

Informed water infrastructure design: improving coupled dam sizing and operation by streamflow forecasts

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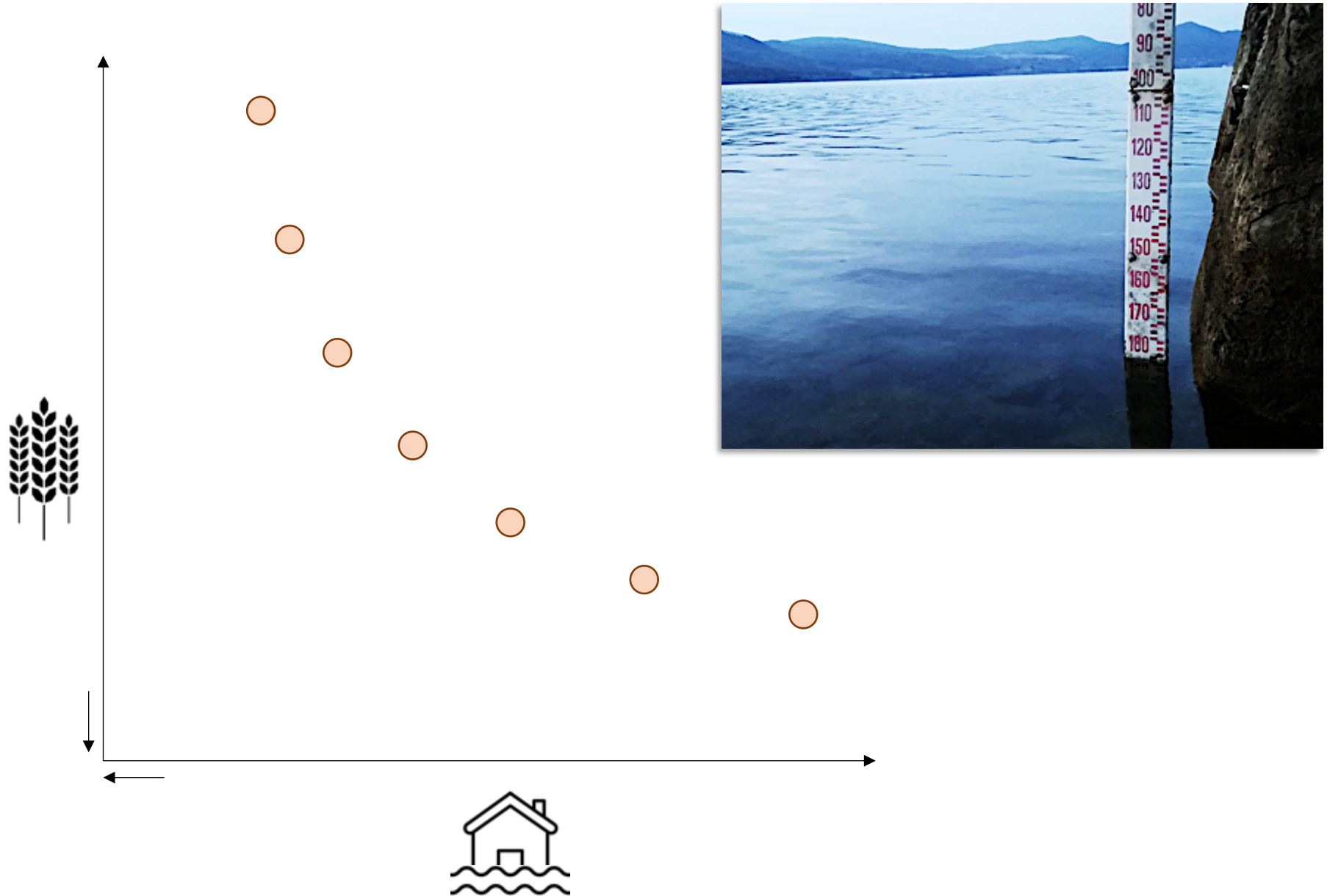


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Reservoir operation usually relies on basic information...



