Water Resources Management, Protection and Conservation

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1. Water Resources Management

Several technique terms:

- ***Water resources development*** **– exploitation of new water sources**
- ***Water resources management*** **– control of water utilization**
- ***Water demand*** **– quantity of water to meet the requirement of use**
- ***Water consumption*** **– quantity of water used**

1.1 Importance of Water and Need for Control

Demand Aspect:

- ***Water resources*** **– critical to human society for their domestic, industrial as well as agricultural needs**
- ***Low-cost supply of large quantities of water*** **– one of the foundations of modern society**
- ***Need for increased water supply*** **– as the result of growing population and industrial expansion**
- ***Water resources development*** **– constructions of dams, reservoirs, river diversions, pipelines, and aqueducts to bring water from more distant, unpolluted sources**

Resource Aspect

- ***Water shortage*** **– huge withdrawal of water for various water users, which creates a shortage of water for themselves and for other users**
- ***Water quality problem*** **– pollution from water disposal and surface runoff, which makes water qualitatively unsuitable for certain uses**

Environmental Aspect

- ***Sustainable development*** **– long-term effects of water use and the loss of water for aesthetic and recreational purpose (quantitative)**
- ***Aquatic environment*** **– effect of pollutants on the aquatic lives and vegetations (qualitative)**

Water resources management

- ***Political considerations*** **– politicians, governments, policies**
- ***Technical considerations*** **– engineering, biology, sociology, geography, and many other specialist fields**
- ***Socio-economic considerations*** **– cost-benefit analysis**
- ***Environmental considerations*** **– environmental protection, sustainable development**

1.2 Objectives in Water Resources Management

The general objective of water resources management is *to maximize the benefits* obtained from the utilization and control of water resources

Evaluation of the benefits:

- **The amount of water to be supplied or controlled**
- **The need for protection or improvement of its quality**
- **The cost of providing the potential benefits to the various users**

1.3 Options for Meeting Water Demands

Two major approaches:

(1) Implementation of large engineering projects to obtain more water from various freshwater systems – *Supply-type*

(2) Increase of water recycling, using both constructed and natural purification systems – *Reuse-type*

Supply options:

(1) Dam and reservoirs

- **Benefits: equalization and control of stream flow, power generation, flood and drought control, recreation**
- **Problems: silting up of reservoirs over time, great evaporation losses**

(2) Large-scale water diversions

- **Benefit: supplying abundant water for regional development**
- **Problems: high cost, evaporative loses, salt buildup and soil deterioration**

(3) Groundwater

- **Benefits: higher quality, decentralized water supply**
- **Problems: lowering groundwater table**

(4) Desalination

- **Benefits: using salty water or sea water as the resource for water supply**
- **Problems: high construction cost (e.g. RO), high energy consumption**

(5) Relocation of water users

- **Benefits: mitigation of regional water shortage**
- **Problems: high cost, social impact**

Reuse options:

(1) Reuse and recycling of wastewater

- Increasing the number of times that water can be reused before its return to the hydrologic cycle – efficient way to meet water demand in the long term

(2) Reducing evaporation from water surfaces

- Especially in the case of agricultural irrigation, the largest single user of water resources

(3) Water conservation techniques

- Installation of water-saving faucet or shower fittings, water-saving industrial equipment, leakage prevention etc.

1.4 Quantifying Ecological and Social Effects

Predicting the effects of a water project:

- **Effects on ecological systems – short-term and long-term**
- **Effects on social societies – short-term and long-term, benefits and adverse impacts**

Example: **Questions to be asked before a water structure, such as a dam, can be designed –**

- **How much water will the dam have to retain?**
- **At what rate will settlement of silt reduce reservoir capacity?**
- **When should water be released for flood control, stream augmentation, or recreational use?**
- **Will undesirable plant growth be stimulated by the impounded water?**
- **What is the expected benefit of recreational facilities?**
- **How will have land submerged by reservoirs affect local residents?**

Example: Adverse consequence of the construction of Aswan Dam in Egypt –

- **Destroyed the country's sardine industry**
- **Created downstream erosion**
- **Promoted the spread of disease**

How about the consequence of the Three Gouge Dam in the future? – Unknown.

