CHAPTER 6

CHECKLISTS AND CONCLUDING REMARKS

6.1 CHECKLISTS FOR SUSTAINABLE RESERVOIR DEVELOPMENT AND MANAGEMENT

The following are checklists for sustainable reservoir development and management for which a brief rationale was introduced in 2.2.7. They refer to three stages of reservoir development:

- a planning and design stage;
- a construction stage; and
- an operation and maintenance stage;

and five broad areas, where disadvantages can be critical:

- the conservation of nature;
- inter-generational equity;
- intra-generational equity;
- efficiency; and
- integrated water management.

PLANNING AND DESIGN STAGE

Conservation of nature

- **EIA** Adequate environmental impact assessment is carried out (the necessary time and resources are invested, embracing breadth of perspective, low-probability extreme events, long time horizons and spatially remote impacts).
- **Co-existence with nature** Such alternatives that have fatal effects on ecological systems should be excluded, especially on biodiversity, rare species and the number of population required to ensure the natural evolution process.
- **Minimum environmental impact alternative** The alternative selected is the one that accompanies the minimum environmental impact as compared with other alternatives that can yield the same level of satisfaction on the objectives.

- **Environmentally conscious design** The reservoir is designed to minimize the adverse effects of storing water, segmentation of the habitat, inundation etc. by facilitating sediment discharge gates, sediment bypass channels, fish ladders, bio-recovery sanctuary (biotopes) etc.

Inter-generational equity

- **Explicit consideration of future generations** The impact on future generations is explicitly considered in plan formulation and evaluation.
- **Benefit exceeds cost for future generations** The long-term benefit will exceed the long-term loss due to long-term environmental impacts.
- **Land safety and productivity** The construction and planned water use will not cause long-term environmental and geomorphological deterioration of the land, neither waterlogging upstream, coast line retreat and sea-water intrusion downstream or salinity problems on irrigated land.
- **Socio-cultural heritage** The protection of historical and archaeological sites, cultural heritage and unique landscapes is taken care of in project planning.

Intra-generational equity

- **Democratic decision-making process** The construction plans and alternatives are known to the broad public and made available for public discussion with full information disclosure among all the stakeholders, in particular, the indigenous people in any inundated area. Public consent is sought at all stages in the decision-making process.
- **Proper rehabilitation of involuntarily relocated people** The people to be relocated are taken care of until their lives and their community in the new location have been stabilized.
- **Upstream and downstream equity** The benefit obtained from the reservoir is shared equally with the people in the reservoir area.
- **Income redistribution** The economic benefit of the reservoir output is considered for people in need thus contributing to an equalization of income distribution.

Efficiency

- **Economic efficiency** The project is financially feasible with satisfactory cost recovery for the capital investment.
- **Use of technology favouring resilience** Every possible technology is utilized to make the reservoir system resilient so as to adapt efficiently to

unexpected surprises in nature, as well as society, including extreme hydrometeorological phenomena, changes in the public value system and other conditions.

- **Multipurpose use** The reservoir is planned and operated in a multipurpose manner.
- **Evaporation loss** The estimated water losses (evapotranspiration and seepage) are acceptable.
- **Hydropower generation** The power generation component is included in the set of purposes. It is always recommended, if a reservoir is to be built, to utilize environmentally clean hydropower regardless of the prime purposes and the size of reservoir, so long as it is economically justifiable.

Integrated water management

- **Thorough consideration of non-reservoir options** The non-reservoir alternatives to reach the planning objectives are thoroughly considered.
- **Demand management** Special consideration of demand management, re-allocation of water rights, urban water storage and infiltration are fully taken into account before choosing the reservoir option.
- **Integrated multi-sectoral water management** The reservoir is planned with multi-sectoral cooperation in an integrated way with institutional, managerial, economic, physical and all other relevant means.
- **Basin-scale water management** The reservoir is planned and operated as a part of the overall basin-scale water management.