...but it can be improved by exploiting forecasts value

Short-term forecasts for short-term objectives



short-term forecasts



...but it can be improved by exploiting forecasts value

Long-term forecasts for long-term objectives



short-term forecasts



long-term forecasts

Different trade-offs need different forecast lead times

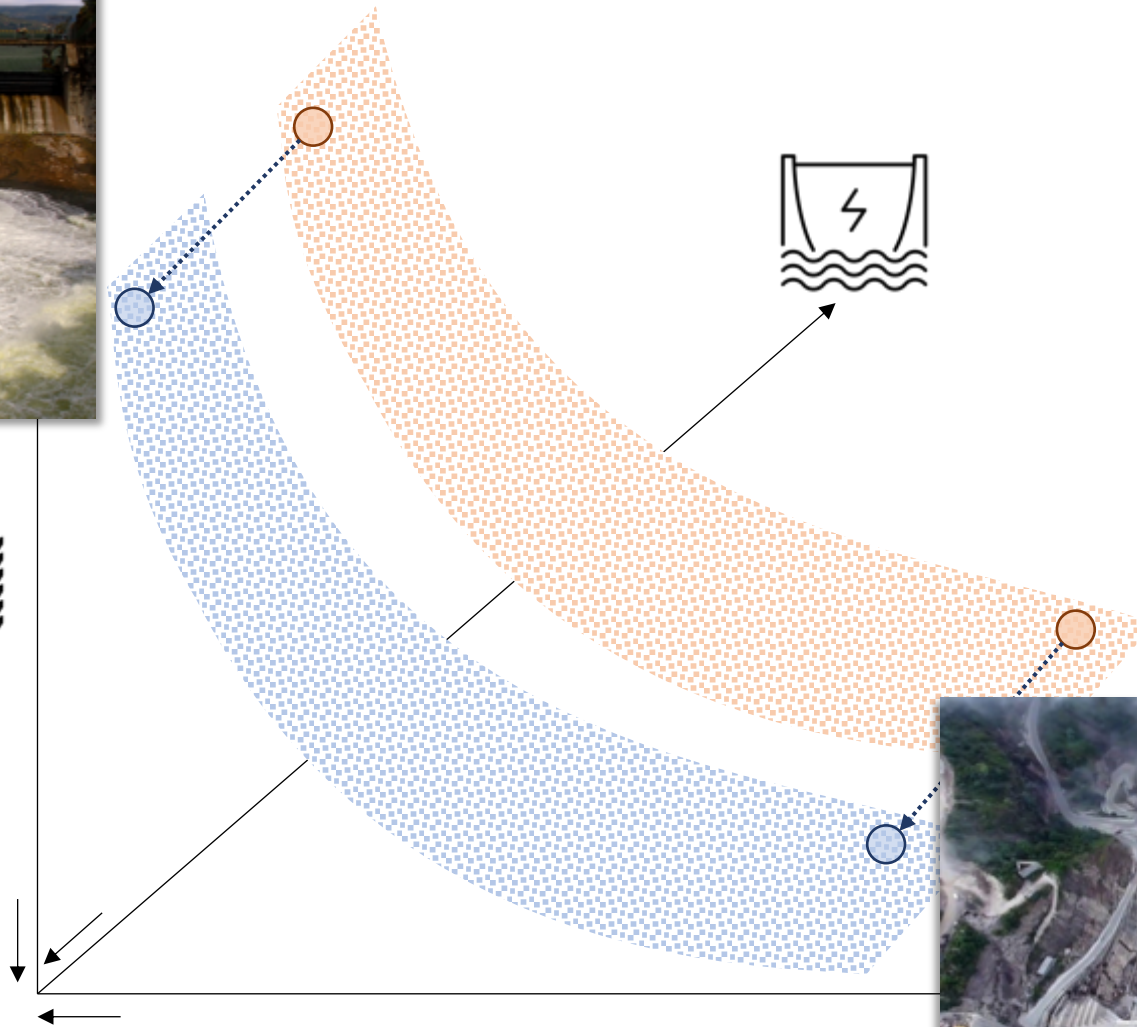


short-term