Computer models in assisting quantification of ecological and social effects

- **Computer models, although they have limitations, can be run quickly to assess the possible cumulative effects on the anticipated benefits of any water control proposal.**
- **Computer models often involve probability on the basis of accumulated data, which provide foundation for reliable prediction.**
- **Many diverse considerations and interactions involved in planning long-term water resource projects are becoming so numerous that evaluation unaided by computing assistance is too unreliable.**

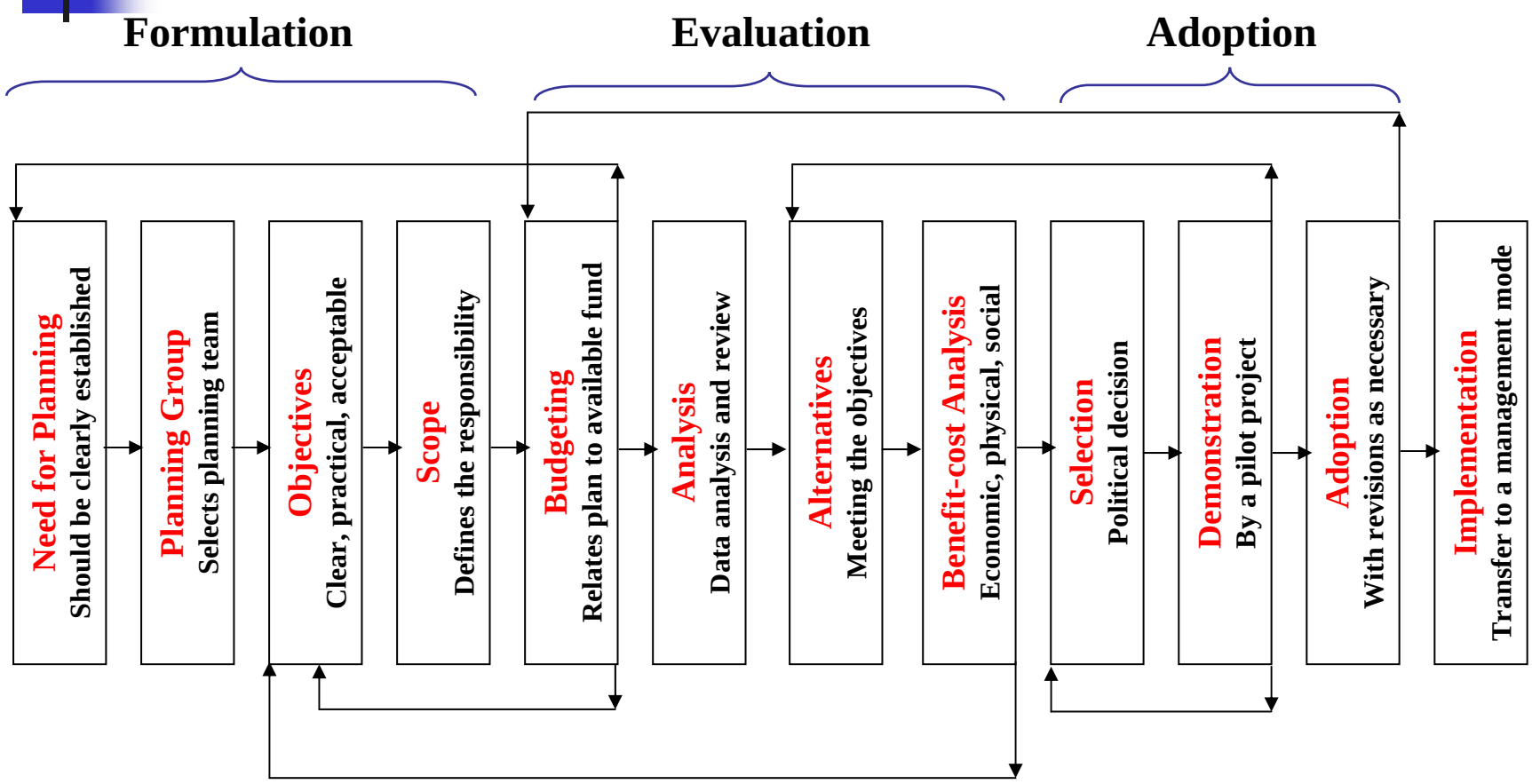
2. Planning Requirement

Planning – the process preceding the implementation of a project

Purpose of planning

- **To inform those making a decision as to the consequences of their actions**
- **To find an acceptable compromise between competing needs while using water resources in the most efficient manner**

