocation, impacts of multiple stressors on water resources, and sustainable water management, policy and practice. She leads several research projects that combine field hydrology, low-cost sensing, citizen science and simulation modelling to find solutions to critical water problems. Dr. Srinivasan received her PhD from Stanford University's Emmet Interdisciplinary Program in Environment and Resources. She holds a Masters in Energy and Environmental Studies from Boston University and a B-Tech in Engineering Physics from Indian Institute of Technology, Mumbai.

Sharachchandra Lele

Dr. Sharachchandra Lele is a Distinguished Fellow in Environmental Policy and Governance at ATREE. Sharad's research interests include conceptual issues in sustainable development and sustainability, and analyses of institutional, economic, ecological, and technological issues in forest, energy, and water resource management. He attempts to incorporate strong interdisciplinarity in his own research and teaching, which straddles ecology, economics, and political science. Dr. Lele completed his B.Tech. in Electrical Engineering in IIT Bombay. He moved to the Indian Institute of Science, Bangalore, where he completed an M.S. in Systems Science in 1987, working on the optimal sizing of hydropower projects incorporating the energy and economic costs of land submergence. He went on to the University of California, Berkeley, where he completed a Ph.D. in Energy & Resources in 1993. He then spent a year at the Pacific Institute for Studies in Development, Environment, and Security, Oakland, as a Senior Research Associate and a year at Harvard University as a Bullard Fellow for Forest Research, before returning to Bangalore to work in collaboration with the Institute for Social & Economic Change, and eventually to being involved in the founding of CISED in 2001. He was Coordinator of CISED for 8 years until CISED merged with ATREE.

Priyanka Jamwal

Dr. Priyanka Jamwal is a Fellow in the Centre for Environment and Development at ATREE. She is in charge of the Water and Soil Laboratory at ATREE. She is interested in the problem of water pollution, including point and non-point source pollution, biological and industrial contamination, and surface and ground water. She is also interested in determining pollution abatement through wastewater treatment and contamination/decontamination approaches in water distribution network. Her work involves field sampling, laboratory simulations and modelling approaches. Dr. Jamwal holds a PhD in Environmental Engineering and Management from the Indian Institute of

Technology Delhi. She has been a Visiting Fellow at the Water Institute, University of Waterloo, Canada (2016) and a Research Fellow, CEREVE, ENPC Paris France (2004).

Durba Biswas

Dr. Durba Biswas is a Fellow at the Centre for Environment and Development at ATREE. Dr. Biswas Has a PhD in Environmental Economics. Her areas of research interest are Economic Valuation, Gender and water interlinkages, Institutional economics and water resource policies. Prior to joining ATREE she was a post-doctoral Associate at the School of Social Sciences, National Institute of Advanced Studies (NIAS), Bangalore. She has previously served as a Research Associate at National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi and a Consultant Economist at International Water Management Institute (IWMI), Colombo, Sri Lanka and Delhi, India.

Jagdish Krishnaswamy

Dr Jagdish Krishnaswamy has a B.Tech in Civil Engineering from Indian Institute of Technology, Mumbai, India, an MS in Statistics and Decision Sciences and a Ph.D in Environmental studies, Duke University, North Carolina, USA. His research and teaching interests include ecohydrology, landscape ecology, conservation planning, ecosystem services and applications of bayesian approaches in understanding complex changes in the environment over space and time. He has coordinated the establishment of instrumented catchments in the Western Ghats and in the Himalayas to study the impacts of land-cover and climate variability on hydrological processes. He has recently become involved in defining and assessing ecological flow requirements of rivers in the Western Ghats and the Ganga basins with as special focus on endangered species such as the gharial and river dolphin. His work on climate science and climate change includes vegetation response to climate and land-cover change in India, Central America and Africa. Over the years, his work has contributed to various policy and actions such as the declaration of the Western Ghats as a UNESCO World Heritage Site, the investment of the Critical Ecosystem Partnership Fund in the Western Ghats and a special report on Himalayan Springs to the Niti Ayog. He has designed capacity building and field hydrology training courses for aquatic ecologists and grass roots NGOs. He is a Coordinating Lead Author of the Special IPCC Report on climate change, desertification, degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