forecasts



long-term
forecasts

Different dam sizes need different forecast lead times

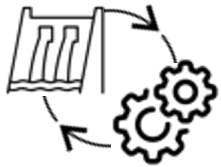


Novel framework for dam design informed by streamflow forecasts

Informed dam design framework



Multiple objectives



Joint dam sizing and operation design



Streamflow forecasts

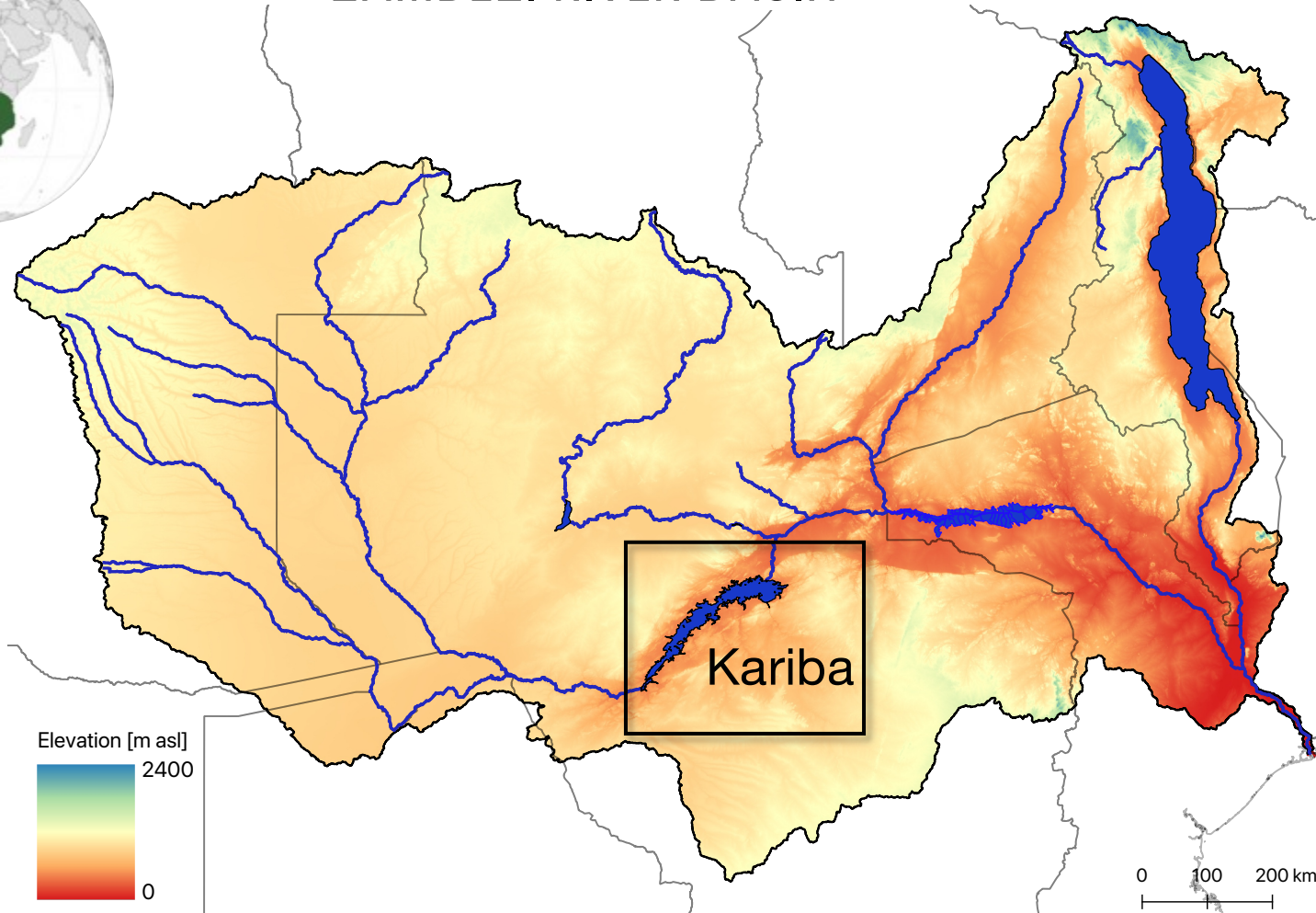
Features