CONSTRUCTION STAGE

Conservation of nature

- **Environmentally careful construction work** The reservoir is constructed in the least environmentally damaging manner related to water quality, erosion, air pollution, liquid and solid waste, noise during various construction works such as access roads, bypass tunnels, rock and soil material quarrying as well as the dam construction itself.
- **Biomass inundation** Organic decomposition does not lead to critical dissolved oxygen deficits in the waters of the reservoir.
- **Rescue of animals and plants** Transferable animals and plants are relocated (in a way so as not to create serious transmigratory impacts on the receiving ecological community).

OPERATION AND MAINTENANCE STAGE

Conservation of nature

- **Rehabilitation of surrounding areas** Adequate measures are taken to rehabilitate damaged natural environment in the affected areas.
- **Normal maintained flow** Streamflow below the dam is sufficient to maintain the normal biotic life.
- **Natural flow pattern** The reservoir is operated with a provision for natural release patterns (seasonal and diurnal variations, minimum hygienic flow, low flow characteristics, flow requirements for aquatic species) with similar hydrological extremes, wherever desirable, to ensure quasi-natural biotic conditions downstream.
- **Post audit** The ecological impacts on aquatic fauna and flora as well as on water quality and sedimentation are continuously monitored over the long term.

Inter-generational equity

- **Sediment control and safety** The reservoirs are designed not to lose their capacity, safety, and other functions for centuries. This requires undertaking proper measures for mitigating reservoir sedimentation (built-in sediment discharge gates or bypass channels), safety design against overtopping and earthquakes and against structural decline with proper provision for routine structural monitoring.
- **Catchment management** Continuous efforts are made on land (hillslope) management, forests and native vegetation maintenance, effluent discharge control so as to avoid the adverse effects from upper basin development such as farmland reclamation, urbanization, industrialization, residential and recreation activities, on the quality and quantity of reservoir water.

Efficiency

- **Combined use** The reservoir is operated in the manner integrated with other reservoirs, aquifers, and storage facilities.
- **Use of available forecasts** Hydrometeorological forecasts and water demand predictions are, if available with reliable accuracy, properly utilized.
- **Use of computer-aided information management and decision support technology** The knowledge base for flood control, drought management, water quality control, navigation, hydropower etc. is properly managed and transmitted to the available decision support technology, such as expert systems, artificial intelligence and others, wherever appropriate for enhancing efficiency and reliability.

- **Health risk reduction** The reservoir operation avoids health risks due to mosquitoes, filaria, schistosomes etc.
- **Maximum environmental value** The new lake is managed to produce the maximum environmental value.

Integrated water management

- **Integrated operation of multi-component water resource system** The reservoir is operated and maintained in conjunction with all the related components of water resource systems in a comprehensive manner, for multipurpose flood control, water supply, environmental quality control etc.
- **Flexible allocation of water resources** The water allocation rule is flexible enough to react to the real needs of the region whenever necessary, such as during prolonged droughts, or when social needs and preferences may change in the long term.

6.2 CONCLUDING REMARKS

Reservoirs are undoubtedly one of the most important means of water resources development and management, and they have been built since earliest historical times. Human beings have been successful in achieving the necessary control of water by reservoirs for agriculture, flood control, hydropower generation, water supply, navigation and recreation. Engineering technology for reservoir construction has saved many lives and made development possible. However, it is also true that many large reservoirs were built, at least in part, without proper account of environmental, social and economic interactions. Critics who claim that many large dams are environmentally destructive, socially tragic and economically unsuccessful should be listened to carefully and their concerns scientifically analysed. New approaches must be taken.

In the 21st century plainly more water will be needed for an increasing world population which aspires to a higher standard of living, and that surface water development through reservoir construction is likely to be the major source. In these circumstances, scientific diagnoses must be subject to a broad public discussion among interested and affected parties. It is no longer acceptable simply to point out the impacts of reservoir construction in terms of some future benefits and disadvantages.

Sustainable reservoir design and management is a new concept in the sense that not only the efficiency of current performance and physical safety should be considered, but also that intra- and inter-generational needs and equity must be taken into account. The general sustainability principle has been widely acknowledged at all levels, yet its concrete implementation in individual