Valuing ecosystem services linked to river flows in Lower Zambezi basin, Mozambique

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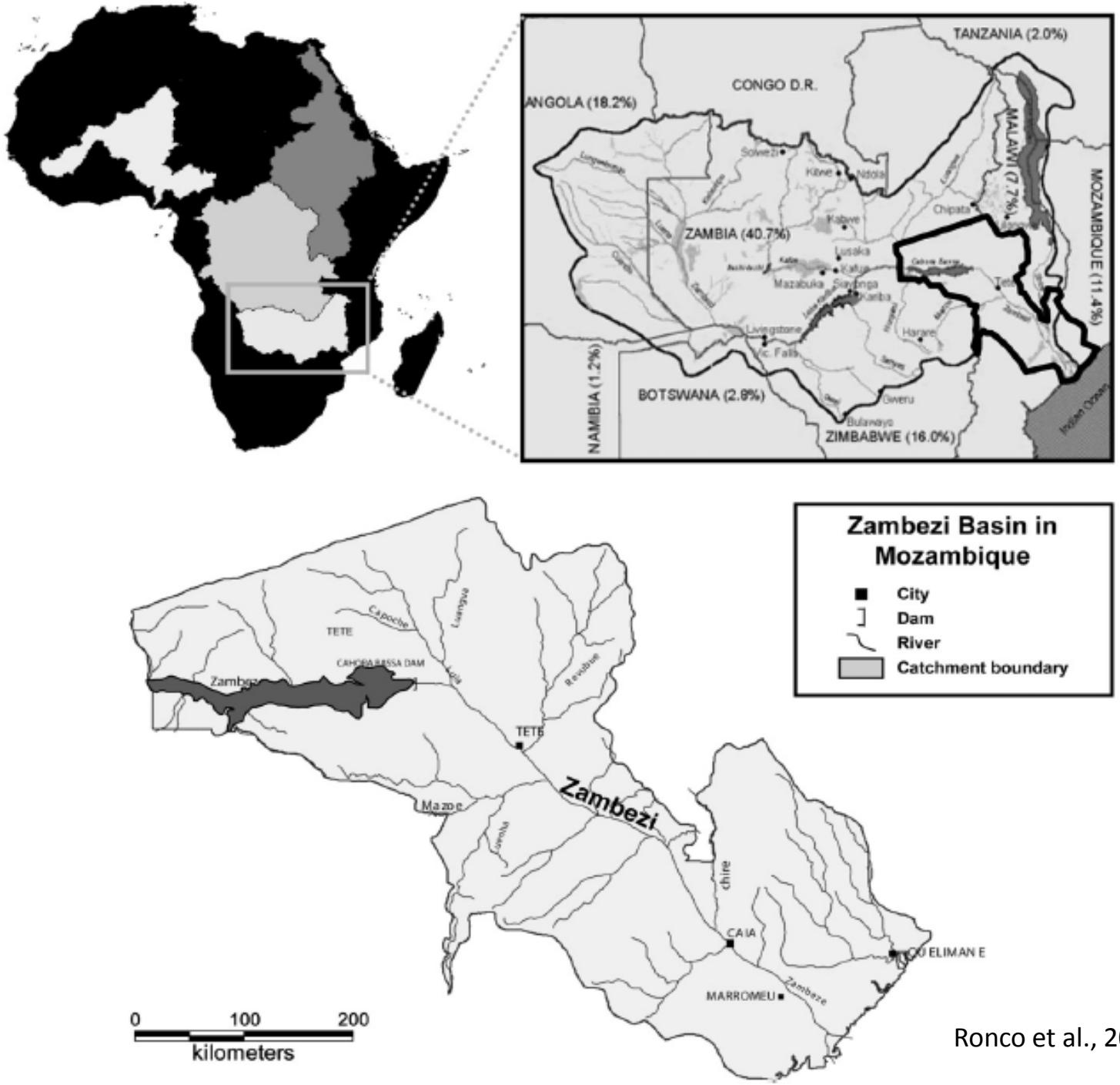
Institute for Water Education

Content

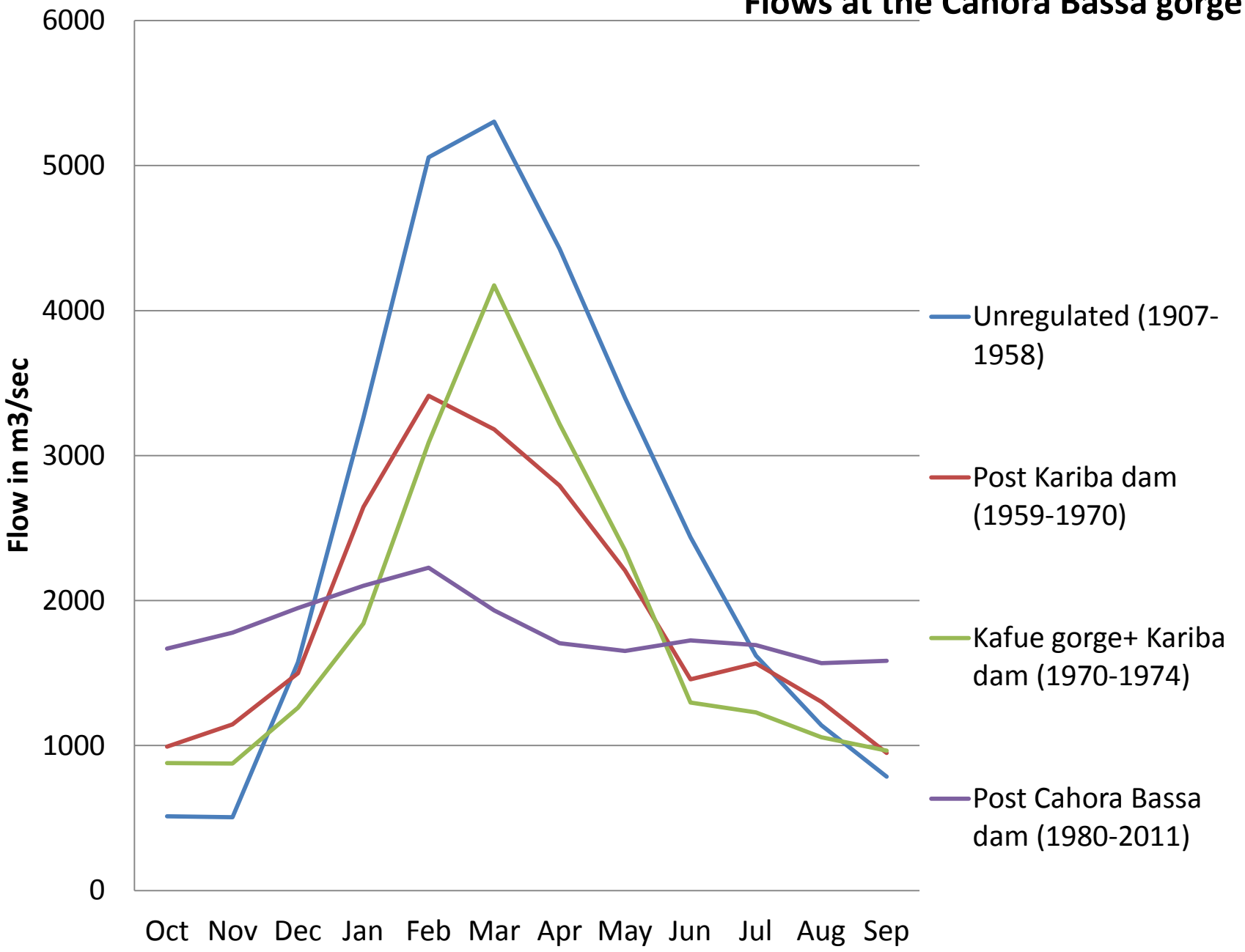
- Introduction
- Problem statement
- Research Objective & Research questions
- Methodology
- Data analysis
  - Economic value
  - Service suitability Curves
  - Service Provision Index
- Results
- Limitations and advantages
- Conclusion
- Q&A