Ex-post analysis of the existing Kariba dam



ZAMBEZI RIVER BASIN



Zambezi
River

Irr 1

Kariba

Irr 2

Hydropower
plant

Irrigation
district

Research questions

- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs

Research questions

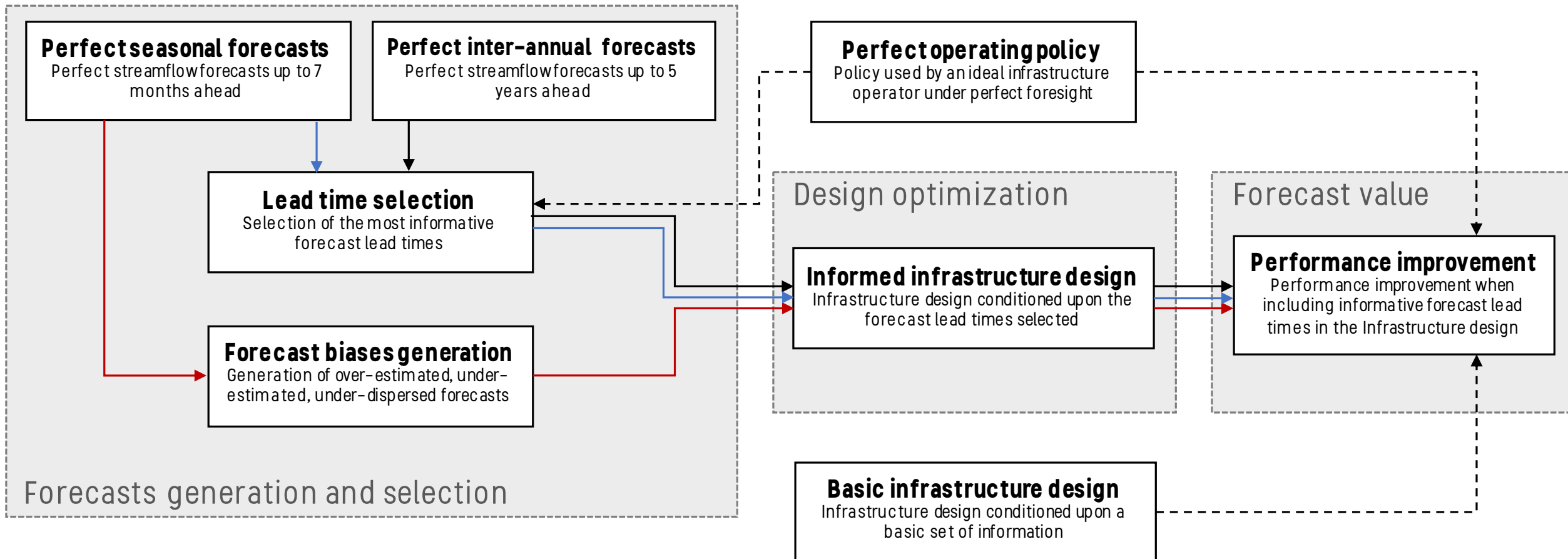
- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs
- b. Analyze potential benefits when including forecasts in dam design

