Water and Development

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Objectives. The key objectives of this course is to provide a quick introduction to engineers and physical scientists on how water appears as a development need, its basic scientific and engineering processes and the governance and policy context within which it operates. The course is aimed at engineers who want to work in the development sectors as entrepreneurs and development professionals such as district coordinators, or within NGOs, or want to pursue the study of the sector as a researcher. Our focus is largely on drinking water and to some extent on water for irrigation. The course begins by defining the development context and ends by concrete case-studies. The middle part provides the science and engineering needed to execute the case-studies. We utilize a regional approach to explain the basic stocks and flows such as ground water, and basic units of analysis such as watersheds. We also explain basic interventions in the sector such as tanks and bunds and water supply systems.

Part I: A Development Framework for Water.

- **Development**. Development: seek environmental and cultural well-being. Predictable, comfortable and cultural existence. Millenium development goals and sustainability goals. Data: Census data and maps. Various graphs and plots. Attributes and their description. Access to drinking water, sanitation, water quality and water for irrigation. Conculsions and the development agenda.

- **The Elementary Structure of Society**. The household and its environmental and cultural needs. Sustenance as the key need. The organization of society as State, Market and Civil Society and Assets and Institutions. Efficiciency and Equity as auxilliary needs.

- **Agents and transaction**. The basic agent (in a short loop). The generation of value, the knowledge and rigour. The basic transactions of the state, market and civil society. Agents in long-loops and employees. The need for monitoring and evaluation. Measurements and data-sets.

- **The Development Professional**. The diagnosis of poor development-knowledge formation, information asymmetry, institutions, resource constraints. The role of science, engineering, agents and processes. Various mitigation measures and interventions. The roles and skills of the development professional.

- **The regional water system**. Images of Ghodegaon regional water system. Identification of demand, supply, transmission and seasonality. Identification of various

stocks, flows and their dimensions. The assets, their objectives and their design criteria and processes. Listing of agents and processes. Efficiency, sustainability and equity in the regional water system.

- **Tutorial 1: System analysis I. Basic Attributes** The *Siddhagadwadi* and *Narivili* village systems. The IIT Bombay campus as a water system.

Part II: The Basic Science of Water.

- **The nature and use of water**. Basic properties and distribution. The basic hydrological cycle. Global and national availability of water. Water for crops, for industries, for drinking. Sustainable water use.

- **The Basic stocks**. Water in atmosphere and water in snow. Groundwater as soil moisture, unsaturated zone and saturated zone. The aquifer and its properties (thickness, layers and yield). The *Gudwanwadi* bore-log. Water in reservoirs. Measurement of various quantities. The Gudwanwadi reservoir.

- **The flows-I**. Rainfall and its measurement. Regional rainfall measurements and estimation of net rainfall. Infiltration, its determinants and excess water and run-off. Evaporation, evapo-transpiration and capillary forces as upward forces. Descent into saturated zone and water table.

- **The flows-II**. Surface flows and its measurement. Open channel flow. Watertable and Base-flows. Sub-surface seepage. Typical stream profile after a rainfall event. Water-table and pond interaction.

- **A simple water balance**. Aquifer, water-table, agriculture, population and rainfall data. The pre-monsoon and the post-monsoon as key epochs. Computation of all flows and stocks. Assumptions on farming practice and its effects. Modelling different situations. Demand as a function of depth.

- **Tutorial II**. Regional rainfall estimation. Water in a channel. Water balance for a drought-prone village in *Sangamner* taluka.

Part III: Regional Water Systems.

- **Groundwater flow**. The aquifer as a grid. Basic properties of a grid element (specific yield, depth, conductivity) and the basic attribute (hydraulic head). Cross-boundary flow, conductivity and Darcy's law. The basic dynamical system. Rainfall and extraction.

- **Steady-state and transient systems.** The linear system with boundary conditions. The saturated monsoon steady-state and the non-monsoon discharge. The well and the cone of depression. The real-life system and its boundary.