Stages in the Planning Process



Formulation of the Planning Study

- **Awareness of the need for planning:** recognizing the interdependence among the components of a system
- **Establishment of a planning group:** provision of specialists covering all fields related to the planning (engineering, socio-economy, public-interest groups)
- **Setting objectives:** objectives set for the study being clearly understood by all parties
- **Establishment of the scope of a planning study:** clear outline of the responsibilities of the participants

Evaluation of the Plan

- **Budgeting:** setting schedules and costing the planning efforts
- **Analysis of the problems:** collection and analysis of reliable data (chemical, physical, social, biological, economic)
- **Generation of alternatives:** consideration of all possibilities and options which may apply to any of the human, physical, and biological systems that govern water use
- **Benefit-cost analysis:** quantifying the tangible (economic) and intangible benefits and choosing the best proposal as the one with the highest benefit/cost ratio

Example: **A planning authority for a small river basin has proposed two alternatives for a flood-control dam, each with an expected life of 40 years. Calculate the benefit/cost ratio for each alternative, using the following data:**

Annual budget for dams (with no recreational benefits)	Alternative	
	A	B
Yearly payment on construction cost	￥ 85,920	￥343,990
Expected average yearly decrease in flood damage claims	￥147,600	￥492,000
Yearly maintenance costs	￥ 20,500	￥ 41,000

Solution:

	Alternative	
	A	B
Total benefits from dams	￥147,600	￥492,000
Total costs of dams	￥106,420	￥384,900
Benefit/cost	1.39	1.28

Alternative A, which has a higher benefit/cost ratio, seems to be better alternative.

Adoption of the Plan

- **Selection of the "best" plan:** usually a political decision on the basis of evaluation.
- **Demonstrative project to verify the choice:** test of the choice of the "best" plan by pilot studies. "Iteration" in the planning process would be needed.
- **Final adoption of the plan:** revision would also be needed in the process of evaluation of implementation program.

3. Case Study: Water Resources Management for Jordan

Country Profile

Area:

96,000 km^2

Population:

4.9 million (1999)

Capital City:

Amman (population 1.8 million)

GDP per capita

1,543 US$

Present Water Supply (1999)

	(million m^3/yr)
➢ Domestic/municipal	240
➢ Industrial	60
➢ Irrigation	620
Total	920

Water Demand (unconstrained)

(million m^3/yr)

	2010	2020
Domestic/Municipal	390	610
Industrial	102	170
Irrigation	730	850
Total	1222	1630

Available Water Resources

Conventional water resources

	(million m^3/yr)
Surface water	350 – 550*
Renewable groundwater	275**
Peace Treaty water***	30 – 60
Subtotal	655 – 885

* Maximum available amount including total base flow and half of the flood flow.

** The present groundwater withdrawal is 420 million m^3/yr which is 53% more than the safety yield and has resulted in a quick depletion of groundwater level.

*** Based on the Jordan/Israel Peace Treaty in 1994.

Non-conventional water resources

	(million m^3/yr)
Fossil groundwater*	100 – 150
Brackish groundwater**	320 – 360
Seawater desalination	as far as feasible
Treated wastewater	as far as possible
Subtotal	420 – 510

* Good quality fresh water but non-renewable.

** With salinity (TDS) from 1500 – 10000 mg/L. Desalination is often required.

Problems

Imbalance between demand and resource

- **The unconstrained demands to 2010 and 2020 are 1222 and 1630 million m^3/yr, far above the available conventional water resources amounted as 655-885 million m^3/yr.**
- **Development of the non-conventional water resources would be needed though this will cost a large budget. However, the total available amount (1075-1395 million m^3/yr) is still lower than the unrestricted demand of 2020.**

Low profit of water supply and high rate of water-loss

- **For domestic/municipal supply, the rate of "unaccounted for water (UFW)" is as high as 45-55%, including a physical loss about 25% and other losses as 20-30%.**
- **Irrigation by far consumed 2/3 of the total water but the production was very low. High rate water loss and improper water use are the main reasons.**

Basic consideration on water resources management

Demand side

- **Irrigation water demand shall be kept at the present level and future development of agriculture shall rely on the introduction of water-saving irrigation.**
- **Domestic/municipal water demand shall be recalculated based on the present level of per capita water consumption. Measures for UFW reduction shall be adopted to increase the real water use.**