Research questions

- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs
- b. Analyze potential benefits when including forecasts in dam design
- c. Assess the sensitivity of the informed dam design to different forecast accuracies

Flowchart of the methodology adopted

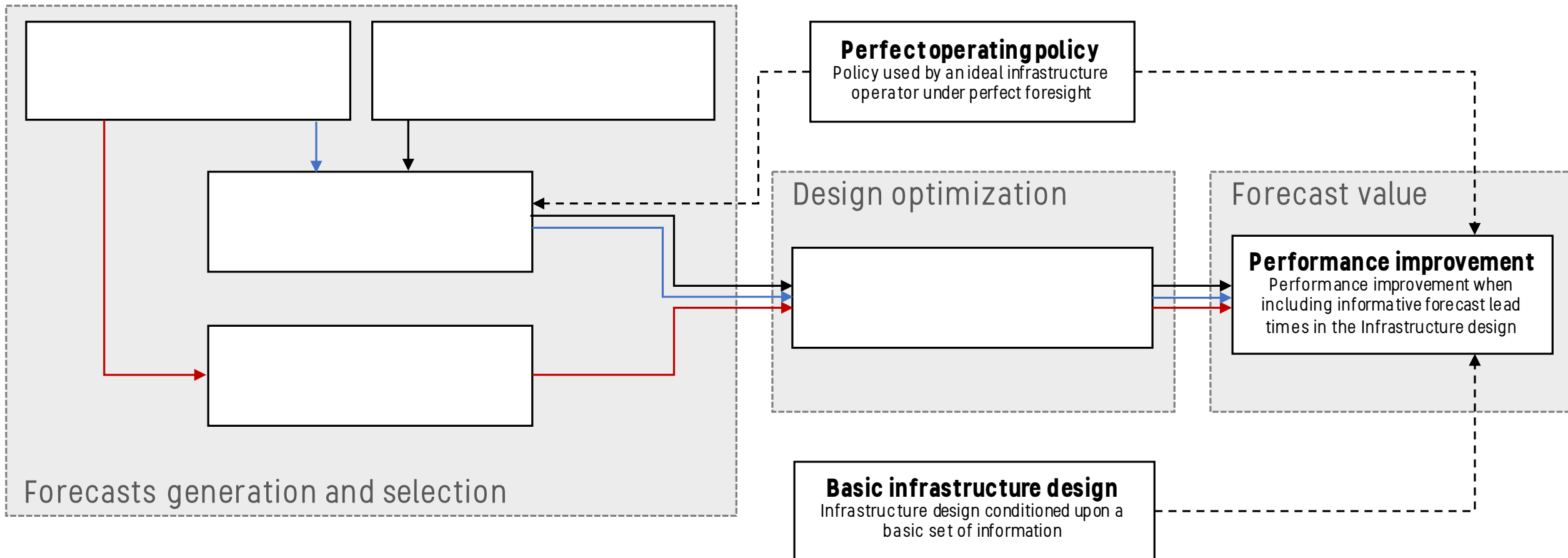
→ Seasonal forecasts → Inter-annual forecasts → Realistic forecasts



