Understanding Environmental Flow in the River Ecosystem

Outline of the presentation

- Introduction
- Importance of E-flow
- Methodology
- Factors affecting river flow
- Case study
- Conclusion
- References

Introduction

- About 71% of the Earth's surface is covered with water, and the oceans hold about 96.5% of all Earth's water.
- The amount of freshwater on earth is less than 2.5% but it supports large proportion of ecosystem and biodiversity.
- Rivers account for only a small amount of surface freshwater(0.46%), this is where humans get a large portion of their water from.
- Rivers are important for many reasons. One of the most important things they do is carry large quantities of water from the land to the ocean.
- River flow is the fundamental process determining the size, shape, structure, and dynamics of riverine ecosystems.

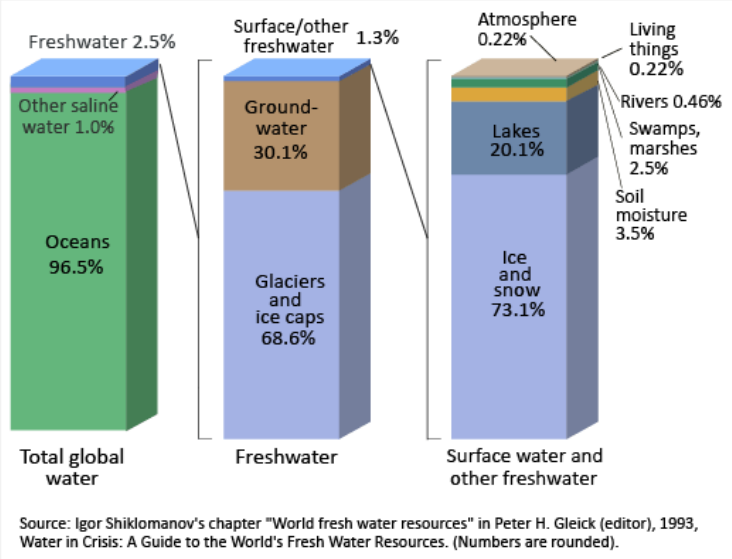

Fig.1 Distribution of water on Earth

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Table 1: Factors determining river flow

Meteorological factors	Geophysical factors
- Type of precipitation	- Elevation, slope
- Rainfall amount, intensity and duration	- Topography, Drainage area
- Distribution	- Basin shape

- According to Central Water Commission(CWC), there are approximately 5264 dams in India for hydropower generation, irrigation purpose.
- These anthropogenic interventions have adverse effect on the ecological health.
- Therefore, it is critical to balance the requirements of various human uses and ecological needs in a river system from a basin wide perspective.
- The concept of E-flow is introduced as “Water for the river”

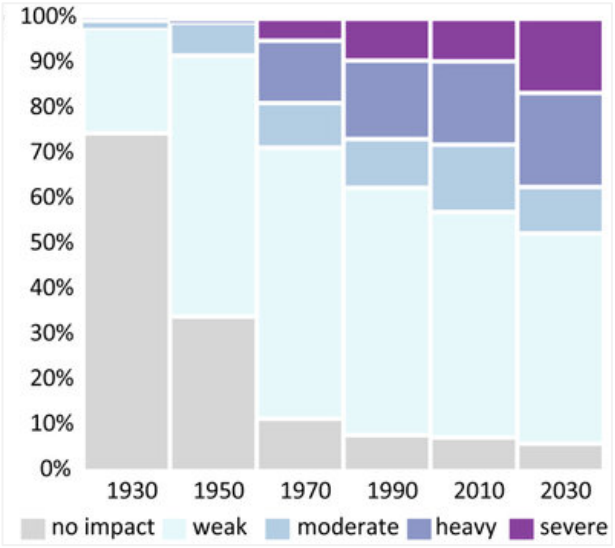


Figure 2: Proportion of global river volume impacted by flow regulation (Grill et al. 2015)

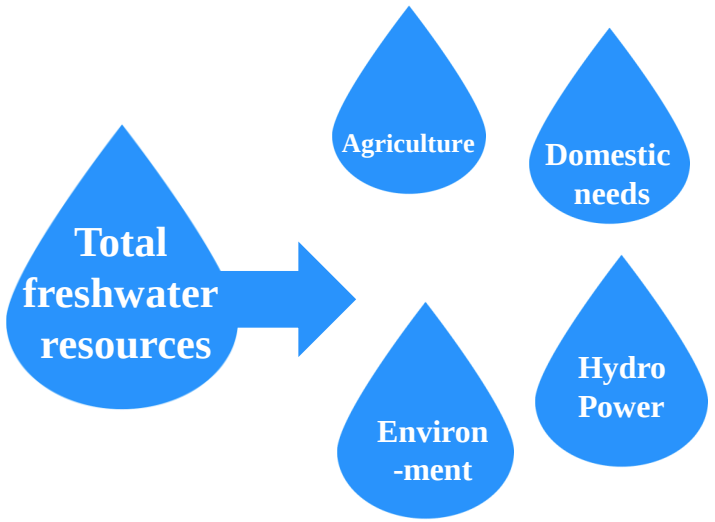
What is E-flow ?