Introduction

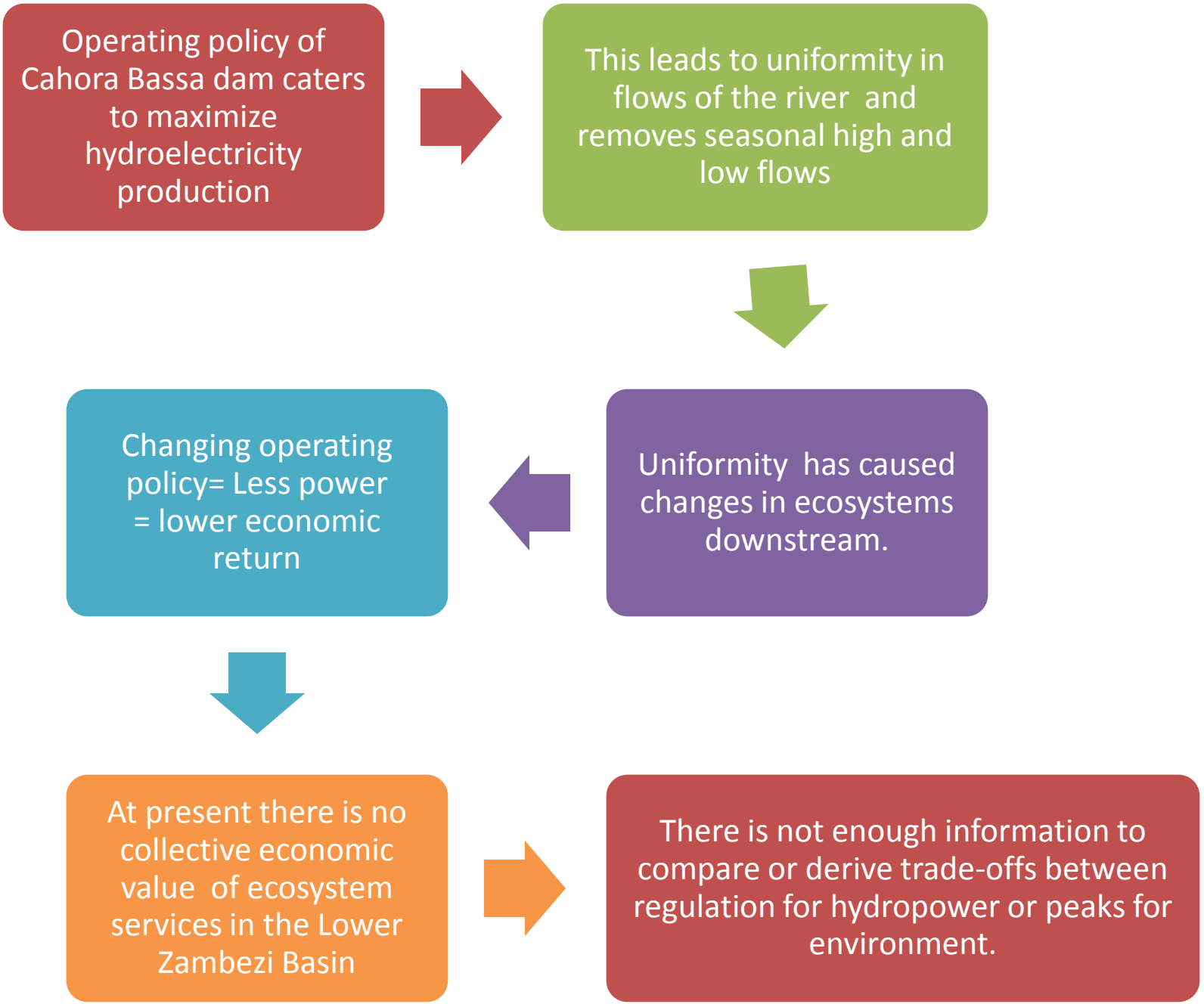


Ronco et al., 2010

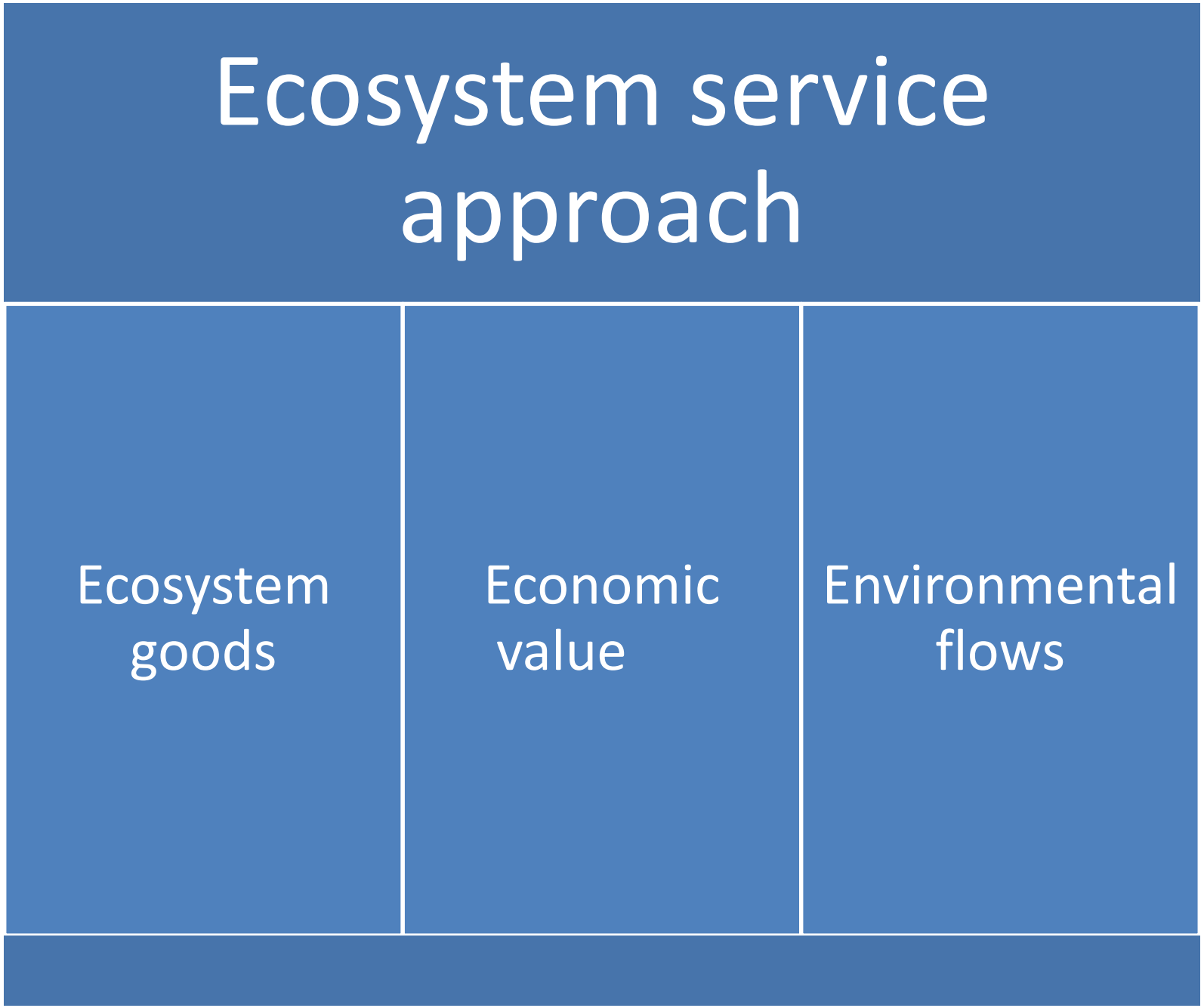
Background


Flows at the Cahora Bassa gorge
Flow in m3/sec
6000
5000
4000
3000
2000
1000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Unregulated (1907-1958)
Post Kariba dam (1959-1970)
Kafue gorge+ Kariba dam (1970-1974)
Post Cahora Bassa dam (1980-2011)

Problem Statement



Concepts


Ecosystem service approach
Ecosystem goods
Economic value
Environmental flows

Research Questions

Link flows of the Lower Zambezi river, with the ecosystem goods to estimate their economic value.

Assess the economic trade-offs between the goods that are provided by the ecosystem service in the Lower Zambezi basin as flows change:

- What are the ecosystem goods provided by the water flows downstream of Cahora Bassa dam?
- How are these goods defined and dependent on the flows of the Zambezi River?
- What are the economic values of these goods?
- What is the trade-off between the dam operating flows for environment and those for hydropower production?

