Chapter 2: Biophysical Characteristics of Lakes

Key Questions

1. What is a lake?

2. What is a lake basin?

3. What is the scope of lake management?

What is a lake?

- Some “key phrases” from past JICA trainees
  - Aquatic ecosystem
  - Water
  - Watershed/Landscape
  - Resources
  - Natural or artificial
  - Biodiversity
  - Wetlands
  - Role in development
  - Capacity for recovery

What is a lake?

- A working definition
  - A lake is a relatively permanent and isolated surface water body with multidirectional flow
    - Consider the terms “relatively permanent”, “isolated”, “surface”, “multidirectional flow” with reference to rivers, wetlands, groundwater and oceans.

What is a lake?

- Alternative Views
  - An alternative view, a “lake as ecosystem” view, is described in Kodarkar, which discusses the “ecosystem approach” for an Indian lake.
  - Tapas covers the much smaller but much more common type of lakes seen in Bangladesh called haors, baors, and beels. This provides an interesting contrast to the generally large lakes covered in this chapter and in most of this training material.

A Set of Three Characteristics

- What makes lakes different from other waterbodies?

- The following set of three characteristics, when taken together, are typical of lakes in contrast to other water bodies.

  - Long retention time
  - Integrating nature
  - Complex dynamics

Long Retention Time

- The lake time scale is much longer than the political time scale.
- By definition, lakes collect and hold.
  - This provides a buffer from sudden changes
  - It also prevents quick recovery

Integrating Nature

- In a lake, everybody is “upstream”
- What one person “puts in” not only gets mixed around and affects others, but may also return to the source.
  - This is similar to the case of greenhouse gas emission and the effects of climate change.
- Contrast this with a river where most problems flow from top to bottom.

Complex Dynamics

- What goes into a lake is not necessarily what comes out!
- As a living ecosystem, lakes display “non-linear” or “complex” behavior.
- It is not always clear what is happening or *what will happen* in a lake.
  - Example of “hysteresis”
  - See Magadza for an interesting case of degradation, improvement, and degradation again.

Complex Dynamics

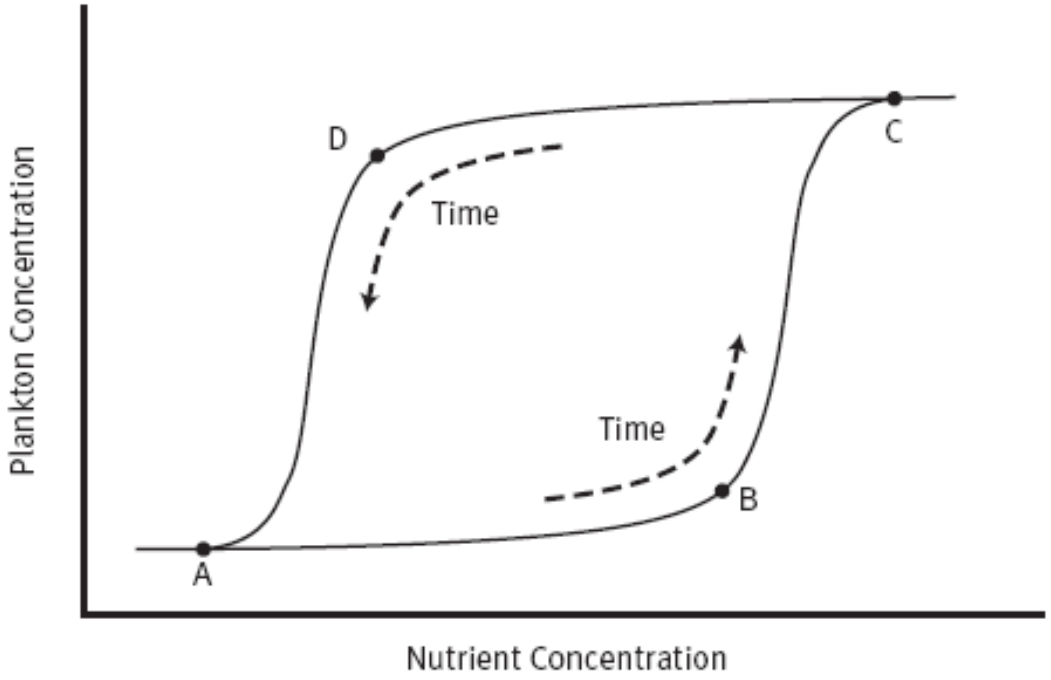


Figure 2.2 An Example of Complex Response Dynamics of a Lake.

