CHAPTER 7: WATER RESOURCES

I. Water use and development in the U.S.

A. Water allocation institutions: governs how water is allocated to different users

1. Riparian rights: allocates the right to use water to the owner of the land adjacent to the water body, e.g. the river, lake, etc.
   
a) The earlier water right doctrine derived from the English common law system
   
b) “Reasonable use” criterion: one right holder’s use of the water should not have a perceptible impact on other riparian land owners.
      (1) Definition of “reasonable” is left to the court
   
c) It allocates water to traditional uses and can block its reallocation to higher-valued uses.
   
d) Provides limited flexibility to allocate water to new uses away from riparian land.
      (1) New uses must be reasonable
      (2) It must not unreasonably impair existing uses
      (3) Once allowed, it has the same legal footing as existing uses

2. Prior appropriation water law: earlier users have more senior rights
   
a) Established during the Gold Rush: water is needed for gold mining, but may not be found at the mining site.
   
b) Any unclaimed water can be diverted for beneficial use. Separation of water right and land.
   
c) When there is water shortage, senior water rights have priority over junior rights.
      (1) This worked well at the beginning, because best lands were settled first
      (2) But a century later, right seniority is typically unrelated to value of water --- the rigidity of the system prevents efficient allocation of water
   
d) Use it or lose it: reduces incentives of water conservation and transfer.
      (1) Now this is being changed.
      (2) But many states require that transfers do not have adverse impacts on other right holders:
          upstream - return flow - downstream
e) Instream water uses: e.g. for fishery

(1) Not considered as having any water rights before

(2) Now it is changing: usually nested with the state government

B. Groundwater allocation:

1. Common-property nature: leads to over-extraction.

2. Rules:

   a) English rule in early years: landowner above the aquifer has unlimited right, if the use is not malicious.

   b) American rule, or Reasonable use rule: the use has to be reasonable, and the export of water from overlying to non-overlying lands is per se unreasonable.

   c) Recent reforms, in conjunctive use of surface and ground water and water markets.

C. Role of the government: mainly in surface water management

1. Two major government agencies:

   a) Army Corp. of Engineers: in-land water ways, flood control, electricity, and later on irrigation (multipurpose dams)

   b) Bureau of Reclamation: irrigation projects: dams, canals, etc.

   c) New roles: water management: mitigation of environmental impacts of past water projects.

2. Subsidies in water development and use: irrigation projects

   a) The Reclamation Act of 1902: Reclamation Fund was used to develop irrigation projects in western states

   b) Homesteads were required to pay back the cost of these projects, in ten years without interest.

      (1) Eckstein (1961) estimated that when r=4%, repayment would account for 21% of true cost of development. When r=7%, repayment accounts for 7% of total cost.

   c) Ability to pay criterion (a percentage of farm income): later payback period and more subsidy for irrigation.

      (1) Wahl (1989) found that the WTP for irrigation water was 10-285 times higher than the ability to pay figure used by the BuRec, for a range of projects.

   d) Many projects require electricity income to compensate for the loss in subsidizing irrigation: multipurpose dams became popular.
(1) Competition between Army Corp. and BuRec. in water projects resulted in more subsidies.

(2) Pork barreling in project authorization: building of many money-losing projects.

3. Water pricing:
   a) Different treatment for irrigation water use and other water use, such as urban and industrial water use.
   b) Regulation of water utility companies:
      (1) Historic average cost pricing
      (2) Marginal scarcity rent is rarely included: water is treated as being free
      (3) Inefficient pricing scheme: uniform rate, decreasing block rate, etc.