M G Shivakumar

Mr M G Shivakumar is Chief Engineer, VJNL, Upper Bhadra Project Zone, Chitradurga He has a B.E. (Civil, 1981) from G.B.D.T College of Engineering, Davanagere, Karnataka with distinction and M.E.(Civil, 1983) from IISc, Bengaluru with distinction. He joined Water Resources Department, Govt.of Karnataka in 1983 and has over 36 years experience in water resources sector. He is a member of Institution of Engineers (MIE), India, Member of Institution of Water Resources Society (IWRS), India and a certified coach of Results Coaching Systems (RCS), Australia. He received Karnataka State 'Balekundri Award' during 2015 for services rendered in the field of Water Resources Development.

Prakash Kulkarni

Dr. Prakash M Kulkarni is a Graduate Civil Engineer and did his Post Graduation M.Tech in Environmental Engineering in SJCE, Mysore and Ph.D. from National Law School India University, Bangalore. He joined the public sector as an Engineer in 1987 and served in water supply both in the

rural and urban areas working in various capacities for Government of Karnataka. Most of these projects were funded by bilateral/multilateral institutions viz., World Bank, The Netherlands and Asian Development Bank. He took VRS after 20 years of service in 2007 and worked as Project Manager, for an International Voluntary Organization – Water and Sanitation for the Urban Poor (WSUP). He is currently the President of Bhageerath, a Technical NGO working in Water and Waste. He is also Director in JMS group of companies. The organizations work with many Departments and Donors on issues relating to Water, Solid Waste, Lakes and related pollution. (BBMP, Bengaluru, City Corporations – Mysuru, Hubli-Dharwad, Gulbarga, Tumakuru etc.)

Shobha Ananda Reddy

Dr. Shobha Ananda Reddy is an Environmental Scientist with over seventeen years of teaching, research and practice experience spanning environment & ecology, renewable energy, integrated water management, participatory governance and community engagement. She has a PhD in Environmental Science from Vinayaka Missions University, Salem, Tamil Nadu. She is a strong proponent of citizen involvement and participatory governance for positive social & environmental transformation. She worked for 12 years at Mount Carmel College, Bangalore where she was teaching Environmental Science and Research methods & Biostatistics. She also initiated and led the activities of Centre for Scientific Research & Advanced Learning and Internal Quality Assurance Cell at Mount Carmel College. As Additional Director-Environment, Energy & Biofuels, Mahatma Gandhi Institute for Rural Energy & Development, she initiated and led several projects of environment & social relevance such as Remote Village Electrification (Solar & pico hydro), Solid Waste Management & Integrated Water Management in rural areas, Model Heritage Village project, Energy efficient Govt rural housing pilot project. She directed and curated content for capacity building programmes for various stakeholders namely PDOs and Elected Representatives of Panchayat Raj Institutions; IFS, IAS, KAS, KFS officers; Academicians, Researchers and students; Bankers and financing institutions on Environmental Sustainability, Renewable Energy & Energy Conservation, Integrated Water Management, Solid Waste Management, Green buildings, etc. In her short stint as Research Assistant at Energy & Environment group, National Institute for Advance Studies, she worked on Grid Connected Roof Top Solar Programme of GoI, Grass roots Innovations in Energy and Water security, Energy For All Policy to Inclusive Manufacturing Forum. As a Senior Consultant, Urban Practitioners' Programme, Indian Institute for Human Settlements, she directed courses and curated content for Engineering and Public Health officials of various states on Urban Missions of GoI. She led a series of workshops on Sustainable Development Goals for School and early College students. She was instrumental in formation of citizen group 'Jalmitra - Guardians of Rachenahalli' which has been working with various stakeholders for revival and maintenance of Rachenahalli lake, Srirampura, Bangalore. She served as a member of Western Ghats Task Force, GoK. She is a NABET - QCI accredited Environmental Consultant for carrying out EIAs in development sector.