Resource/supply side

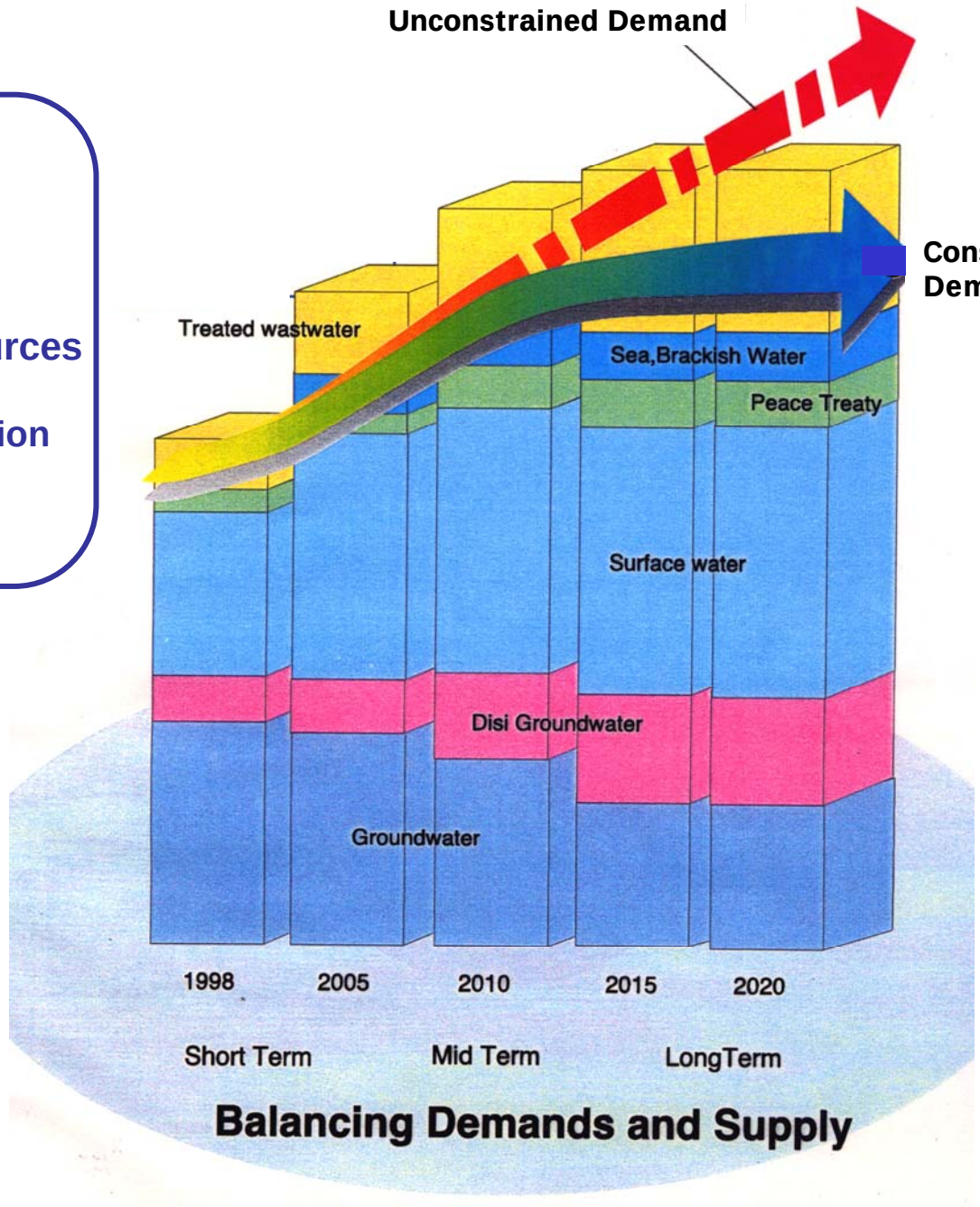
- **Maximum development of the surface water resources, including storage of flood flow.**
- **Decease the amount of groundwater withdrawal to the renewable level.**
- **Using treated wastewater as the main water sources for irrigation in Jordan Valley area and saving fresh water for domestic/municipal uses.**
- **Implementation of brackish water or seawater desalination plants as supplementary resources for water supply as economically feasible.**