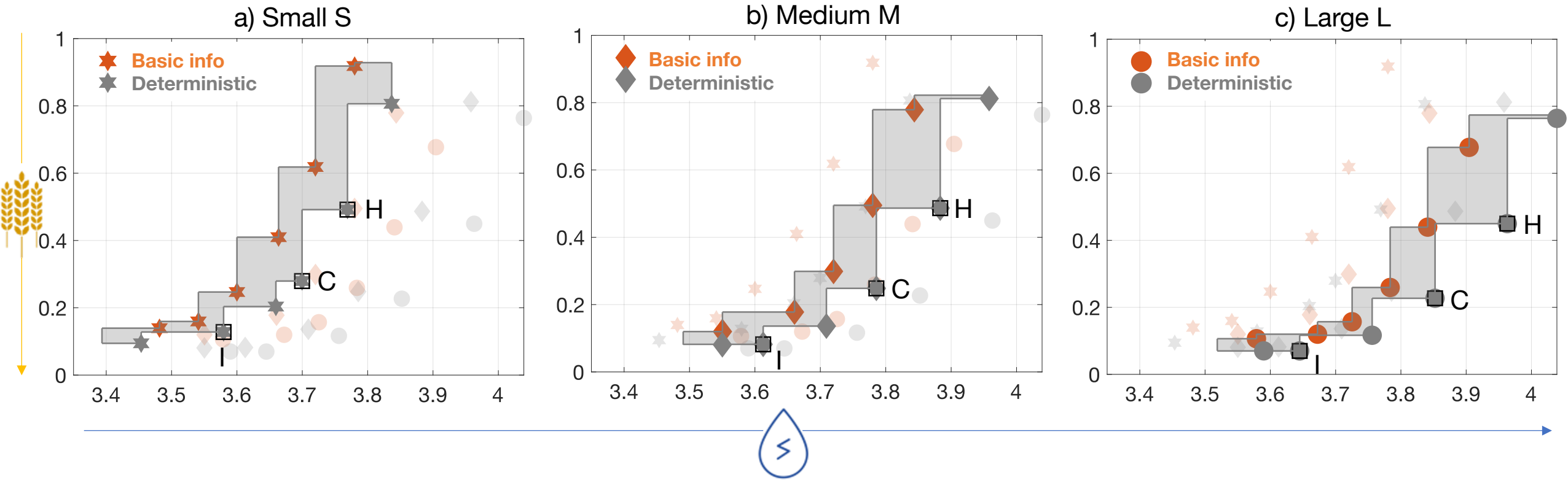
Research questions

- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs

Estimation of the maximum space for improvement



Basically informed vs Deterministic dam designs



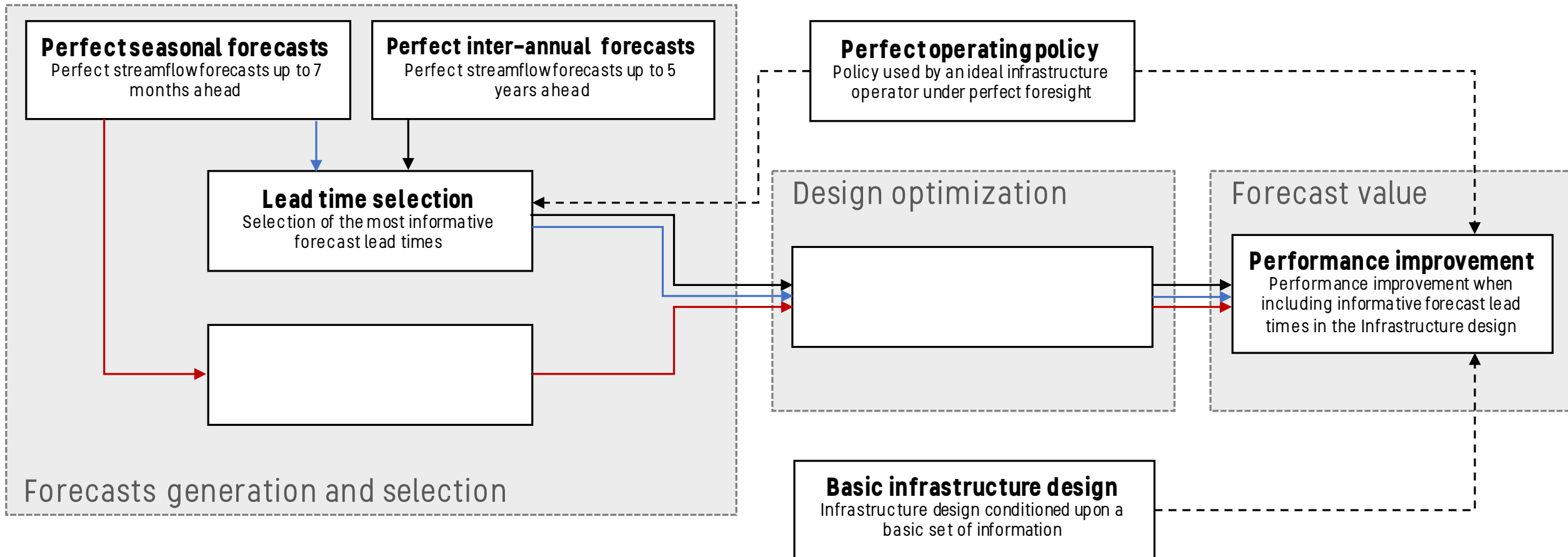
Largest space for improvement for large dams operated for hydropower