- The concept of Environmental flow(E-flow) was introduced in 1970s as, “the minimum flow necessary to preserve an individual species, such as trout, in the river”.

- According to Brisbane declaration(2018), “E-flows are the Quantity, Quality and Duration of the water flow required to sustain the aquatic ecosystem, which in turn supports human culture, livelihood and well-being”.

- Failure to maintain such flows has led to decline in the health of many of the world’s water dependent ecosystems.

- Environmental flow is expressed as a set of flows which mimics the natural flow regime.



Importance of E-flow

Features that could be protected through E-flow:

1. Aquatic animals
2. Aquifer and groundwater
3. Climate resilience
4. Estuaries
5. Floodplains
6. Riparian vegetation
7. Recreational and cultural activities
8. Water quality

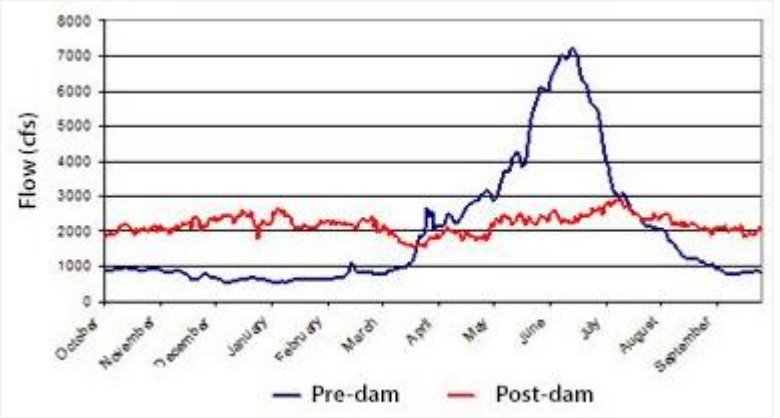


Figure 3: Flow variation in Green river before and after construction of flaming gorge reservoir

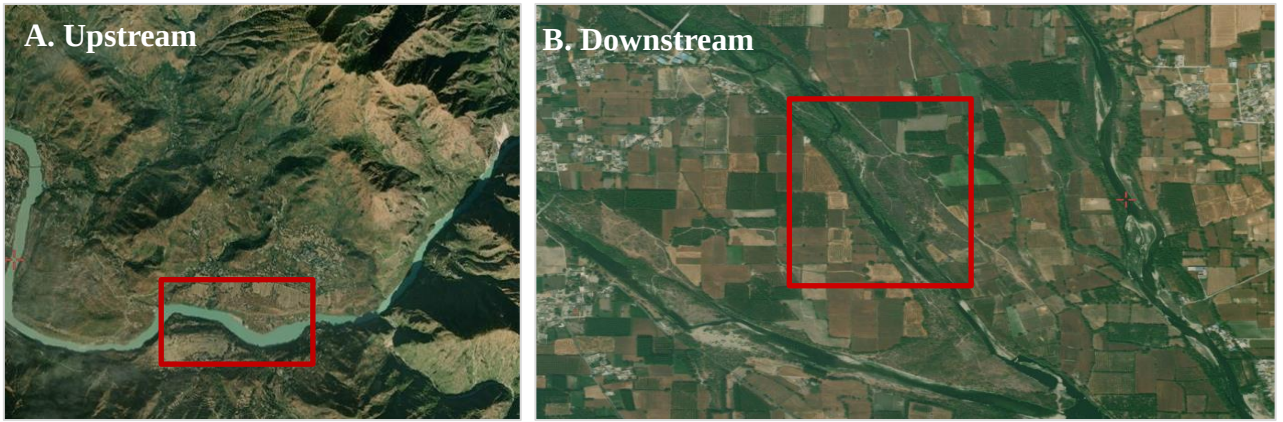


Figure 4: Effect of Pong dam on Sutlej river

Significance Of Different Flows

i. Baseflow

- Baseflow is the amount of water added by the Groundwater to the river.
- Grazing of animals on the fertile flood plain.
- Water quality is severely degraded.