Challenges and Innovation

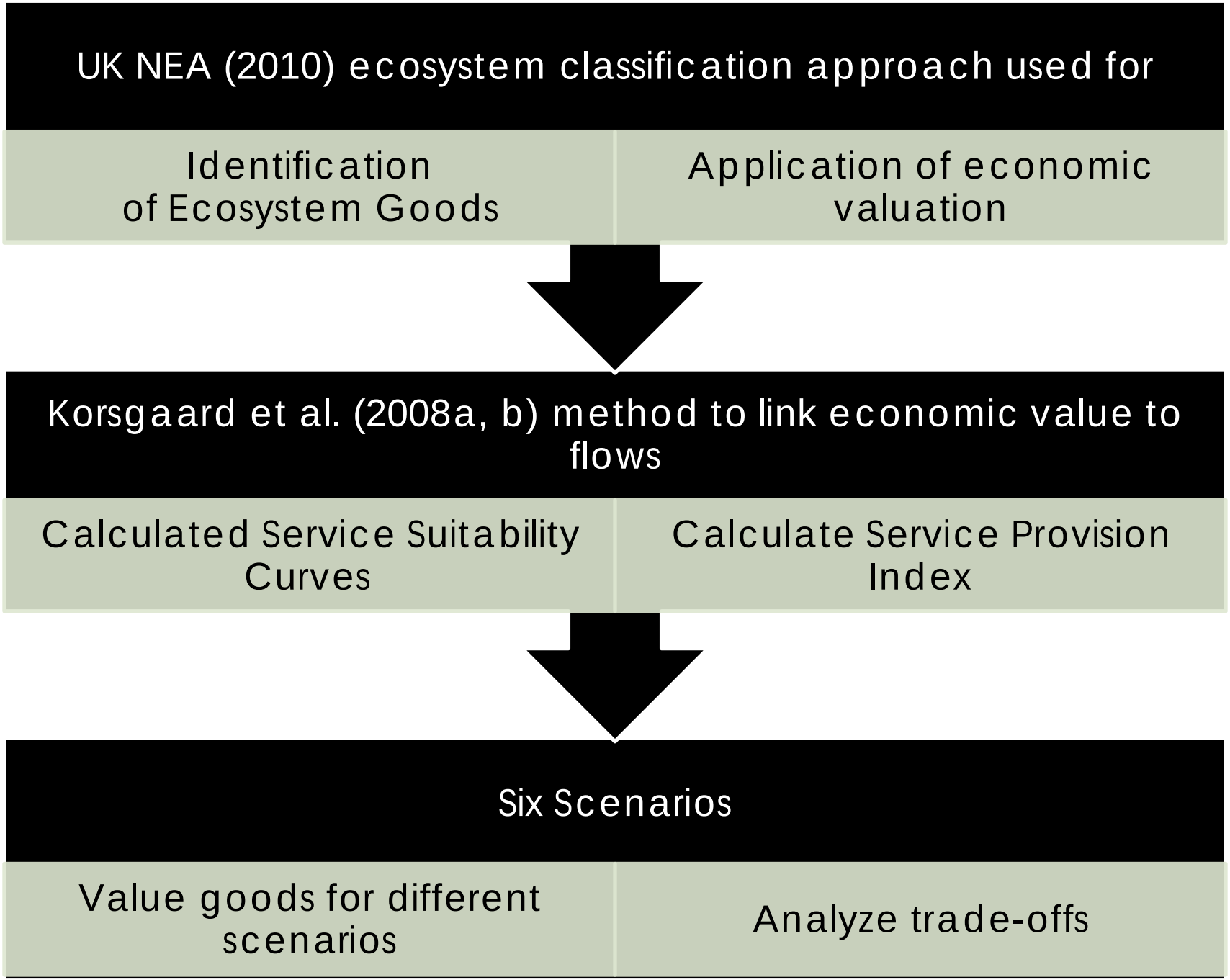
1. Not to double count ecosystem services

   → UK NEA (2010)

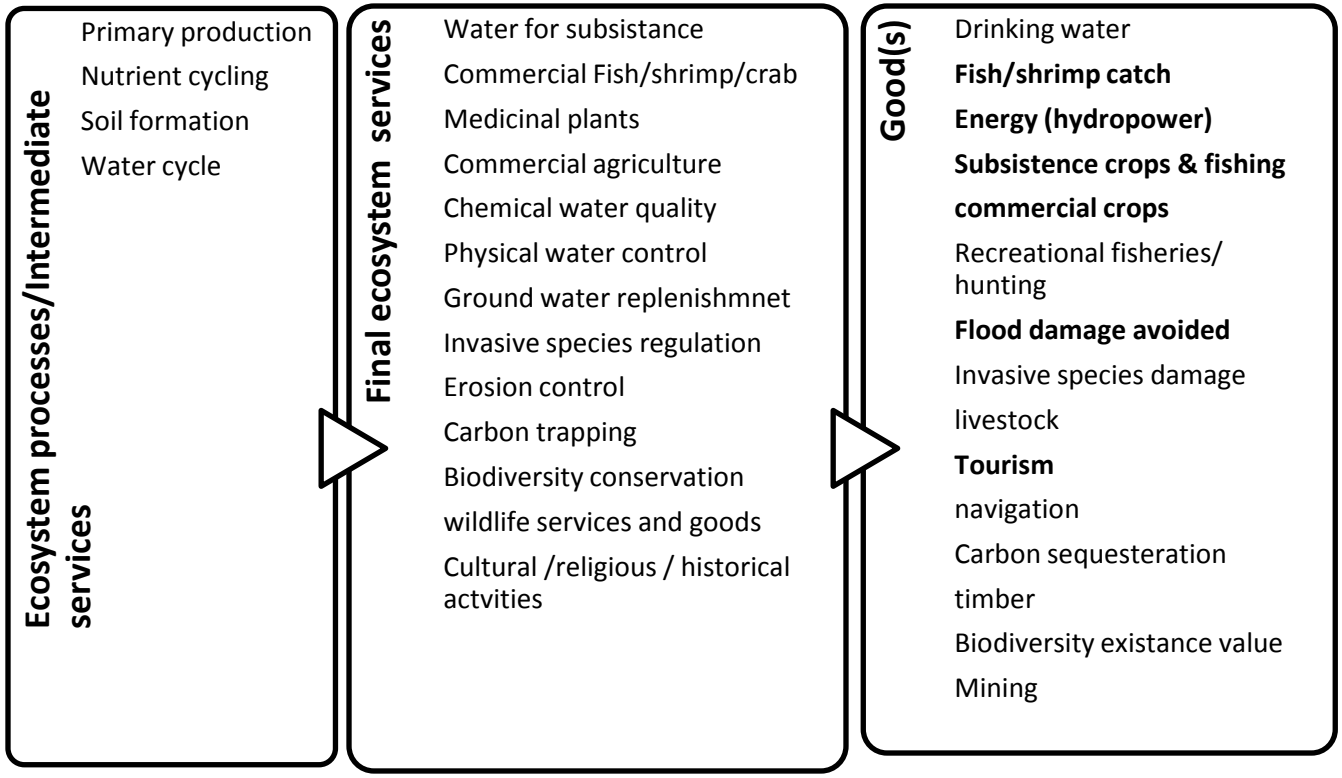
2. To assign a value to a flow *regime* rather than a specific flow or volume

   → Korsgaard (2006)