N. Balakrishnaraj

N. Balakrishnaraj is a social development and gender specialist. He has over 28 Years of experience and has conducted several Training / Workshops on various themes / contents / issues including Participatory Irrigation Management, Integrated Water Resource Management, Watershed Management, Rural and Urban Community Development, Organization Development, Livelihood Income Generation Activities, Non-land based micro enterprises, Institution Building – (formation and Strengthening of Self-Help Groups, Water Users Cooperative Societies, Watershed Committees,

Farmers Area Groups, User Groups, etc.), Pollution Control, Drinking Water Supply and Sanitation, Solid Waste Management, Urban Plantation Development, etc.

Ravichandra Masuti

Mr. Ravichandra Masuti has 7+ years of experience in water resources domain. He has been working on Water resources assessment, Flood risk assessment and Hydraulic and Hydrological modelling related projects-based form United Kingdom (UK), Australia (AU), Hongkong (HK), Middle East (UAE) and Sri Lanka (SL).

Ravi has extensively worked on Basin scale modelling, Urban flood modelling, River modelling and Integrated catchment modelling projects and specialised in Flood economics, Technical report writing and Flood mapping studies, He has software proficiency in various 1D and 1D-2D modelling applications Like InfoWorks ICM, InfoWorks CS, ESTRY-TUFLOW, Flood Modeller Pro (previously known as ISIS), HEC-RAS, along with GIS based applications like ESRI ArcGIS, MapInfo Pro, QGIS, AutoCAD 2019.

Ravi is currently working as River Basin Management specialist with ACIWRM, Bangalore. previously he was working with Atkins India Pvt. Ltd. Bangalore, Jacobs India Pvt. Ltd, Pune as Hydraulic modeller. He has master's degree in Water Resources Engineering and Management from National Institute of Technology, Karnataka (NITK) and bachelor's degree in Civil Engineering form VTU university, Belgaum, Karnataka.

Madhubandti Sadhya

Madhubanti Sadhya is a Teaching Associate at Centre for Environmental Law Education, Research and Advocacy (CEERA), NLSIU, Bangalore. He has a BA LLB (Hons) from University of Calcutta, LLM from West Bengal National University of Juridical Sciences and is completing a PhD at West Bengal National University of Juridical Sciences. She has worked as a faculty member at West Bengal National University of Juridical Sciences and a consultant with UNICEF and SANHITA.

Lianne D'Souza

Lianne D'Souza is a Research Fellow at Centre for Environmental Law Education, Research and Advocacy (CEERA), NLSIU, Bangalore. She has an LLB degree from Christ University, Bangalore, and work experience at various legal firms and the Goa High Court

Dr. Sashikumar N

Dr Sashikumar N is an experienced Consultant with a demonstrated history of working in the research industry. Strong consulting professional with a Research focused in Hydrology, Hydraulics and Water Resources Science from Indian Institute of Science and UVCE, Bangalore University. Have wide range of experience interacting with NGOs, State and Central Government departments, officials in multiple projects. Skilled in Python, R, QGIS, GRASS GIS, ArcGIS, ERDAS Imagine, Google Earth Engine, Machine Learning and Linux. Well versed in providing end to end Information Technology project solutions.

Vijeth Kashyap

Vijeth Kashyap has a bachelors degree in Civil Engineering from MVJ College of Engineering, Bangalore, and a masters in Structural Engineering from RV College of Engineering, Bangalore. He works as an Assistant Engineer in the Water Resources Department, Government of Karnataka and is currently based at ACIRWM. He has additional certifications in basic QGIS, Advanced QGIS for Water Resource Management and Google Earth Engine for Water Resources Management.

Teju Kumar

Teju Kumar N, holds Bachelor's Degree in Civil Engineering from Visvesvaraya Technological University, Belagavi, India. He joined government service as Assistant Engineer in Water Resources Department, Government of Karnataka during 2014. He is competent in Government Procurement policy including preparation of estimate of irrigation canals & structures and has broad knowledge in tendering of works. He has worked in the major Extension, Renovation & Modernization (ERM) project of NLBC canal irrigation system in Upper Krishna Project assisting monitoring of daily execution progress & quality control reports, preparation of estimate of canal gates automation and also served as a member of random inspection team constituted for monitoring of ERM works.