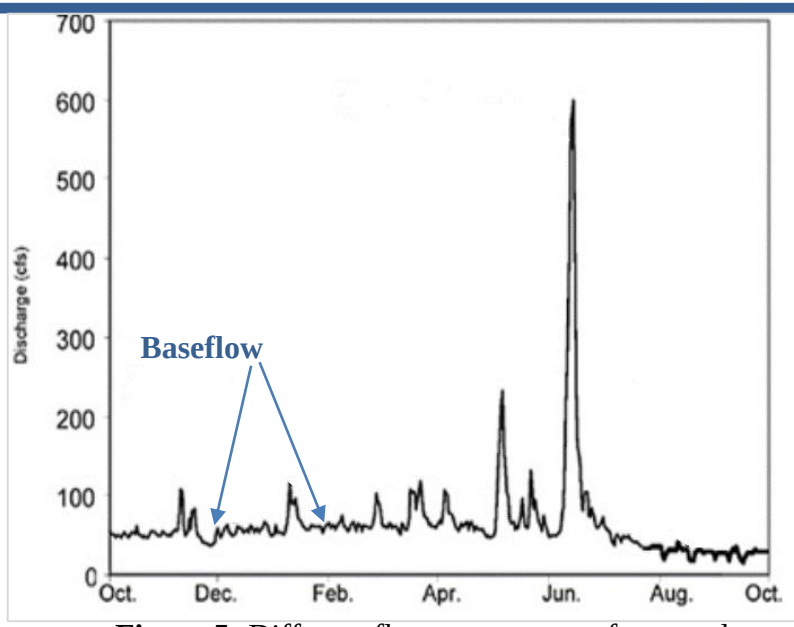


Figure 5: Different flow component of natural river flows

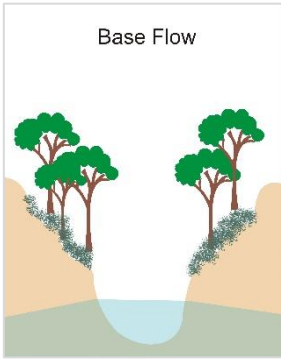


Figure 6: Cross section of river channel depicting different river flows

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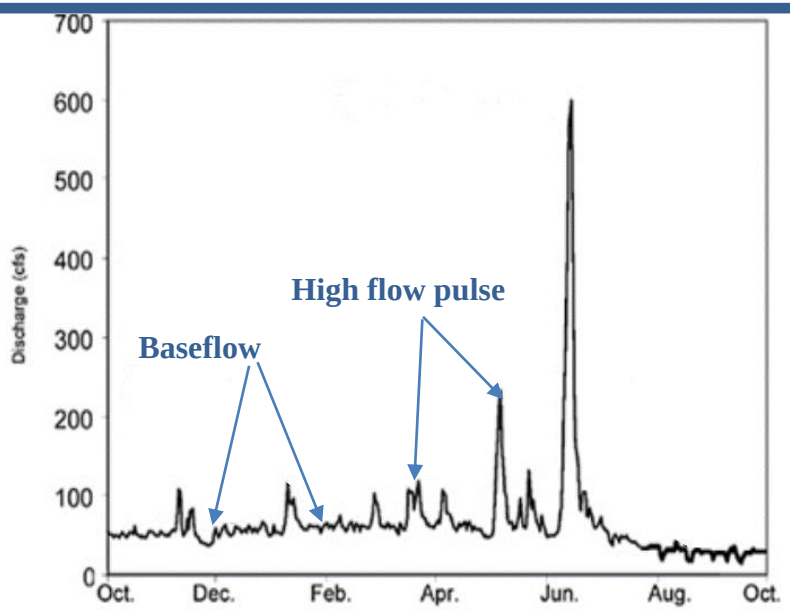
ii. High flow pulse

- Lateral dispersal of species
- Flush out poor-quality water
- Cleanse the riverbed



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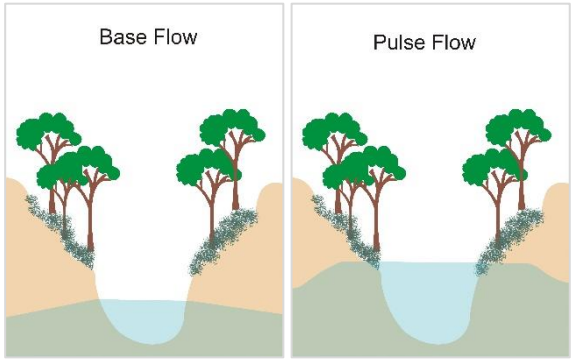

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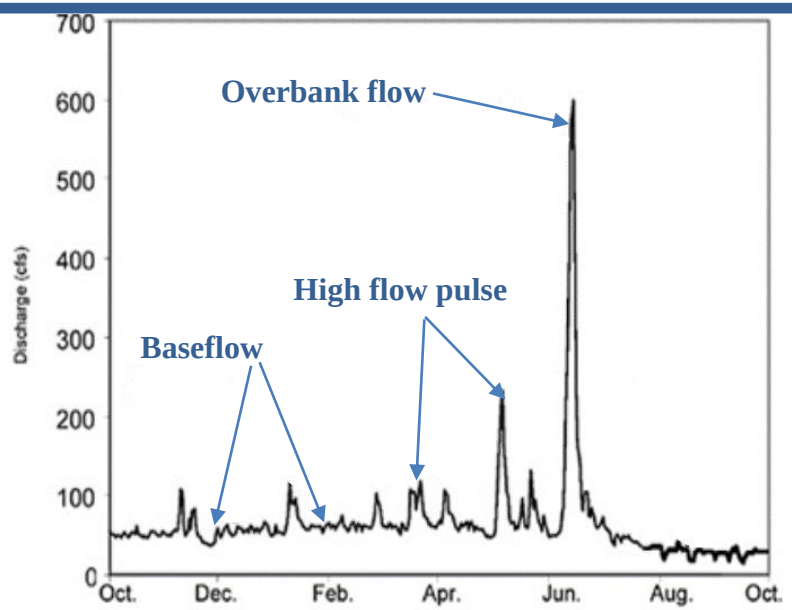
iii. Overbank flow