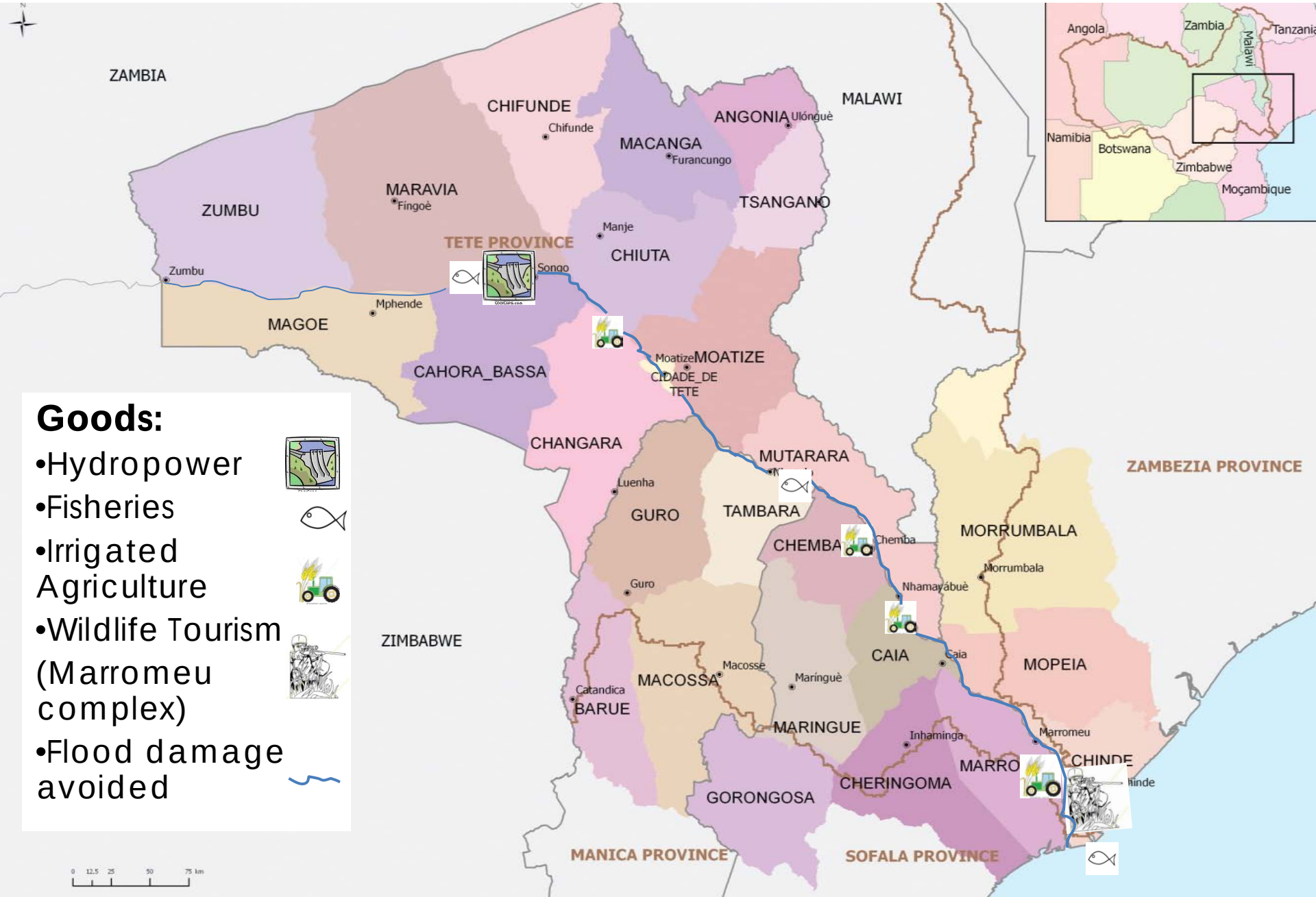
Methodology



❖ Identification of ecosystem goods



❖ Identification of ecosystem goods



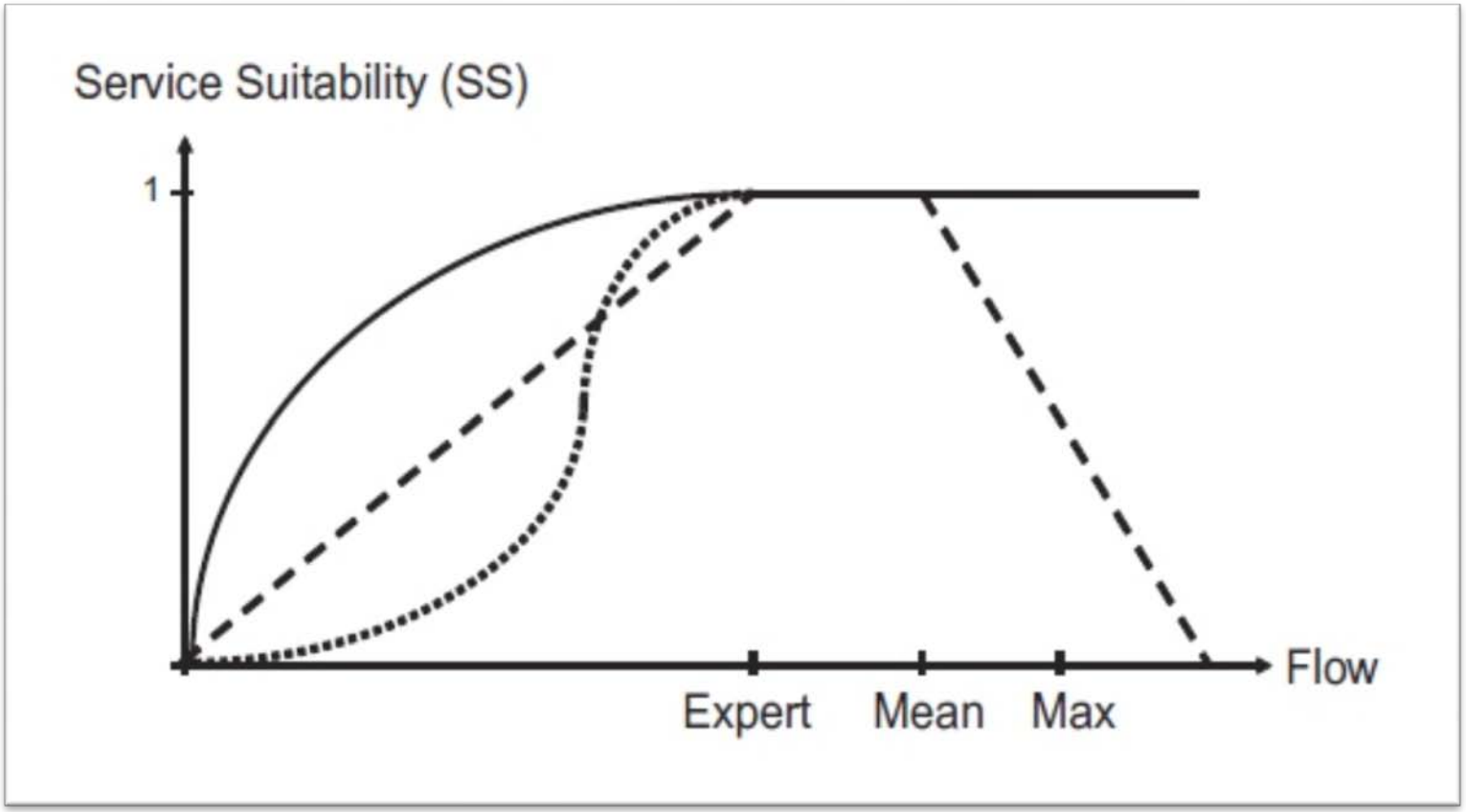
Goods:

- Hydropower
- Fisheries
- Irrigated Agriculture
- Wildlife Tourism (Marromeu complex)
- Flood damage avoided

❖ Application of economic value

Goods	Valuation method used	Information used	Sources
Hydropower	Adjusted market price	-Power generated/ yr -Sale price/yr -Costs	HCB annual reports (2008, 2010) Discussion
Fisheries	Adjusted market price	-Catch rate -Current Market price	IIP, IDPPE (2007 fisheries survey), Mafuca (2007) Source data
Irrigated agriculture	Adjusted market price	-Hectare under cultivation -Average Yield/ha -Production cost	Sena sugars, Discussions with planters
Wildlife tourism (Marromeu Reserve)	Adjusted market price	Wildlife stock Hunting permits & tourism	Guveya and Sukume (2009)
Flood damage avoided	Cost avoided	-Area flooded -Infrastructure, agricultural, housing asset damage	World Bank (2010)

❖ Service Suitability curve



(Korsgaard et al. 2008)

❖ Service Provision Index

$$SPI_j = \sum_{i=1}^{n} w_i SS_i(q)$$

$$= \frac{\left(w_{jan}\left(\frac{1}{Q_{mean,jan}} \times q_{jan}\right) + w_{feb}\left(\frac{1}{Q_{mean,feb}} \times q_{feb}\right) + \ldots + w_{dec}\left(\frac{1}{Q_{mean,dec}} \times q_{dec}\right)\right)}{12}$$

where:

i = period identification

$SS_i(q) = \left(\frac{1}{Q_{mean,jan}} \times q_{jan}\right)$ Service Suitability of period i;

q = flow available for a period (m^3/s);

