SYSTEM COMPONENTS

Water resources management involves the interaction of three interdependent subsystems:

1. **Natural river subsystem** in which the physical, chemical and biological processes takes place

2. **Socio-economic subsystem**, which includes the human activities related to the use of the natural river system

3. **Administrative and institutional subsystem** of administration, legislation and regulation, where the decision, planning and management processes take place

Inadequate attention to one subsystem can reduce the effect of any work done to improve the performance of the others.

PLANNING AND MANAGEMENT – APPROACHES

Two approaches which lead to an integrated plan and management policy are

- From the top down or the command and control approach
- From the bottom up or the grassroots approach

Top down approach: Water resources professionals prepare integrated, multipurpose „master" development plans with alternative structural and non-structural management options. There is dominance of professionals and little participation of stakeholders. In this approach, one or more institutions have the ability and authority to develop and implement the plan. However, nowadays, since public have active participation in planning and management activities , top-down approaches are becoming less desirable or acceptable.

Bottom up approach:

In this approach there is active participation of interested stakeholders – those affected by the management of the water and land resources. Plans are being created from the bottom up Water rather than top down. Top down approach plans do not take into consideration the concerns of affected local stakeholders. Bottom up approach ensures cooperation and commitment from stakeholders The goals and priorities will be common among all stakeholders by taking care of laws and regulations and by identifying multiple alternatives and performance criteria. Tradeoffs are made between conflicting goals or measures of performance.

INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) According to Global Water Partnership (GWP, 2000), IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of the vital ecosystems. An integrated water management model develop solutions by involving all the essential components into an optimization scheme. The resources are used in relation to social and economic activities and functions. There is a need for laws and regulations for the sustainable use of the water resources.

Dublin principles for a good water resources management as described by the United Nations Water Conference in 1977 are:

- The “ecological principle”– to treat water as a unitary resource within river basins, with particular attention to ecosystems.
- The “institutional principle”– to respect the principle of subsidiarity through the involvement of government, civil society and the private sector.
- The “instrument principle”– to recognize water as a scarce economic community by imposing various penalties for excessive usage.

A management policy must be developed only after considering the factors such as cost effectiveness, economic efficiency, environmental impact, ecological and health considerations etc.

PLANNING AND MANAGEMENT ASPECTS

Technical aspects It is first necessary to identify the characteristics of resources in the basin, including the land, the rainfall, the runoff, the stream and river flows and the groundwater Technical aspects of planning involves

- Predicting changes in land use/covers ad economic activities at watershed and river basin levels

  Estimation of the costs and benefits of any measures being and to be taken to manage the basin"s water resource including engineering structures, canals, diversion structures etc.

  Identification and evaluation of alternative management strategies and also alternative time schedules for implementing those measures

Economic and Financial aspects

Water should be treated as an economic commodity to extract the maximum benefits as well as to generate funds to recover the costs of the investments and of the operation and maintenance of the system. Water had been treated for long as a free commodity. Revenues recovered are far below the capital cost incurred. Financial component of any planning process is needed to recover construction costs, maintenance, repair and operation costs. In management policies, financial viability is viewed as a constraint that must be satisfied; not as an objective whose maximization could result in a reduction in economic efficiency, equity or other non-monetary objectives.

Institutional aspects Successful project implementation needs an enabling environment. National, provincial and local policies, legislation and institutions are crucial for implementation of the decisions. The role of the government is crucial since water is (i) not a property right (ii) a resource that often requires large investment to develop and (iii) a medium that can impulse external effects. The main causes of failure

of water resources development project are insufficient institutional setting and lack of a sound economic evaluation and implementation.

CONCEPTS FOR PLANNING WATER RESOURCE DEVELOPMENT

Utilisation of available water of a region for use of a community has perhaps been practiced from the dawn of civilization.

Although many such developments had taken place in the field of water resources in earlier days they were mostly for satisfying drinking water and irrigation requirements. Modern day projects require a scientific planning strategy due to:

1. Gradual decrease of per capita available water on this planet and especially in our country.
2. Water being used for many purposes and the demands vary in time and space.
3. Water availability in a region – like county or state or watershed is not equally distributed.
4. The supply of water may be from rain, surface water bodies and ground water.

This lesson discusses the options available for planning, development and management of water resources of a region systematically.