- High flows that exceed riverbanks
- Improves soil quality in floodplain
- Clears the river channel



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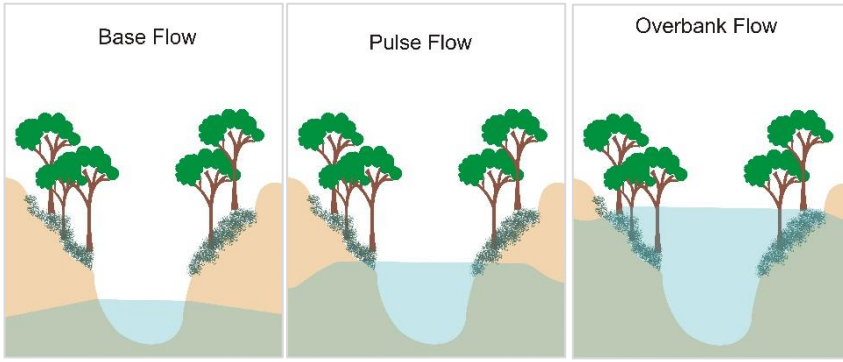

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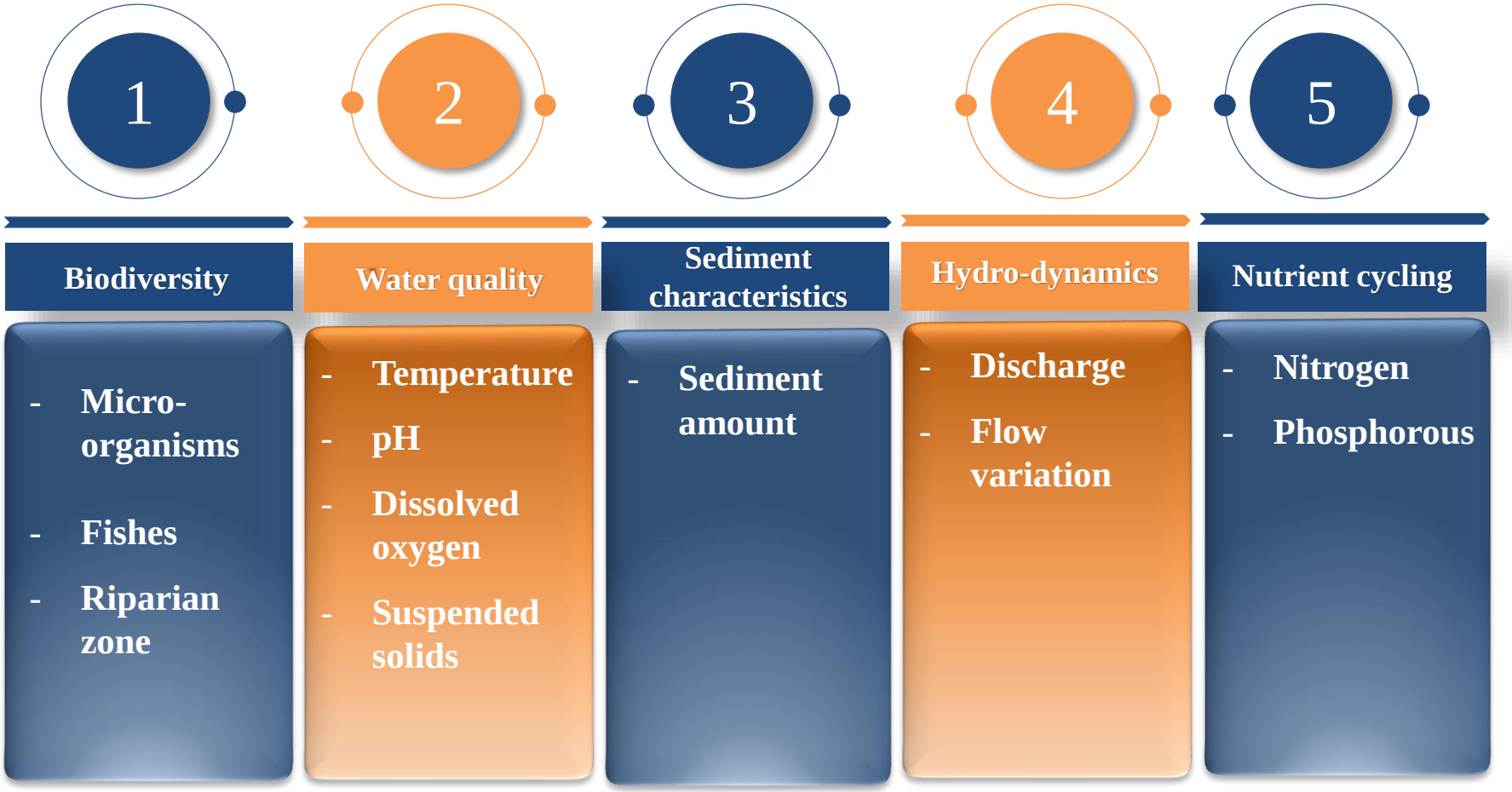
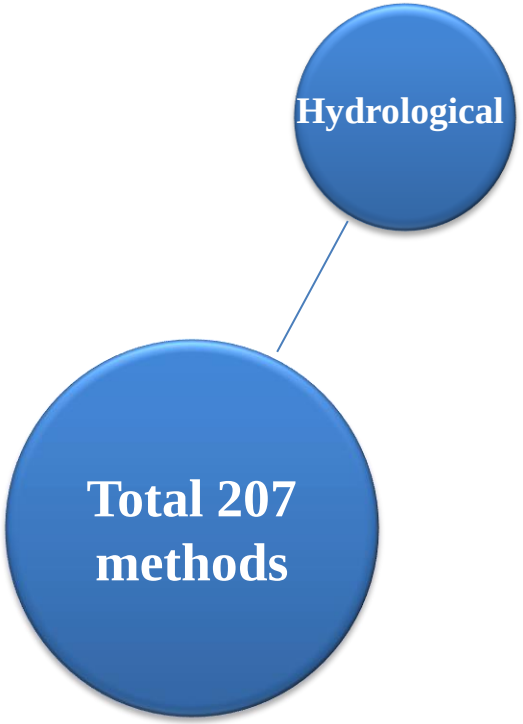
Indicators for a healthy river