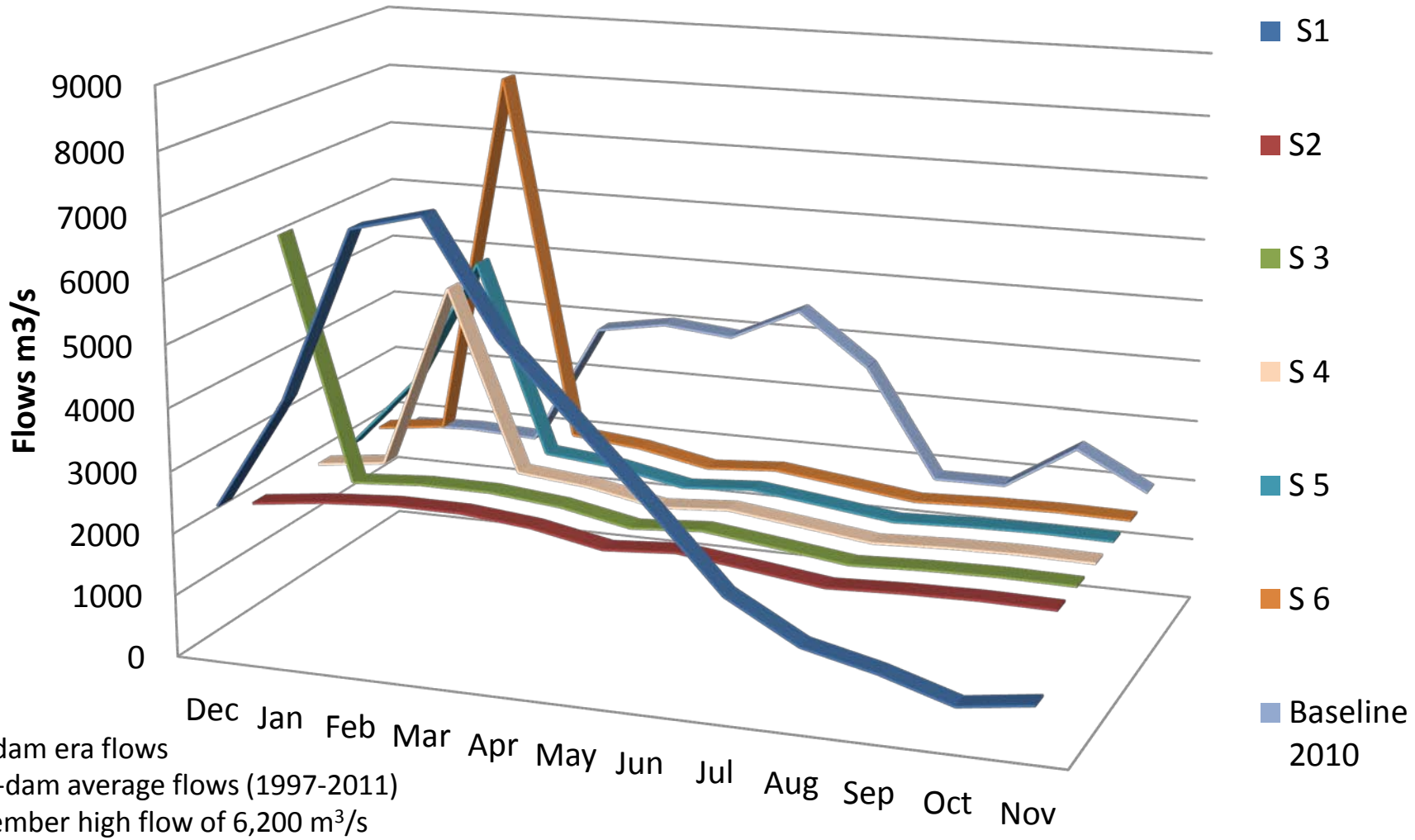
j = service/good identified;

n = total number of periods;

W_i = weightage of period i subject to the constraint $\sum_{i=1}^{n} w_i = 1$

The final economic value is $Value_{fish} = SPI_{Fish} \times \frac{net\ value_i}{SPI_i}$

❖ Scenarios



S1 = Pre-dam era flows
S2 = post-dam average flows (1997-2011)
S3 = December high flow of 6,200 m^3/s
S4 = January high flow 5,250 m^3/s
S5 = Jan and Feb high flows of 3,300 & 5,400 m^3/s
S6 = High flow in February of 8,250 m^3/s

Assumptions

- The calculated values are temporally limited to the same year.
- Spatially, the benefits are calculated for only the lower Zambezi basin.
- The valuation is purely financial and does not take into account existence, option or bequest values.
- Future market dynamics are not taken into consideration in scenario calculations.

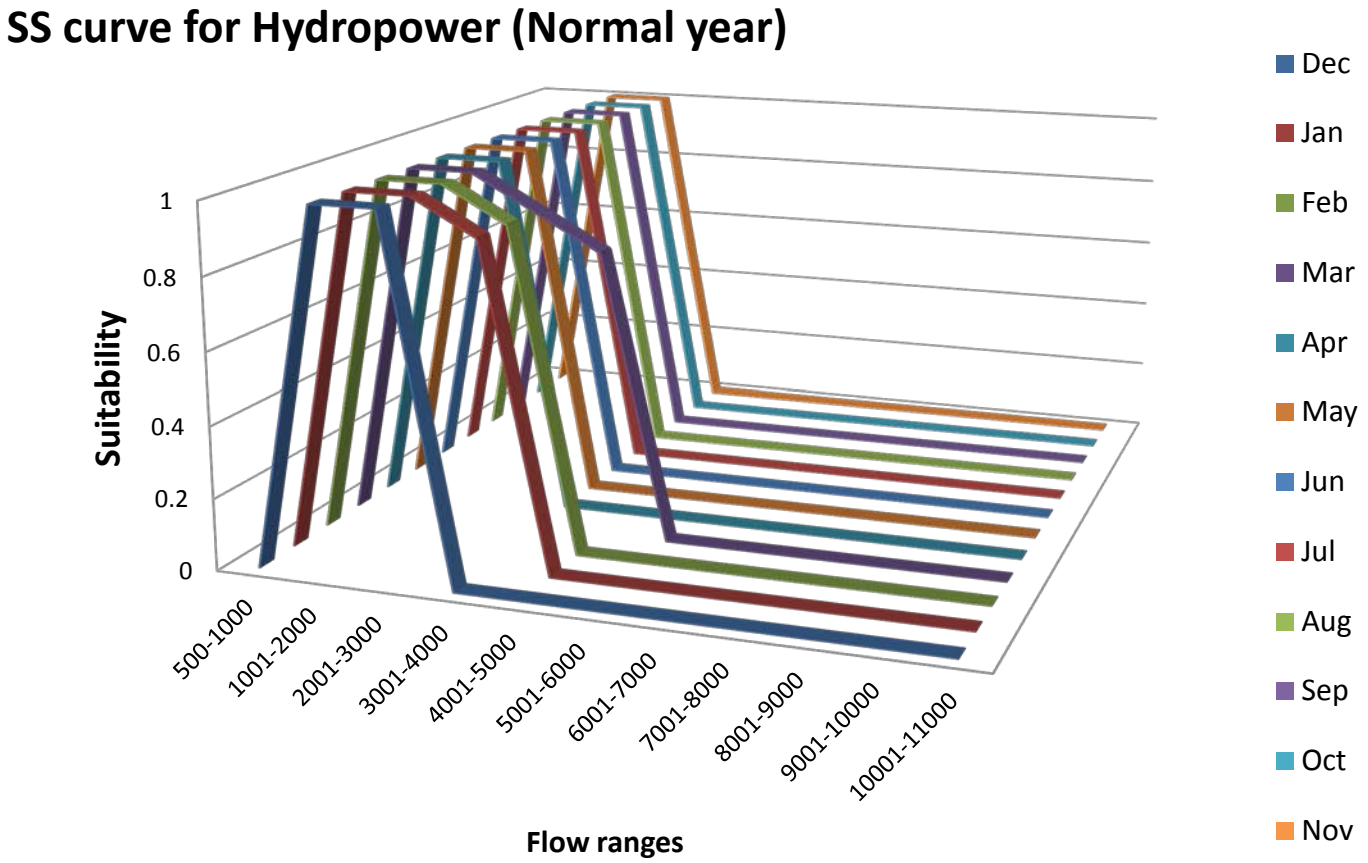
Data analysis

Actual Economic Value for year 2010

Good	Net value (million USD)	% of total	Production per good	Average values /unit
Hydropower	154	52%	14,662 GWh	11 USD/MWh
Irrigated agriculture	53	18%	10,850 ha	4,890 USD/ha
Fisheries (Lower Zambezi Basin)	33	11%	23,339 tons	1,403 USD/ton
Fisheries (Cahora Bassa lake)	47	16%	24,017 tons	1,941 USD/ton
Wildlife tourism (Marromeu delta)	4.5	2%	11,000 km^2	6,774 USD/ km^2
Flood damage avoidance	4.5	2%	-	-
Total value	**296**			