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D. In summary: inefficiencies in water allocation:

1. Restriction on transfers: prevents water to be allocated to its highest value of use.

2. Subsidization of off-stream water use, and lack of water rights for instream use.

3. Inefficient water pricing schemes.

II. Efficient allocation of water use

A. Surface water allocation across different uses: MB should be equalized across different uses. Example:

1. Two uses: urban with \( MB_u \) and agriculture with \( MB_a \).
   \[
   MB_u = 30 - 2q \\
   MB_a = 10 - q \\
   \]
   or
   \[
   q_u = 15 - \frac{p}{2} \\
   q_a = 10 - p \\
   \]

2. Aggregate demand function is
   \[
   q = \begin{cases} 
   15 - \frac{1}{2}p & \text{for } p > 10 \\
   25 - \frac{3}{2}p & \text{for } p \leq 10 
   \end{cases}
   \]
3. Suppose the marginal cost of supplying water is constant, \( MC = 2 \), up to the limit of the capacity \( S \).

   a) When \( S = 25 \), \( p = MC = 2 \), \( q_a = 8 \), \( q_u = 14 \), and \( q = 22 \).

   b) When \( S = 19 \), \( p = 4 \), \( q_a = 6 \), \( q_u = 12 \), and \( q = 19 \).

   c) When \( S = 8 \), \( p = 14 \), \( q_a = 0 \), and \( q_u = 8 \).

   d) When the capacity (or water supply) can satisfy both water uses, their marginal benefits are equalized: For example, in b), \( MB_u = MB_a = p = 4 \).

   e) When the capacity is limited, only the urban use has access to water. Agriculture water use is reduced to zero.

   f) Scarcity rent is positive when water is scarce, e.g. when \( S = 8 \) or 19. It is zero when water is not scarce, e.g. when \( S = 25 \).

B. Water pricing: increasing block rate

1. Two principles in regulating water utilities:

   a) Price should reflect the total marginal cost, including the marginal cost of distributing water, and the marginal user cost.

   (1) Marginal user cost arises from the lost opportunity of using the water for other purposes, such as instream recreation, fishery, etc. *Water is not free.*
(2) The total marginal cost is typically increasing, especially due to the existence of user costs.

b) Fair rate of return of the utility: the utility should not earn the scarcity rent as its excess profit.

2. A uniform price at the total marginal cost generates too much profit for the utility.

3. Increasing block rates have been suggested, and used, to achieve the objectives:

a) The blocks are approximate to the true total marginal cost curve: better approximation is achieved when there are more blocks.

b) Consuming less water results in lower prices: the scarcity rent is accrued to the consumers.

c) Equity: large demanders pay more!

C. Peak-load management

1. Depending on the demand for water, a year can be divided into two periods: peak period and off-peak period.

a) The demand is higher in the peak period.

b) Peak demand and the length of the peak period determine the optimal capacity of water supply.

2. Given a certain capacity of water supply, the peak price \( p_p \) and off-peak price \( p_o \) can be determined similar to that in A.
a) Price is higher in the peak period.

b) Suppose the share of the peak period in a year is \( w \), then

\[ \text{the total surplus} = w \text{ peak surplus} + (1-w) \text{ off-peak surplus} \]

c) The marginal benefit of adding more capacity is \( w p_p \). That is, the peak demand and the length of the peak period determine the MB of increasing the capacity of water supply.

III. Current policies toward more efficient water use

A. Water rights for instream water use

1. Permanent rights nested with the state government

2. Water leasing from farmers for instream water use: the programs of Environmental Defense Fund in Oregon

3. Role of Indian tribes in fishery restoration: more senior water rights and legal actions

B. Changing tasks of BuRec

1. Water management, instead of water project development:

   a) facilitating water exchange

   b) promoting conservation technologies

   c) restoration projects
2. Reducing subsidies to agricultural water use
   a) Re-negotiation of water contracts

C. Water markets:

1. Water markets help allocating water to its highest value

2. Potential problems of water markets:
   a) Transaction costs:
      (1) Conveyance mechanism
      (2) Measuring and metering of water use
      (3) Conveyance loss
   b) Third party and groundwater implications. They have resulted in restrictions on water exchange between watersheds.
      (1) Increased or reduced water transportation may have negative impacts on third parties, due to reduced return flows.
      (2) Groundwater pumping due to common property.
   c) Distributional implications: excess profits of senior water right holders aggravated by water subsidy