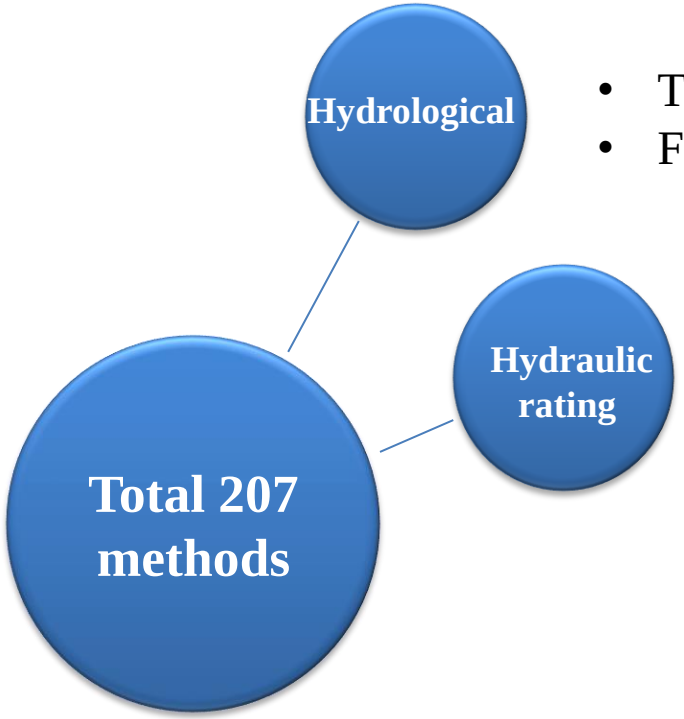


Methodology



- Tennant method
- Flow Duration Curve(FDC)

Methodology



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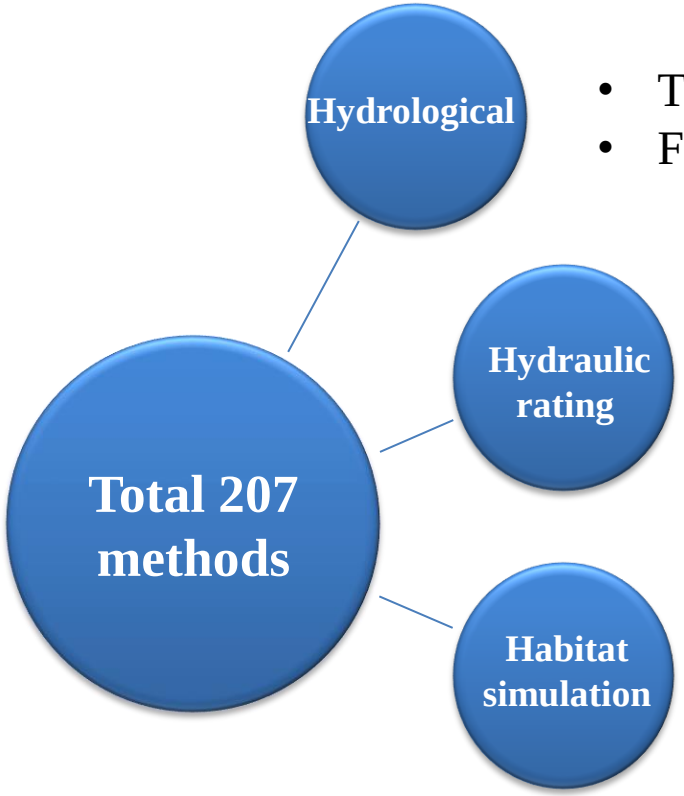
- Wetted Perimeter Method