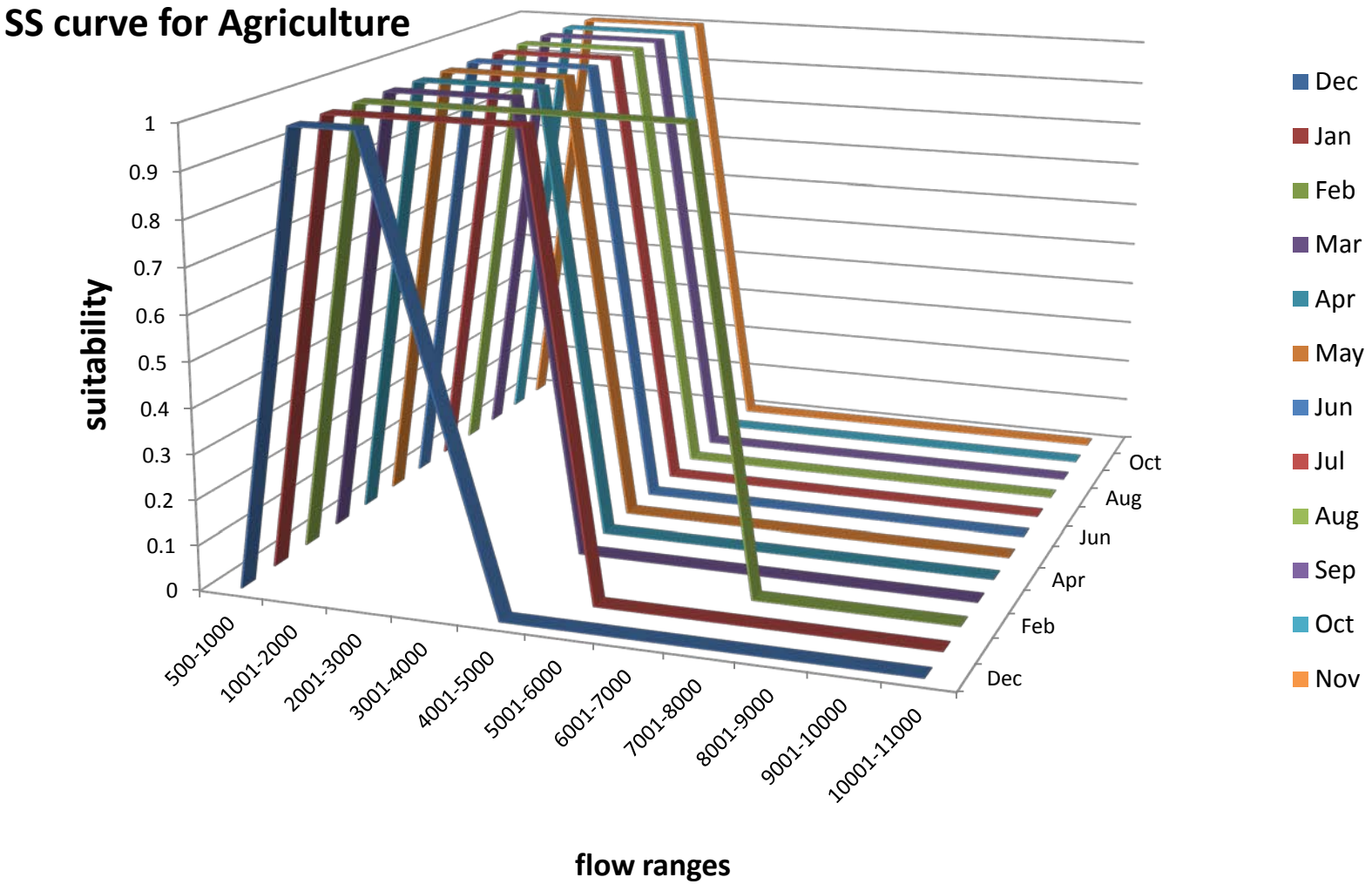
Data analysis

Service Suitability Curves



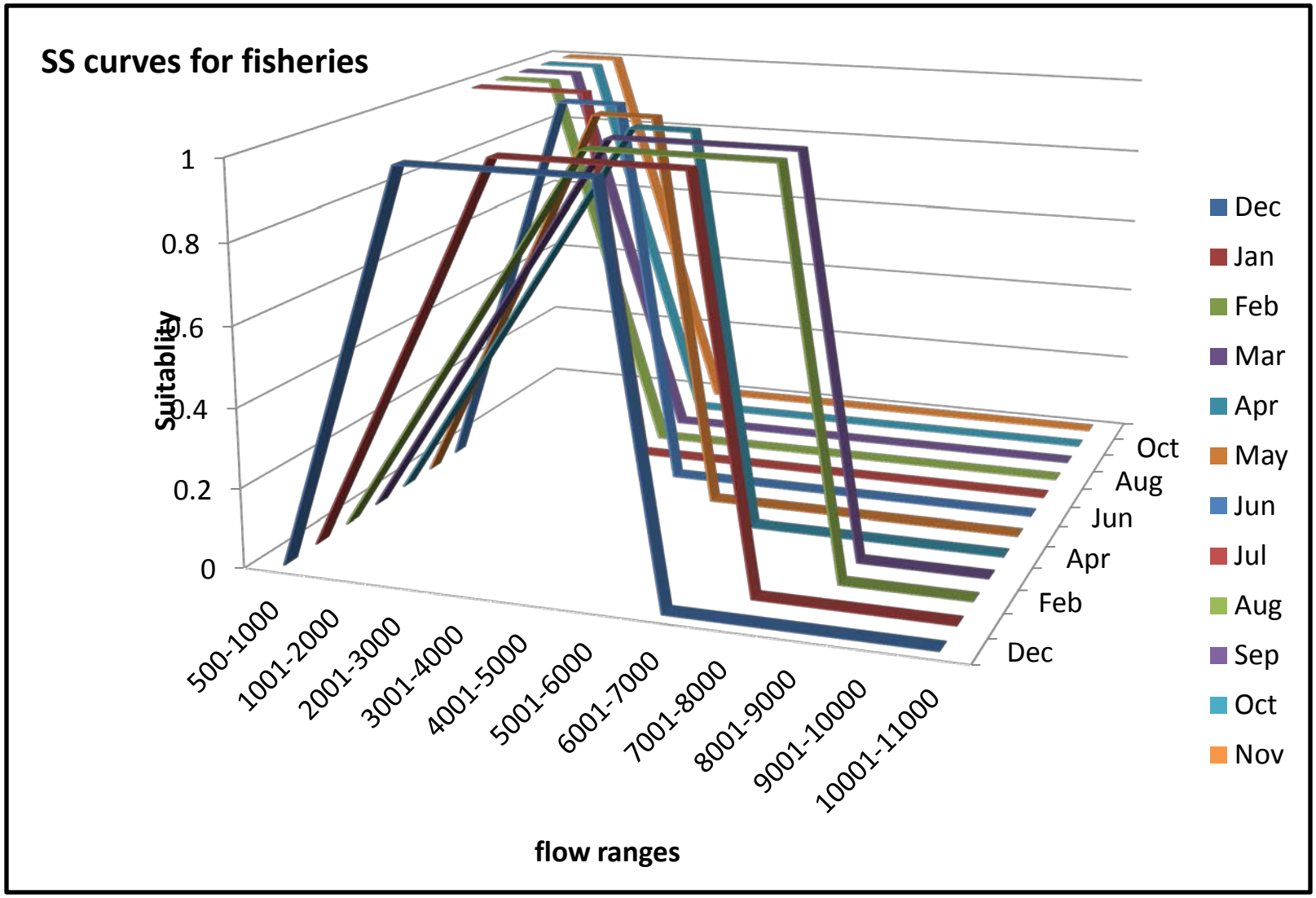
Data analysis

Service Suitability Curves



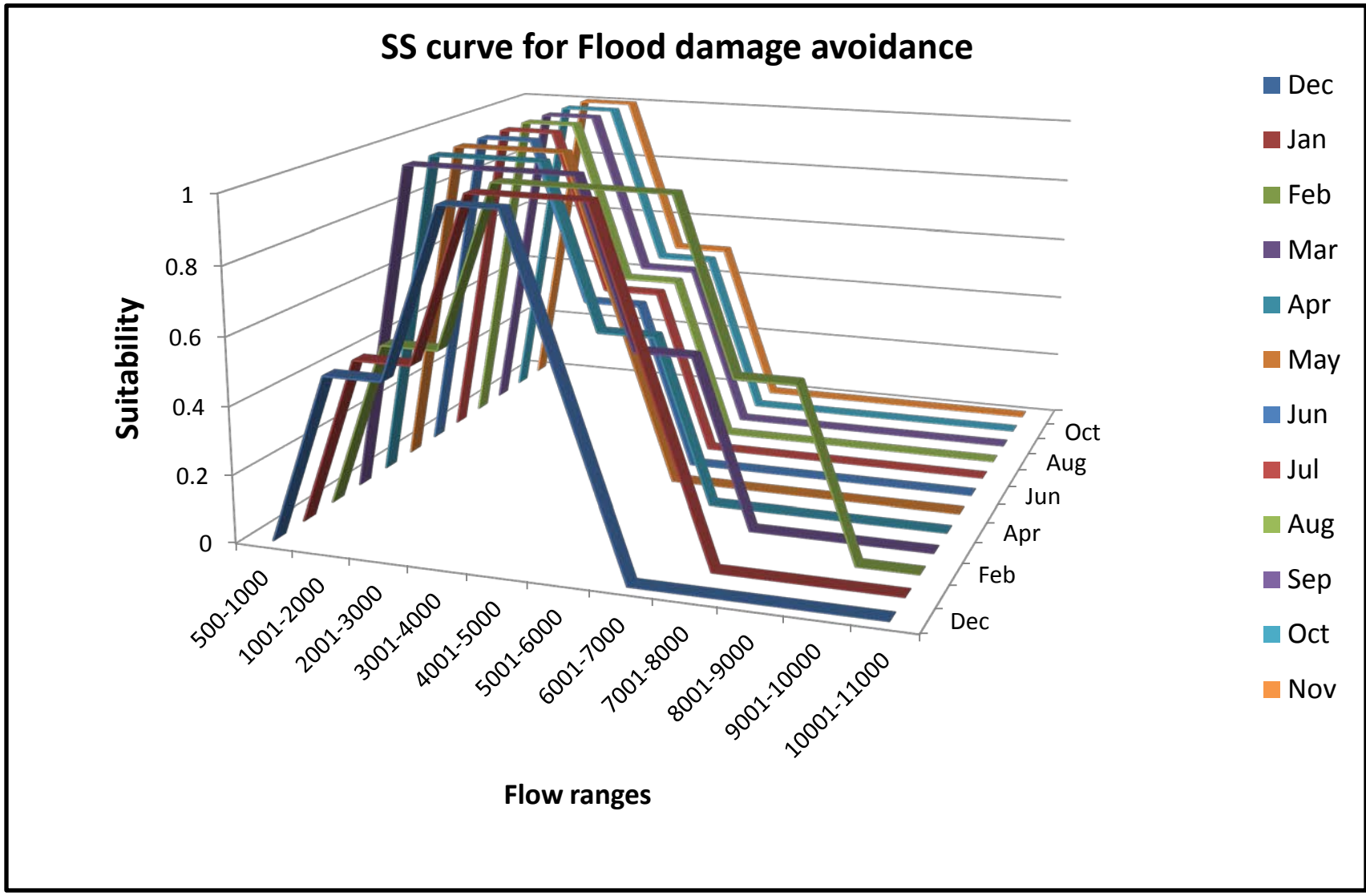
Data analysis

Service Suitability Curves



Data analysis

Service Suitability Curves



Results

Service Provision Index for the year 2010

