Chapter 7: Technological Response

Need for Technological Responses

- Directly changing behavior is difficult
  - Command and control policies are sometimes painful
  - It is hard to implement “prices” for once free things like wastewater disposal to the environment
  - Likewise, subsidies to stop pollution might be attractive but rarely is there money to pay them

Need for Technological Responses

- “Constructing a solution” is a very common response
  - Done correctly, engineering solutions like wastewater treatment systems can greatly lower the negative effects of human activities on a lake.
  - However, if technological responses only treat symptoms of problems rather than root causes, they will be done in vain.
  - Plus, they usually cost money…

Types of Technological Responses

- Watershed-based Measures
  - Point Source Control
    - Wastewater Diversion
    - Conventional Wastewater Treatment (Primary and Secondary Treatment)
    - Advanced Wastewater Treatment (Tertiary Treatment)
    - Industrial Wastewater Treatment
  - Nonpoint Source Control
    - Recycling/Reuse of Runoff
    - Constructed Wetlands
    - Reforestation

Types of Technological Responses

- In-Lake Measures
  - Biological Measures
    - Predators
    - Biomanipulation
  - Chemical Measures
    - Biocides
  - Physical Measures
    - Aeration
    - Freshwater Diversion into a Basin
    - Dredging
    - Harvesting

Wastewater Diversion

- One way to avoid wastewater contamination in a lake is to divert the wastewater out of the basin before it reaches the lake.
- Diversion is sometimes preceded by partial or full treatment of wastewater.
- Sometimes, however, the sewage is completely untreated, with large implications for the downstream receiving waterbodies.

Wastewater Diversion

- Examples of wastewater diversion include:
  - The Laurentian Great Lakes, where in Chicago (USA), over 100 years ago, due to typhoid and cholera outbreaks, sewage discharge was diverted from Lake Michigan to the Mississippi River. This improved the problem in Lake Michigan (but perhaps caused problems in the receiving rivers)
  - The Bhoj Wetland, where partially treated sewage is pumped into a downstream river

Conventional Wastewater Treatment

- Primary (sedimentation) and Secondary (biological degradation of organic material) Treatment are commonly carried out.
- Such treatment can greatly reduce the burden on lakes and improve their quality and values.
- However, even for these simple systems, operations and maintenance are often problematic.
  - See Muhandiki for a discussion on the problems with maintaining conventional treatment systems in Africa and India.

Advanced Wastewater Treatment

- Tertiary treatment to remove substances like nutrients, etc. is commonly carried out only in developed countries.
- Such treatment can greatly reduce the eutrophication of lakes and improve their quality and values.
- However, the costs of this form of treatment, not to mention the needs for operations and maintenance, put it out of reach of most developing countries.

Notes on Wastewater Treatment

- It is important to note that in many cases, wastewater treatment is implemented not for lake protection but rather as an amenity (toilets in the home, etc.)

- Also, the timing of water supply systems needs to be aligned with wastewater treatment systems as one affects the other (see Box 7.2 in the main chapter for discussion)

Industrial Wastewater Treatment

- A main reason for requiring industrial wastewater treatment systems it to prevent toxic contamination of lakes.

- Implementation extent is similar to advanced wastewater treatment, i.e., limited to developed countries (with exceptions)

Reuse/Recycling of Ag. Runoff

- The reuse and recycling of runoff from agricultural fields is becoming more and more common in developed countries.
- Watanabe discussed how this is done in Japan and the US for rice fields.
- Even the difficult to control nonpoint source problems sometimes have “win-win” solutions.

Wetland Construction

- Wetlands surrounding a lake are functionally like “kidneys” and serve to purify the water entering a lake from the basin.
- Unfortunately, these littoral wetlands are often the first natural areas destroyed in development.
- Replacement (constructed wetlands) is a common policy in lakes where wetland loss have already occurred.

Reforestation/Afforestation

- Like wetlands, forests cover in a basin is important for preventing soil erosion as well as buffering hydrological cycle.
- Again, similar to wetlands, forests are often cut down for firewood or to make room for agriculture or housing.
- A common policy in many lake basins is to try to replace once existing forests (reforestation)
- Sometimes, forests are planted where there never were any (afforestation)

In-Lake Measures

- The main chapter provides discussion on many of the methods used to deal with lake basin management problems *directly in the lake*.
- These methods include:
  - Biological methods such as introducing predators (see Lake Victoria case for introduction of weevils to control water hycinth)
  - Chemical methods such as the application of algicides
  - Physical methods such as dredging and aeration

In-Lake Measures

- Overall, in-lake measures tend to “treat the symptoms” and not the root causes of problems.
- However, many of cases show that they can be important stop-gap measures because:
  - Even if root causes are control, lakes have long retention times…sometimes in-lake measures can “speed” things up.
  - Sometimes they can be the cheapest solution.

In-Lake Measures

- Interesting cases include:
  - Construction of a dike between the Small and Large Aral Seas to prevent further water loss from the Small Aral (see Aladin for a full report)
  - The dredging of a channel to the sea from the Chilika Lagoon, India to improve the lagoon's water regime (see Pattnaik for discussion on how the "natural" ecosystem was restored)

Some Key Lessons

- Technological interventions by themselves are not sufficient: root causes must be addressed.
- When diverting wastewater, don't forget about the "new" downstream.
- It is cheaper to prevent toxic contamination that to dredge a lake.
- Extensive research is needed to ensure that the introduction of a biological agent to a lake will not have unexpected effects.

Some Key Lessons

- If root causes of macrophytes growth (high nutrient levels) are not addressed, successful removal of one species can just make way for another species to invade.
- Water diversion schemes, while they may have a positive effect on the receiving basin, can be disastrous for the exporting basin.
- If the root cause of a problem has been controlled, then dredging can have a positive, long-term effect.

Final Thought

- One case that does not really fit into the framework above, but one that is valuable nonetheless, is for the Putrajaya Lake and Wetland in Malaysia.

- Akashah describes this case in detail, in particular, about how the lake itself is one large technical intervention carried out within the context of urban development.