Outline of the water resources management plan for Jordan

- **Target year:** 2020
- **Short term (before 2010) objective:** surface water development and reduction of UFW to meet the constrained demand
- **Mid term (2010) objective:** restriction on renewable groundwater withdrawal and start of large scale use of treated wastewater
- **Long term (to 2020) objective:** equilibrium between demand and supply to establish a stable and well managed water system

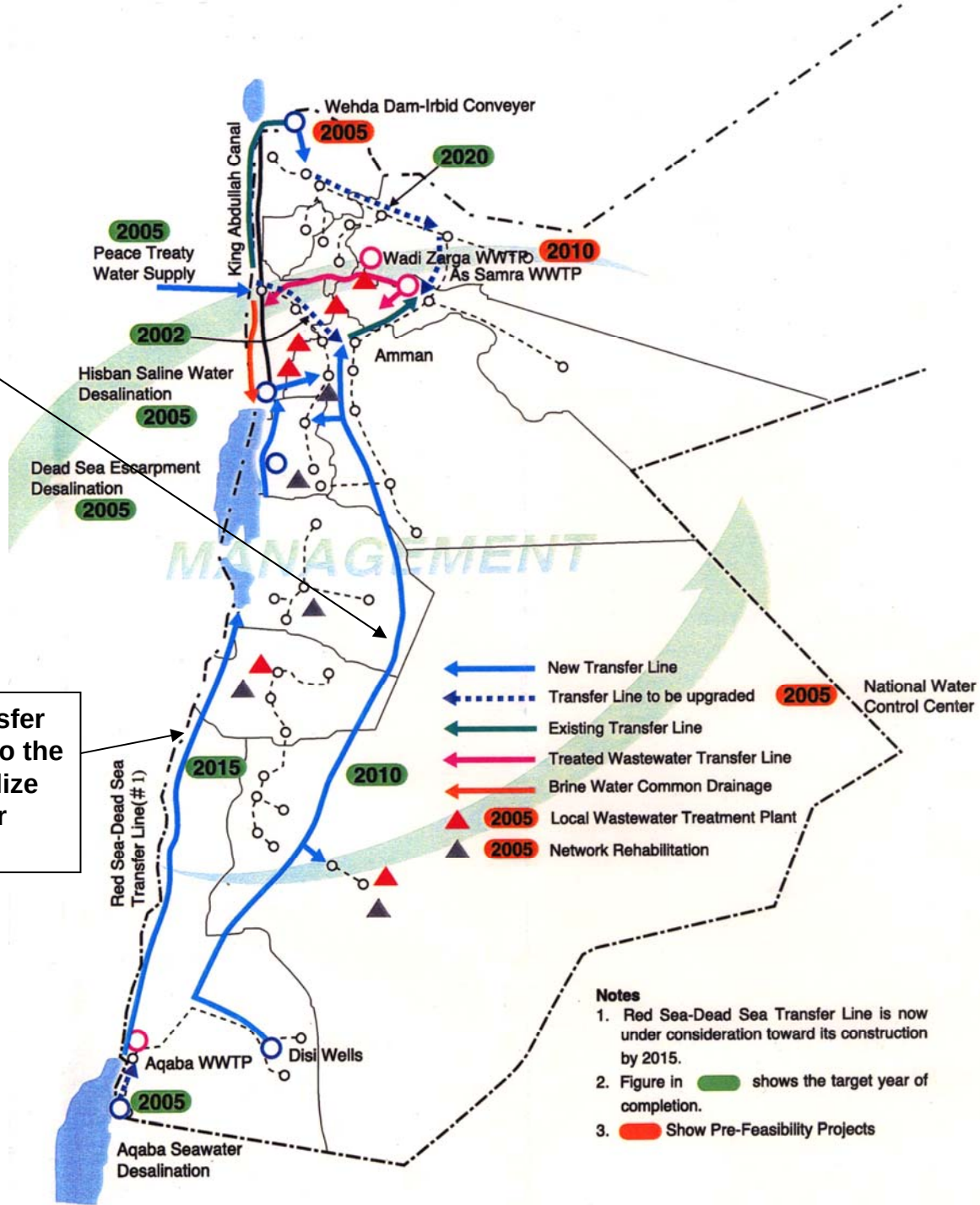
Resources Development
Conventional Resources
- Surface water
- Groundwater