- Hydropower: 1.0
- Fisheries: 0.38
- Irrigated agriculture: 0.77
- Flood damage avoided: 0.62
- Wildlife tourism: 0.40

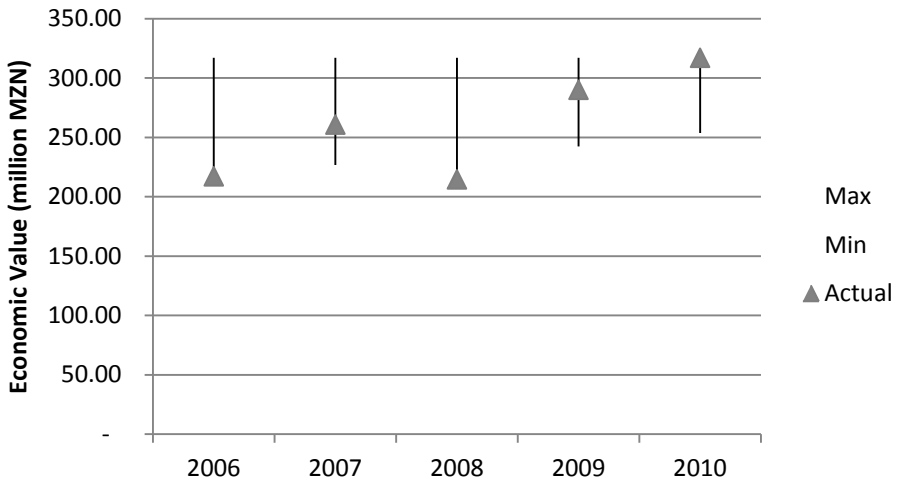
The current flow regime maximises hydropower generation only

Results

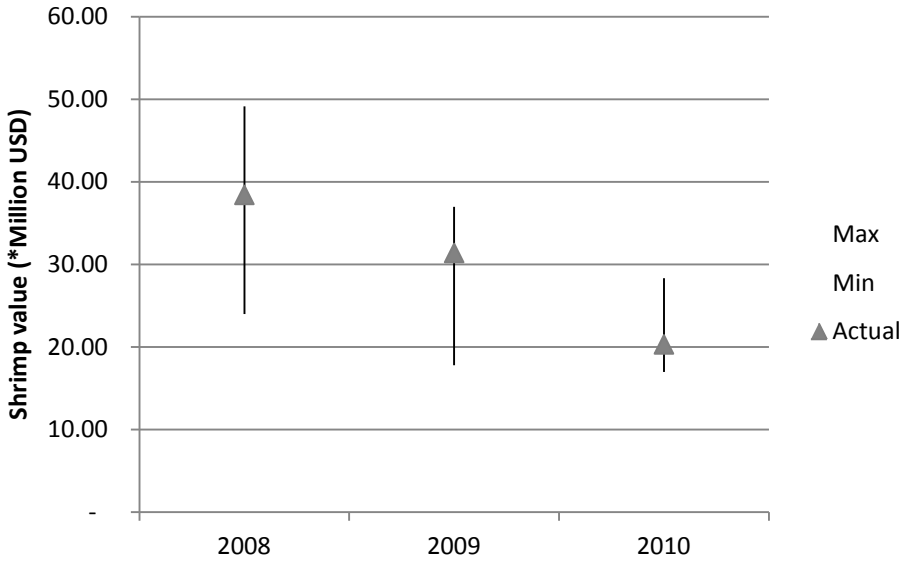
Service Provision Index for the year 2010