Teju Kumar has participated in trainings notably RAP MASSCOTE for assessing canal irrigation systems applied to Tungabhadra Left Bank Canals & Vijanagar Channels, Krishnarajasagar Irrigation system and Malaprabha Canal system, Transformative Scenario Planning (TSP) for Bengaluru water crisis, River Basin Modeling using HEC and Source modeling platforms. Presented papers at National Conferences namely River Basin Modeling of K8 sub-basin at IIT Delhi, Water Resources Information System at 2nd International conference on Sustainable Water Management under National Hydrology Project and Road Technology for Highway Management in Karnataka.

Presently, he is posted at Advanced Centre for Integrated Water Resources Management and involved in development of Karnataka Water Resources Information System (KWRIS), River Basin Modeling of K2, K8 & K9 sub basin, River Basin Profile & Planning, & remote sensing based Water Productivity assessment and centers administrative works.

Dr. Sachin Warghade

Dr Sachin Warghade is Assistant Professor, Centre for Water Policy, Regulation and Governance , School of Habitat Studies at the Tata Institute of Social Sciences. Sachin has contributed in the design and launch of a pioneering academic program in TISS in the field of regulatory policy and governance. He currently teaches courses related to regulatory policy and instruments in TISS. He is also a visiting faculty for the Masters program on Public Policy at the National Law School of India University, Bangalore. He specializes in regulatory policy with focus on infrastructure and public utilities. In the past he has worked in the field of agriculture, disaster management, and water policy during his decade long association with the policy think-tank named PRAYAS-Pune. He led a pioneering work on water regulation in PRAYAS. Apart from numerous research and publications, his work was instrumental in public-interest protection in regulatory issues of water allocations and tariff. He has contributed as a member in the Planning Commission's XIIth Plan sub-group for development of 'Model Bill for State Water Regulatory System'. He was awarded a Doctoral Fulbright Fellowship at the Washington University in St. Louis in 2011-12.

Payal Pruthi

A media and communication professional with over 15 years of experience, Payal joined ACIWRM as Principal Coordinator (Communications) in the middle of 2020. Before this, she worked with ATREE – a global socio-environmental think tank and led an integrated communications program that included online engagement, media relations, events, and multi-stakeholder outreach.

A key dimension of Payal's role at ATREE was working cross functionally both internally and with external agencies towards conceptualisation, storyboarding and implementation of campaigns, workshops, donor/fundraising engagements, press briefings, content generation and public events.

She often sees herself as an enabler for making new ideas come alive by building the right content, community, and conversations around them and has worked on multiple campaigns with industry influencers.

Payal's earlier professional experience includes work as a journalist with mainstream media covering beats like health, education & IT and as communication specialist in the non-profit sector. She has also worked as a PR professional and content editor. Payal University has a master's degree in Mass Communication and a BA in English Literature from Panjab. She is a mentor, Yes Foundation Media for Social Change Fellowship and likes to interact with students, as visiting faculty.

Acknowledgements

This was the fourth Management Development Programme on Integrated Water Resources Management for Karnataka State Water Resource Engineers and Managers that was conducted jointly with ACIWRM with support from ACIWRM-GoK and Asian Development Bank. We appreciate the enthusiastic participation of all attendees and congratulate them on their achievements.

On behalf of ATREE, we would like to thank all the resource persons for sharing their knowledge and insights, particularly the external resource persons who accepted our invitations and delivered sessions M. G. Shivakumar, N. Balakrishnaraj, Ravichandra Masuti, Dr Shobha Reddy, Prakash Kulkarni, Bhageerath, Madhubandti Sadhya, Lianne D'Souza, Dr. Sashikumar N, Vijeth Kashyap, Teju Kumar, Dr. Sachin Warghade, Payal Pruthi.

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