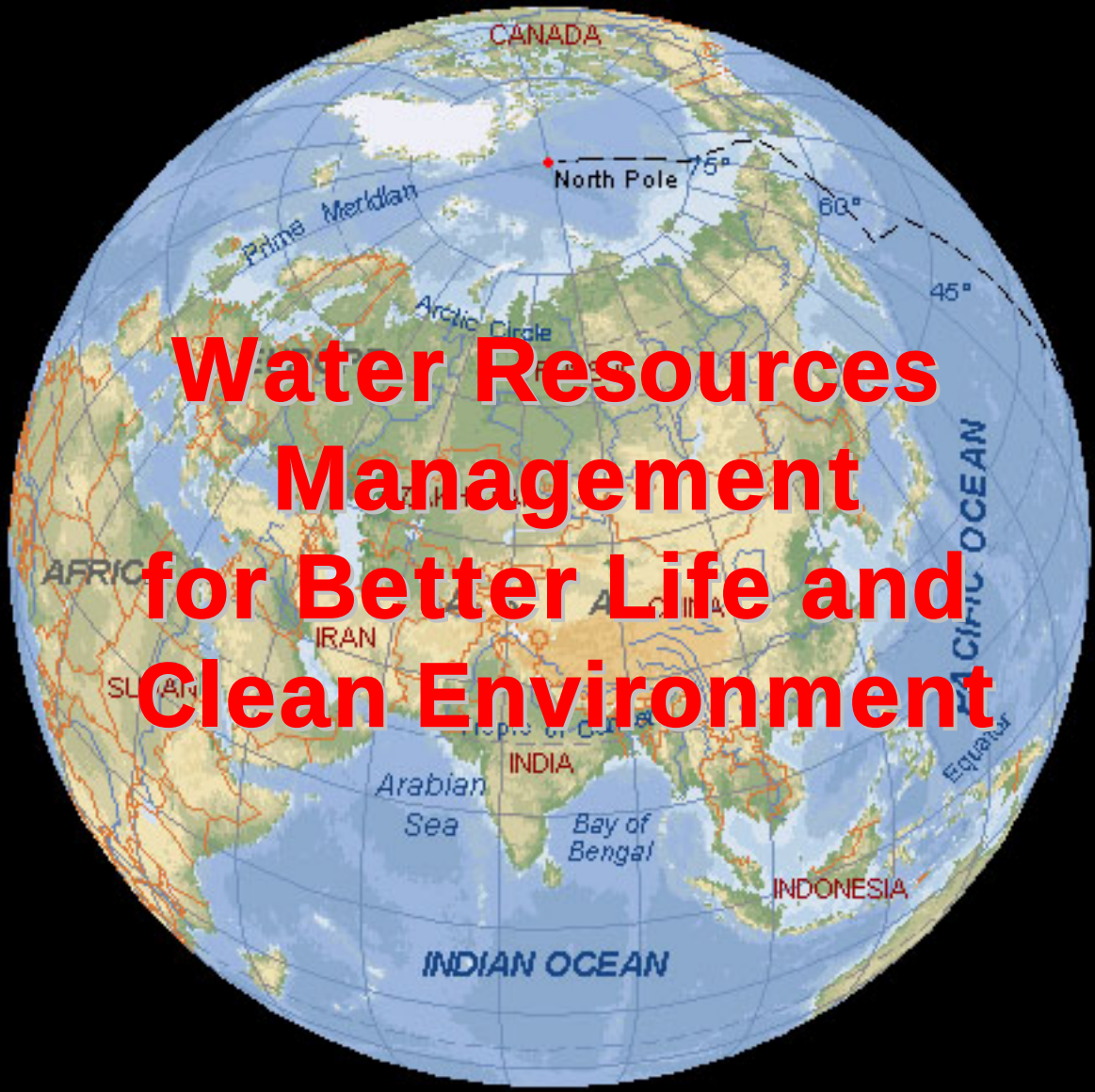
Non-conventional Resources
- Treated wastewater
- Brackish water desalination
- Seawater desalination
- Fossil groundwater



A pipeline to transfer fresh Groundwater from south to north for water supply to the capital city Amman and northern Provinces.

An international plan to transfer Seawater from the Red Sea to the Dead Sea by gravity, and utilize the gravitational potential for seawater desalination.





Water Resources Management for Better Life and Clean Environment