Sensitivity analysis

- Hydropower

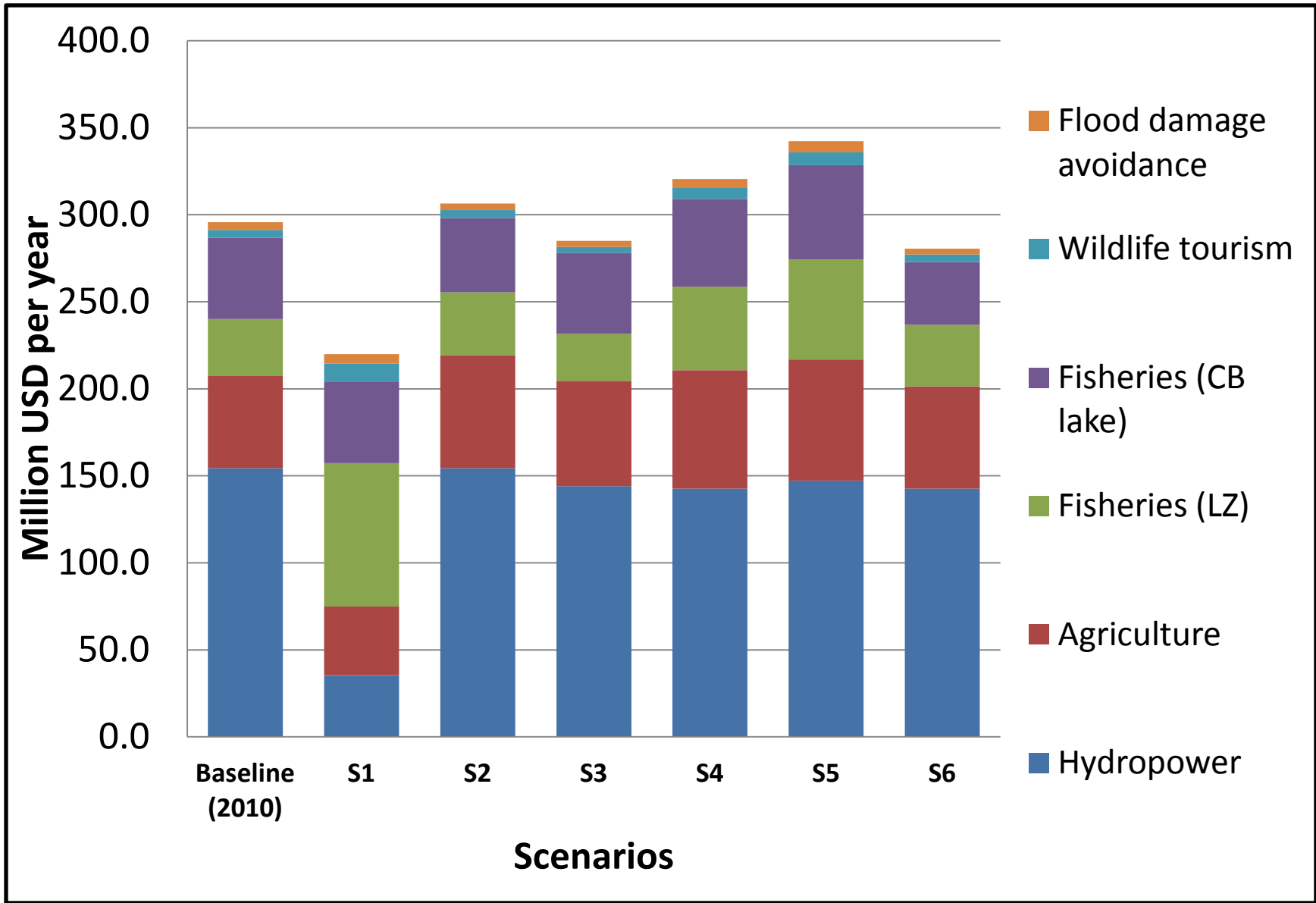


- Fisheries (shrimp)



Results

Calculated Economic Values based on scenarios



Conclusion

- The total economic value for 2010 is 296 million of which hydropower is 52%.
- Service suitability curves have shown that:
  - hydropower and irrigated agriculture love uniformity of flows
  - fisheries, wildlife tourism and flood damage avoidance require peaks to be sustained
- Scenario 5 *(Jan & Feb high flows of 3,300 & 5,400 m^3/s)* gives highest global benefits, with downstream users benefiting a lot (55 Million USD/yr) and hydropower losing less (-7 Million USD/yr)
- So trade-offs are, in theory at least, feasible.

Conclusion

Strengths

- Utilizes the flow regime rather than marginal value per volume of water
- Avoids double counting of ecosystem services
- Workable even in data scarce region
- Total economic value is likely to be higher, since some services were not included

Challenges

- Conceptual: ecosystem goods vs. services
- Variation in values over the years
- Range of SPI values with large uncertainties
- The SPI method is limited, as damages occurring in one months are not carried over to the next month

Future considerations...

- Once the annual flooding events are implemented it is necessary to monitor how the ecosystem responds, in order to check and improve the current model.
- What if hydropower generation capacity (HCB left bank; Mpanda Nkuwa) would be increased significantly?

Thank you!

References

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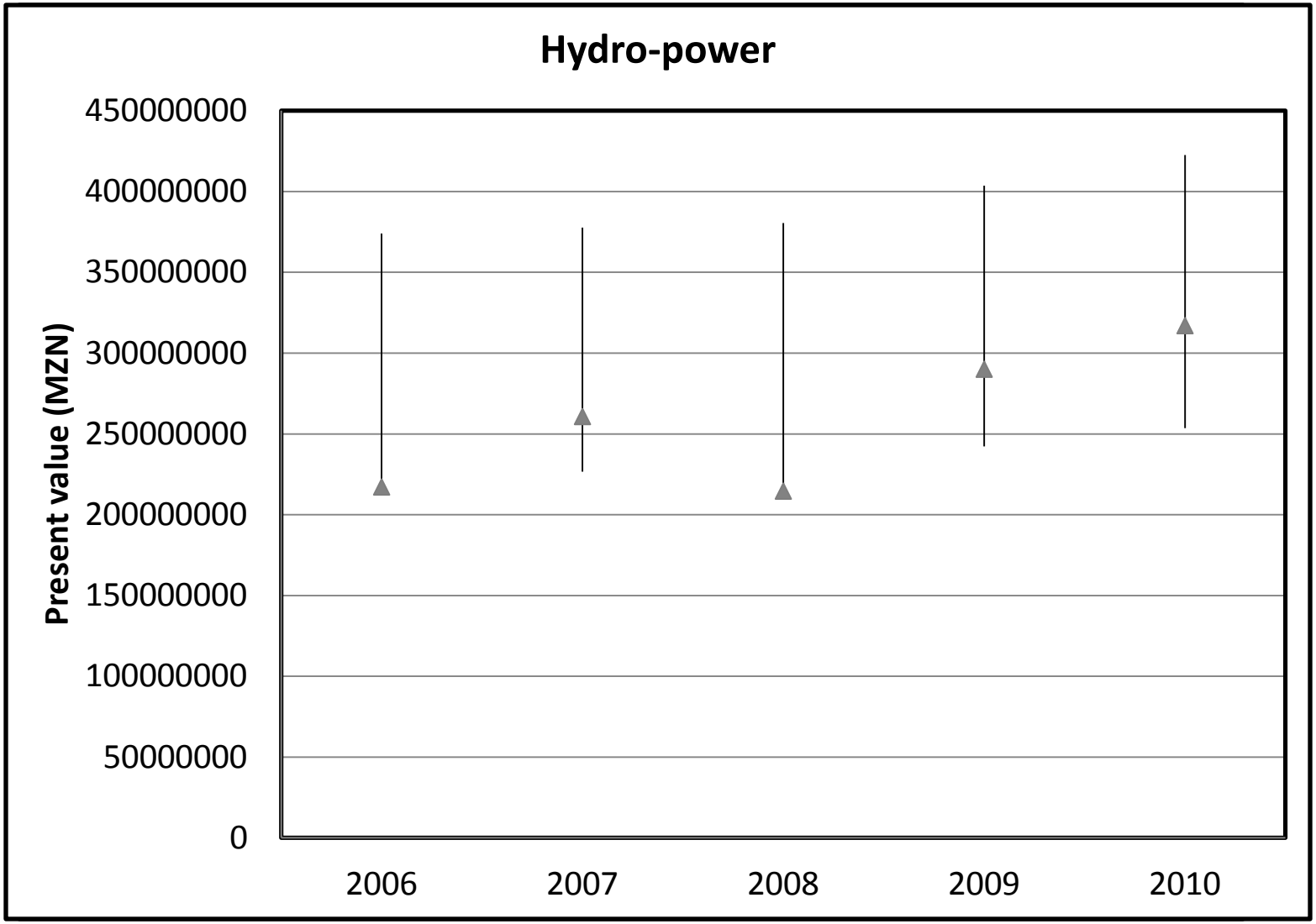
Sensitivity

Annex 1



Annex 2 (max-min values)