Methodology



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- Wetted Perimeter Method

- Physical Habitat Simulation Model(PHABSIM)

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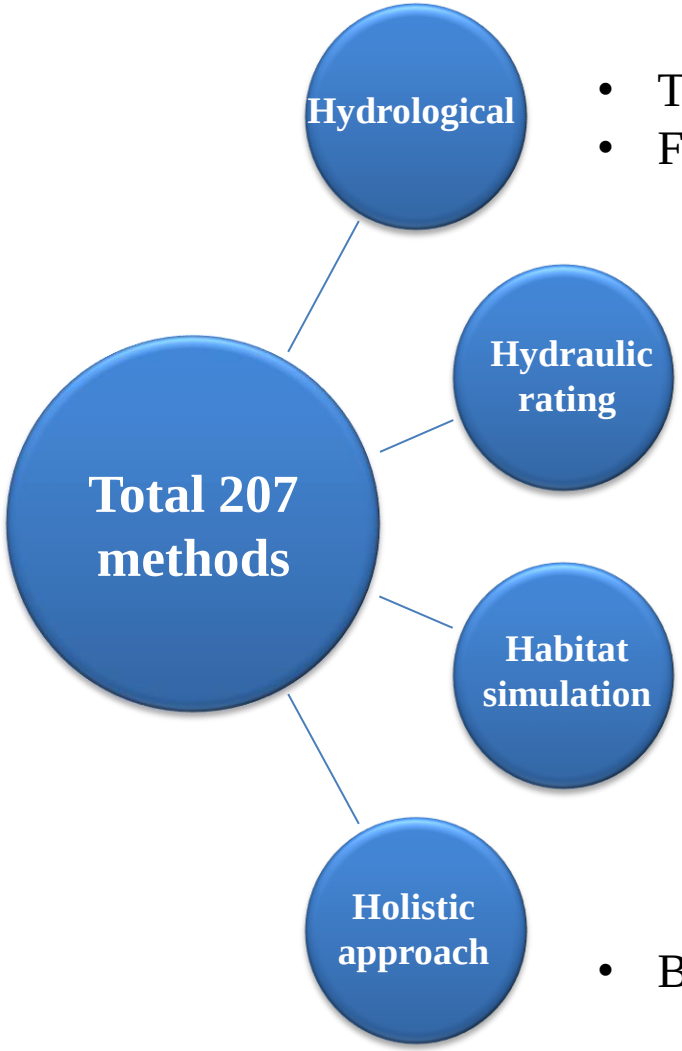


- Tennant method
- Flow Duration Curve(FDC)

- Wetted Perimeter Method

- Physical Habitat Simulation Model(PHABSIM)

- Building Block Methodology(BBM)

1. Hydrological methods

These methods are based on historical streamflow data

I. Flow duration curve(FDC)

It gives the relationship between stream discharge exceeding a particular value to the percent of the time.

Applications of FDC-

-To maintain minimum river flow for target fish species and Environmental flow assessment

-For contaminant dilution

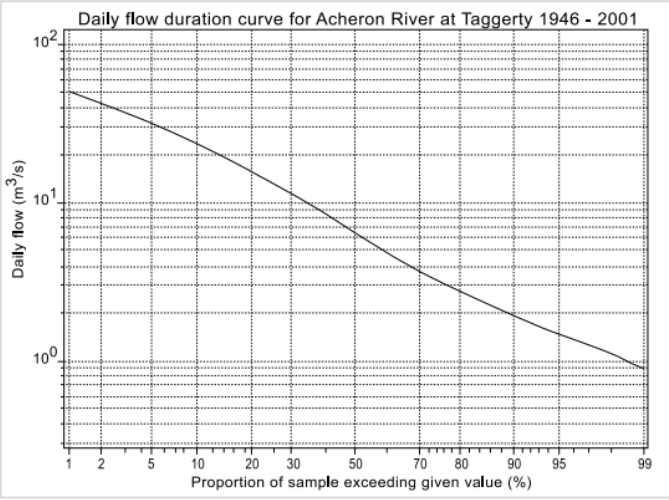


Figure 7: Flow Duration curve (Gordon et al. 2004)

Flow condition	October–March	April–September
Flushing flow	200% AAF	200% AAF
Optimum range of flow	60–100% AAF	60–100% AAF
Outstanding	40% AAF	60% AAF
Excellent	30% AAF	50% AAF
Good	20% AAF	40% AAF
Fair or degrading	10% AAF	30% AAF
Poor or minimum	10% AAF	10% AAF
Severe degradation	10% AAF to zero flow	10% AAF to zero flow

Table 2: Percentage of Average Annual Flow(AAF) for different flow condition (Tennant, 1976)

II. Tennant method

- This method was given by Tenant(1976) for stream in Montana, Wyoming and Nebraska(USA)
- Environmental flow regimes are prescribed on the basis of the mean daily discharge or the Average Annual Flow(MAF)
- This method requires stream morphology to be similar to those streams targeted. It remain difficult to apply because requirement criteria are not given.
- Thus, the output remains of low confidence.