Implications

- All three characteristics have implications for management. In short:
  - **Long retention time**: the problems last longer than typical human decision making scale
  - **Integrating nature**: everyone is downstream
  - **Complex dynamics**: there are lots of uncertainties and surprises

What is a lake basin?

- From a management perspective, it is pointless to talk about lakes but not their drainage basins.
- The issue is not lake management…
- The issue is **lake basin management**!
- Therefore, the type of basin is important.

Basin Types

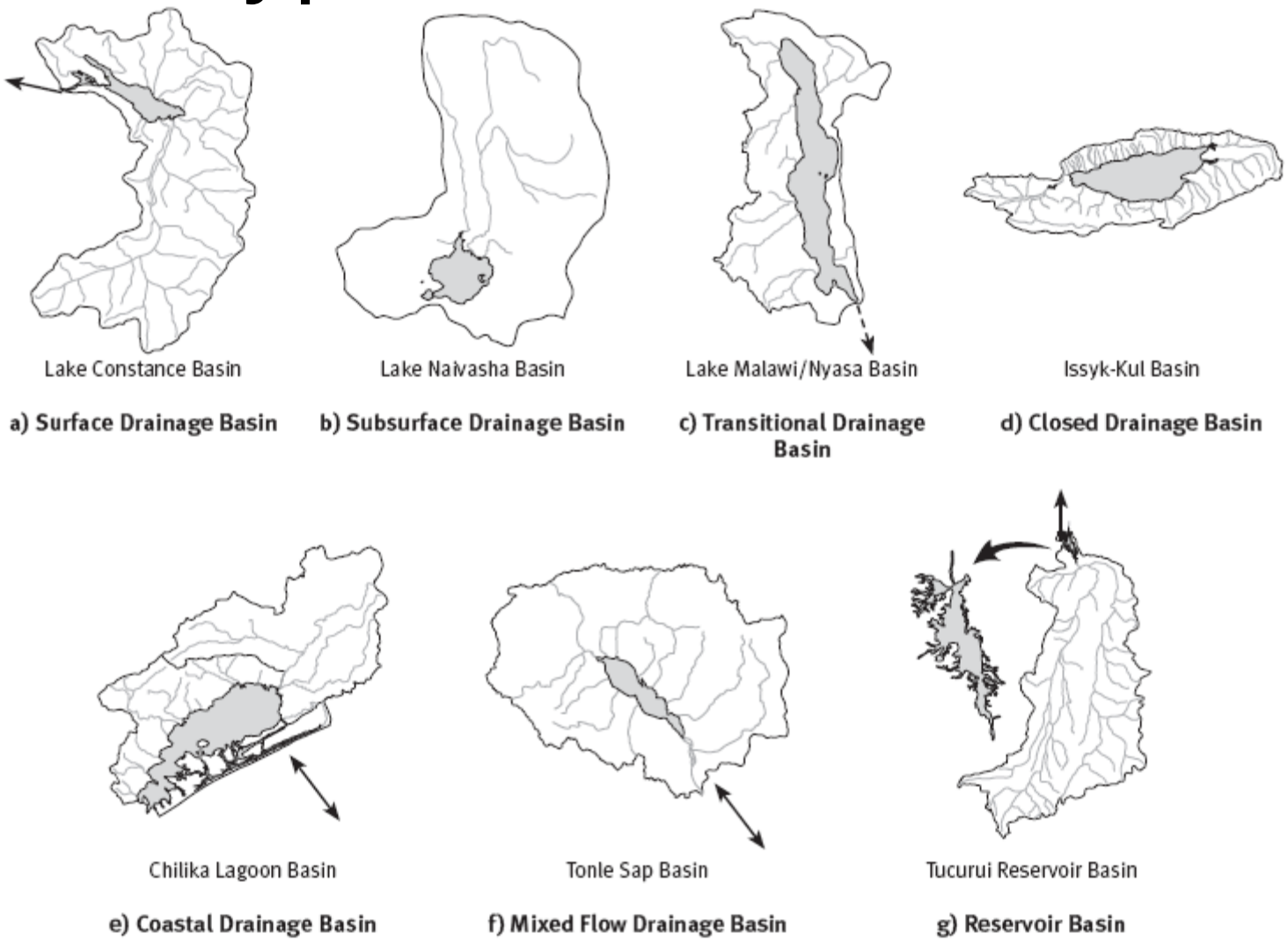


Figure 2.1 The Variety of Lake Basin Types.