- **The Watershed**. Elevation and its representation. The DEM. Surface water flows and the watershed of a point. Watershed delineation. The watershed as a unit of analysis. A supply-demand example from *Mokhada* and *Parbhani*. Basic interventions: wells and *bunds*.

- **The GIS and maps**. Basic maps and their types. Issues of projection, scale and interpolation. Elevation and watertable maps. Conductivity maps. Rainfall maps. The GIS and its architecture. Basic types: raster and vector. Types of vector entities. A GIS dataset-*Pedgaon* and *Thane*.

- **Tutorial III**. Examples of groundwater systems. Watershed computation on maps. Managing a GIS data-set.

Part IV: Engineering.

- **Wells**. The ordinary well and its construction. The well as an extraction and storage device. Yield tests and the well-curve. Elementary analysis of wells. Bore-wells and their construction. Wells through many layers and artesian conditions. The hand-pump and various pumps. The pump-curve.

- **An Earthen-Dam Percolation Tank**. The basic objectives-recharge and storage. The basic engineering attributes of a tank-submergence, alignment, dam. The choice of alignment. The basic structure and attributes of the earthen dam.

- **Area and In-stream structures.** Kolhapur-type weir. Concrete *nalla bund*. Chaining of KT-weirs and CNBs. Gabians. Loose-boulder structures. Farm-ponds, farm-bunding and farm-leveling. Contour trenches and their design. Stability of slopes under moisture.

- **Piped Water Supply**. The basic problem and the solution. Key attributes of the input. The architecture of the solution. The source, the rising main, the MBR and the distribution network. The hydraulic head and the friction equation. Solution of a gravity-fed hydraulic system. Various Issues.

- **Irrigation**. The architecture of an irrigation system. The canal network and the command area. Operation of the canals. Theoretical and actual operations. Groundwater and surface water irrigation. Tariff. KT-weirs and lift irrigation.

- **Tutorial IV**. Capacity of CNBs and KT-weirs. Estimating irrigable lands using contours. Design of a PWS. Design of a PWS with two zones.

Part V: Processes.

- **The Structure of the State**. The basic administrative set-up from GP to the Ministry. Various functionaries and institutions. The ZP and the Collectorate and the District Planning Committee. Different ministries in the water sector and their offices and the state, district, taluka and GP level.

- **Routine Processes and Asset-Creation Cycle**. The project-cycle for a PWS. The expression of demand and the proposal. The technical and administrative clearance. Implementation, M&E and maintenance. The MIS and the annual action plan. The lacunae in processes. The basic structure of a government resolution. The role of programs.

- **A State-Level Program**. The Jal-yukta Shivar program. The GRs and their textual analysis. The background of drought and rural stress. Agricultural water as the key objectives. The key steps and the data used. Critical analysis.
- **A Centrally-Funded Scheme**. The NRDWP. The history of drinking water as a central program. The World Bank and its reports. The design of the NRDWP. Its implementation in Maharashtra. Critical analysis.
- **Tutorial V**. Reading of a case-study and an accompanying paper. Outlining stakeholders, basic scientific, engineering, policy and processes.

Part VI: Finally.

- New directions. Research at CTARA. Areas missing above-Urban Water, Water Quality. Irrigation. Climate change.

Case-Studies.

1. The Gudwanwadi check-dam.
2. The GSDA district level water-balance for Thane.
3. Tadwadi-Morewadi failure Analysis of a PWS.
4. The Anjap-Sugave Multi-village scheme.
5. GSDA data-set and its analysis.
6. Khardi peri-urban PWS scheme.
7. Mokhada regional PWS.
8. Ikhari-cha-pada and Mograj GW simulation.
9. Shahpur DW security planning.
10. RWS policy analysis paper.
11. Maharashtra Sujal-Nirmal analysis-Jawhar.
12. Urban water-Parbhani.
13. Site-visit report of the Jal-yukta shivar program.
14. Rural policy assessment-Shahpur.
15. The Kurlod-Botoshi watershed system.