WATER RESOURCES PROJECT PLANNING

The goals of water resources project planning may be by the use of constructed facilities, or structural measures, or by management and legal techniques that do not require constructed facilities. The latter are called non-structural measures and may include rules to limit or control water and land use which complement or substitute for constructed facilities. A project may consist of one or more structural or non-structural resources. Water resources planning techniques are used to determine what measures should be employed to meet water needs and to take advantage of opportunities for water resources development, and also to preserve and enhance natural water resources and related land resources.

The scientific and technological development has been conspicuously evident during the twentieth century in major fields of engineering. But since water resources have been practiced for many centuries, the development in this field may not have been as spectacular as, say, for computer sciences. However, with the rapid development of substantial computational power resulting reduced computation cost, the planning strategies have seen new directions in the last century which utilises the best of the computer resources. Further, economic considerations used to be the guiding constraint for planning a water resources project. But during the last couple of decades of the twentieth century there has been a growing awareness for environmental sustainability. And now, environmental constrains find a significant place in the water resources project (or for that matter any developmental project) planning besides the usual economic and social constraints.

Priorities for water resources planning

Water resource projects are constructed to develop or manage the available water resources for different purposes.

water allocation priorities for planning and operation of water resource systems should broadly be as follows

1. Domestic consumption This includes water requirements primarily for drinking, cooking, bathing, washing of clothes and utensils and flushing of toilets.
2. Irrigation
Water required for growing crops in a systematic and scientific manner in areas even with deficit rainfall.
3. Hydropower
This is the generation of electricity by harnessing the power of flowing water.
4. Ecology / environment restoration
Water required for maintaining the environmental health of a region.
5. Industries
The industries require water for various purposes and that by thermal power stations is quite high.
6. Navigation
Navigation possibility in rivers may be enhanced by increasing the flow, thereby increasing the depth of water required to allow larger vessels to pass.
7. Other uses
Like entertainment of scenic natural view.

This course on Water Resources Engineering broadly discusses the facilities to be constructed / augmented to meet the demand for the above uses. Many a times, one project may serve more than one purpose of the above mentioned uses.

Basin – wise water resource project development

The total land area that contributes water to a river is called a Watershed, also called differently as the Catchment, River basin, Drainage Basin, or simply a Basin.

A watershed may also be defined as a geographic area that drains to a common point, which makes it an attractive planning unit for technical efforts to conserve soil and maximize the utilization of surface and subsurface water for crop production. Thus, it is generally considered that water resources development and management schemes should be planned for a hydrological unit such as a Drainage Basin as a whole or for a Sub-Basin, multi-sectorially, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations.

Let us look into the concept of watershed or basin-wise project development in some detail. The objective is to meet the demands of water within the Basin with the available water therein, which could be surface water, in the form of rivers, lakes, etc. or as groundwater. The source for all these water bodies is the rain occurring over the Watershed or perhaps the snowmelt of the glacier within it, and that varies both temporally and spatially.

Further due to the land surface variations the rain falling over land surface tries to follow the steepest gradient as overland flow and meets the rivers or drains into lakes and ponds. The time for the overland flows to reach the rivers may be fast or slow depending on the obstructions and detentions it meet on the way. Part of the water from either overland flow or from the rivers and lakes penetrates into the ground and recharge the ground water. Ground water is thus available almost throughout the watershed, in the underground aquifers. The variation of the water table is also fairly even, with some rise during rainfall and a gradual fall at other times. The water in the rivers is mostly available during the rains. When the rain stops, part of the ground water comes out to recharge the rivers and that results in the dry season flows in rivers.

Note:

Temporal: That which varies with time

Spatial: That which varies with time

Tools for water resources planning and management

The policy makers responsible for making comprehensive decisions of water resources planning for particular units of land, preferably a basin, are faced with various parameters, some of which are discussed in the following sections.

The supply of water

This may be divided into three sources

- **Rain falling within the region**-This may be utilized directly before it reaches the ground, for example, the roof – top rain water harvesting schemes in water scarce areas.

- **Surface water bodies.** These static (lakes and ponds) and flowing (streams and rivers), water bodies may be utilized for satisfying the demand of the unit, for example by constructing dams across rivers.

- **Ground water reservoirs.** The water stored in soil and pores of fractured bed rock may be extracted to meet the demand, for example wells or tube – wells.

Water transferred in and out of the unit

If the planning is for a watershed or basin, then generally the water available within the basin is to be used unless there is inter basin water transfer. If however, the unit is a political entity, like a nation or a state, then definitely there shall be inflow or outflow of water especially that of flowing surface water. Riparian rights have to be honored and extraction of more water by the upland unit may result in severe tension.

Note: Riparian rights mean the right of the downstream beneficiaries of a river to the river water.