2. Hydraulic rating methods

- Wetted Perimeter method

- It shows the relation between discharge and wetted perimeter measured at a riffle section.
- The invertebrate species varies with the wetted perimeter (Lohr, 1993 & C Heinz, 2013)
- The breakpoint is discharge below which the food production declines rapidly.
- The inconvenience of this method is that it requires river hydraulic measurements and is specific to each river section.

Wetted Perimeter = 2*Average depth + Wetted width

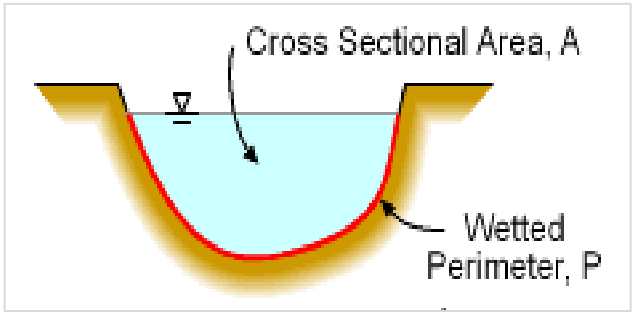


Figure 8: River cross section showing the Wetted Perimeter

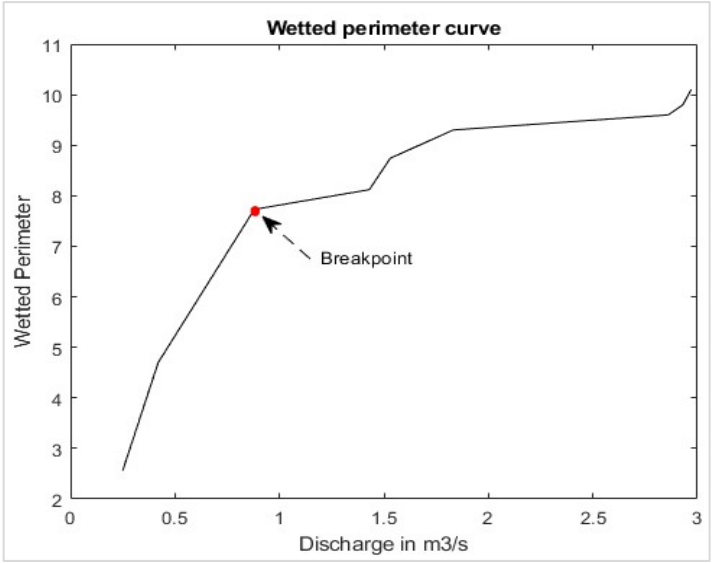


Figure 9: Wetted Perimeter curve for Binwa river, Himachal Pradesh (Prakasam et. al 2021)

3. Habitat Simulation methods

- Physical Habitat Simulation Model(PHABSIM)

- This method was given by Bovee in 1982
- PHABSIM uses habitat requirements of selected fish species.
- The objective is to establish a relationship between river discharge and, typically, the amount of wetted perimeter and/or the wetted usable area (WUA)

Table 2: Comparison of E-flow methods

Type of method	Name of method	Data type			Output confidence
		Hydrologic data	Channel sampling	Biota sampling	
Hydrological	Tennant				Low
	Flow duration curve				Low
Hydraulic rating	Wetted Perimeter				Medium
Habitat simulation	PHABSIM				High