Basin Type: Surface Drainage Basin

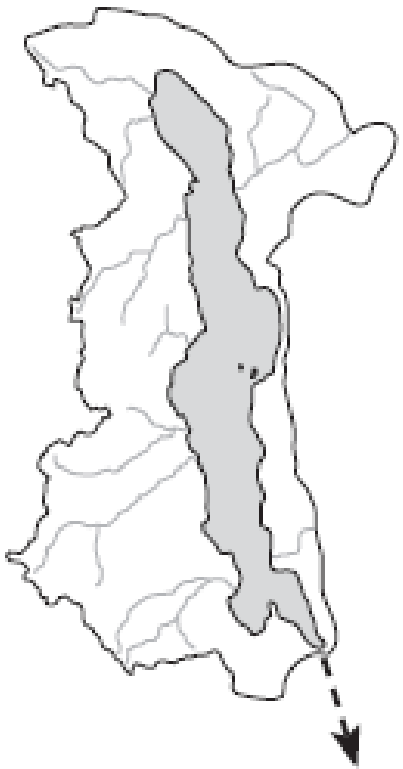
a) Surface Drainage Basin

- This type of lake has significant surface water outlet(s).
- The lake water is fresh.

Basin Type: Sub-surface Drainage Basin

- This type of basin has significant subsurface inlet/outlet(s).
- Freshwater inflow and outflow from groundwater can keep the lake water fresh.

Basin Type: Transitional Drainage Basin

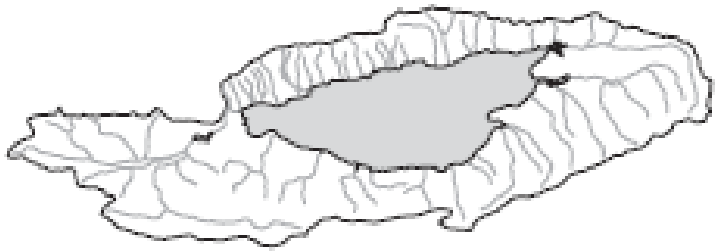


Lake Malawi/Nyasa Basin

c) Transitional Drainage Basin

- This type of lake has significant evaporation.
- Typically found in lakes in low latitudes (dry/semidry areas).
- The salinity and water levels can fluctuate significantly.

Basin Type: Closed Drainage Basin



Issyk-Kul Basin

d) Closed Drainage Basin

- In this type of lake, water leaves mainly through evaporation.
- Therefore, these lakes tend to be saline.

Basin Type: Coastal Drainage Basin

Chilika Lagoon Basin

e) Coastal Drainage Basin

- This type of basin has flows to and from ocean.
- The lake ecosystem is attuned to this natural fluctuation in salinity.

Basin Type: Mixed Flow Drainage Basin

Tonle Sap Basin

f) Mixed Flow Drainage Basin

- This type of basin has inflowing rivers that reverse direction depending on the season.
- This is a rare case, best exemplified by Tonle Sap in Cambodia.

Basin Type: Reservoir Basin

Tucurui Reservoir Basin

g) Reservoir Basin

- A drainage basin with a dammed river.
- Reservoir basins tend to have a very high basin to lake area ratio.

Some Other Features of Lakes

In addition to basin type, the following features are also important for understanding a lake

1. Origin/age
2. Climate
3. Salinity
4. Mixing/stratification

Origin/Age

- Coastal lakes
  - Example: Chilika Lagoon
  - Relatively new: approximately 6,000 years old
  - Naturally susceptible to siltation (coastal lagoons)
- Glacial lakes
  - Formed as a result of glacial retreat
  - Example: Constance, Great Lakes
  - 75% of world lakes fall under this type
- Tectonic Lakes
  - Example: Lake Baikal (over 20 million years old)
  - Tend to be deep and old: longer retention time, likely to contain more endemic species

Climate

- 6 major climate types
  - Polar, cooler humid, warmer humid, dry, tropical humid, and highland
- Degree of precipitation and evaporation changes
- Climate affects seasonality of flows into a lake, thermal properties of the lake, and biological processes in the lake

Salinity

- Lakes with a concentration of total ions >3g/L are considered saline lakes
- Aral sea
  - Upstream diversion caused increase in salinity, resulted in the loss of biodiversity
  - See Aladin1 for a complete overview of this interesting case.
- Nakuru
  - Low rainfall caused a shift in aquatic community; phytoplankton-rich community to zooplankton-rich community

Mixing/Stratification

- Heat/Energy enter from the surface. Warm water is lighter than cool water: hence, under certain conditions, lakes can be “stratified”.
- That is, the top water can not mix with the bottom water.
- Lake Malawi/Nyasa and Tanganyika are permanently stratified because of their great depths and the different densities of upper and lower water layers.

Final Thoughts

- There are a lot of lakes in the world: over 5 million bigger than 1 ha.
- Many of them are precious resources for surrounding people.
- The characteristics of lakes make them both:
  - Valuable
  - Vunerable