Regeneration of water within the unit

Brackish water may be converted with appropriate technology to supply sweet water for drinking and has been tried in many extreme water scarce areas. Waste water of households may be recycled, again with appropriate technology, to supply water

The demand of water

Domestic water requirement for urban population

This is usually done through an organized municipal water distribution network. This water is generally required for drinking, cooking, bathing and sanitary purposes etc, for the urban areas. According to National Water Policy (2002), domestic water supplies for urban areas under various conditions are given below. The units mentioned "lpcd" stands for Liters per Capita per Day".

1. 40 lpcd where only spot sources are available
2. 70 lpcd where piped water supply is available but no sewerage system
3. 125 lpcd where piped water supply and sewerage system are both available. 150 lpcd may be allowed for metro cities.

Domestic and livestock water requirement for rural population

This may be done through individual effort of the users by tapping a local available source or through co-operative efforts, like Panchayats or Block Development Authorities. The accepted norms for rural water supply according to National Water Policy (2002) under various conditions are given below.

• 40 lpcd or one hand pump for 250 persons within a walking distance of 1.6 km or elevation difference of 100 m in hills.

• 30 lpcd additional for cattle in Desert Development Programme (DDP) areas.

Irrigation water requirement of cropped fields

Irrigation may be done through individual effort of the farmers or through group cooperation between farmers, like Farmers' Cooperatives. The demands have to be estimated based on the cropping pattern, which may vary over the land unit due to various factors like; farmer's choice, soil type, climate, etc. Actually, the term "Irrigation Water Demand" denotes the total quantity and the way in which a crop requires water, from the time it is sown to the time it is harvested.

Industrial water needs

This depends on the type of industry, its magnitude and the quantity of water required per unit of production.

Structural tools for water resource development

This section discusses the common structural options available to the Water Resources Engineer to development the water potential of the region to its best possible extent.

Dams

These are detention structures for storing water of streams and rivers. The water stored in the reservoir created behind the dam may be used gradually, depending on demand.

Barrages

These are diversion structures which help to divert a portion of the stream and river for meeting demands for irrigation or hydropower. They also help to increase the level of the water slightly which may be advantageous from the point of view of increasing navigability or to provide a pond from where water may be drawn to meet domestic or industrial water demand.

Canals/Tunnels

These are conveyance structures for transporting water over long distances for irrigation or hydropower.

These structural options are used to utilise surface water to its maximum possible extent. Other structures for utilising ground water include rainwater detentions tanks, wells and tube wells.

Another option that is important for any water resource project is **Watershed Management practices.** Through these measures, the water falling within the catchment area is not allowed to move quickly to drain into the rivers and streams. This helps the rain water to saturate the soil and increase the ground water reserve. Moreover, these measures reduce the amount of erosion taking place on the hill slopes and thus helps in increasing the effective lives of reservoirs which otherwise would have been silted up quickly due to the deposition of the eroded materials.

Management tools for water resource planning

The following management strategies are important for water resources planning:

- Water related allocation/re-allocation agreements between planning units sharing common water resource.
- Subsidies on water use
- Planning of releases from reservoirs over time
- Planning of withdrawal of ground water with time.
- Planning of cropping patterns of agricultural fields to optimize the water availability from rain and irrigation (using surface and/or ground water sources) as a function of time
- Creating public awareness to reduce wastage of water, especially filtered drinking water and to inculcate the habit of recycling waste water for purposes like gardening.

Research in water management: Well established technological inputs are in verge in water resources engineering which were mostly evolved over the last century. Since, then not much of innovations have been put forward. However, it is equally known that quite a few of these technologies run below optimum desired efficiency. Research in this field is essential for optimizing such structure to make most of water resource utilization.

Tasks for planning a water resources project

The important tasks for preparing a planning report of a water resources project would include the following:

• Analysis of basic data like maps, remote sensing images, geological data, hydrologic data, and requirement of water use data, etc.

• Selection of alternative sites based on economic aspects generally, but keeping in mind environmental degradation aspects.

• Studies for dam, reservoir, diversion structure, conveyance structure, etc.

- Selection of capacity.
- Selection of type of dam and spillway.
- Layout of structures.
- Analysis of foundation of structures.
- Development of construction plan.
- Cost estimates of structures, foundation strengthening measures, etc.

• Studies for local protective works – levees, riverbank revetment, etc.

• Formulation of optimal combination of structural and non-structural components (for projects with flood control component).

• Economic and financial analyses, taking into account environmental degradation, if any, as a cost.

• Environmental and sociological impact assessment.

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