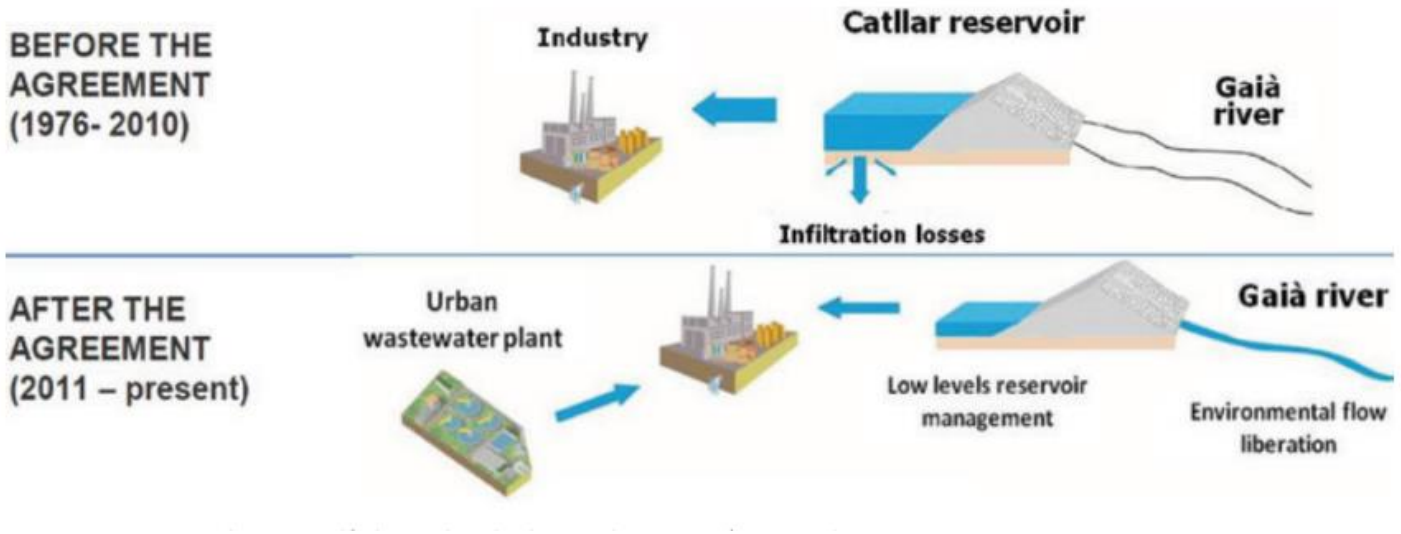
Factors affecting river flow

- **Anthropogenic activities**
- Deforestation
- Urbanization
- Dams and barrages

- **Climate change**
- Increase in flash floods
- Glacial retreat
- Sea water intrusion
- For every 1 °C increase in River water temperature, there will be about 2.3% decrease in dissolved oxygen saturation level concentrations for Indian catchments (Rajesh, 2021).

Case study

1. Gaiá river, Spain



E-flows in India

- In India, environmental flow assessments are still in a nascent stage.
- The concept of E-flow was introduced in the National Water Policy (NWP, 2012). It specifies “water is essential for sustenance of eco-system, and therefore, minimum ecological needs should be given due consideration”.
- National Green Tribunal (NGT) in 2015 has directed all States to maintain a minimum environmental flow of 15-20% of the average lean season flow in their rivers.
- Johnson et al. (2017) studied the “Ecological flow requirements for fishes of Godavari river using PHABSIM method”. The recommended E-flow is 50 m^3/s(Downstream).
- Prakasam et al. (2020) studied the “Environmental flow requirement for Binwa river in Himachal Pradesh using Wetted Perimeter method” and found E-flow value to be 0.9 m^3/s(Downstream).

Conclusion

- The amount of freshwater on earth is less than 2% but it supports lot of ecosystem and biodiversity functioning
- To maintain a healthy river ecosystem, EF must mimic the natural river pattern.
- Actual EF remain differed from estimated EF, strict policies are needed to implement the research.
- Environmental Flows are an integral part of the modern management of a River basin.
- Thus, a multidisciplinary approach is needed for the accurate analysis.

References

- Arthington, A.H., Bhaduri, A., Bunn, S.E., Jackson, S.E., Tharme, R.E., Tickner, D., Young, B., Acreman, M., Baker, N., Capon, S. and Horne, A.C., 2018. The Brisbane declaration and global action agenda on environmental flows (2018). *Frontiers in Environmental Science*, *6*, p.45.
- Bovee KD (1982) A guide to stream habitat analysis using the IFIM. US Fish and Wildlife Service Report FWSIOBS-82I 26. Fort Collins
- Gordon, N.D., McMahon, T.A., Finlayson, B.L., Gippel, C.J. and Nathan, R.J., 2004. *Stream hydrology: an introduction for ecologists*. John Wiley and Sons.
- Grill, G., Lehner, B., Lumsdon, A.E., MacDonald, G.K., Zarfl, C. and Liermann, C.R., 2015. An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales. *Environmental Research Letters*, *10*(1), p.015001.
- Heinz, C. and Woodard, M.E., 2013. Standard operating procedure for the wetted perimeter method in California. *California: California Department of Fish and Wildlife*.
- Lohr, S.C., 1993, Wetted stream channel, fish-food organisms and trout relative to the wetted perimeter inflection method: Bozeman, MT, Montana State University, Ph.D. dissertation, 246 p.
- Prakasam, C., Saravanan, R. and Kanwar, V.S., 2021. Evaluation of environmental flow requirement using wetted perimeter method and GIS application for impact assessment. *Ecological Indicators*, *121*, p.107019.
- Rajesh, M. and Rehana, S., 2022. Impact of climate change on river water temperature and dissolved oxygen: Indian riverine thermal regimes. *Scientific Reports*, *12*(1), p.9222.
- Tennant, D.L., 1976. Instream flow regimens for fish, wildlife, recreation and related environmental resources. *Fisheries*, *1*(4), pp.6-10.
- Ward J V 1989 The four-dimensional nature of lotic ecosystems J. North Am. Benthological Soc. 8 2–8

Thank You for your attention