Research questions

- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs
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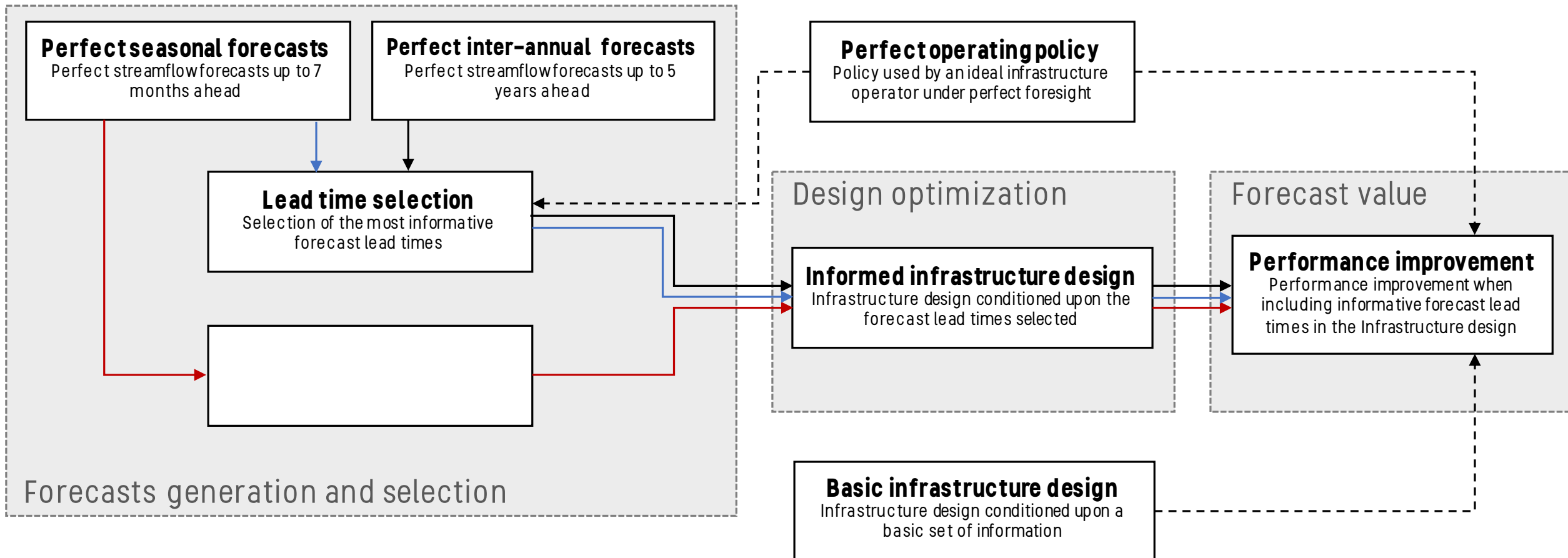
Selection of the most informative lead times for seasonal forecasts

→ Seasonal forecasts → Inter-annual forecasts

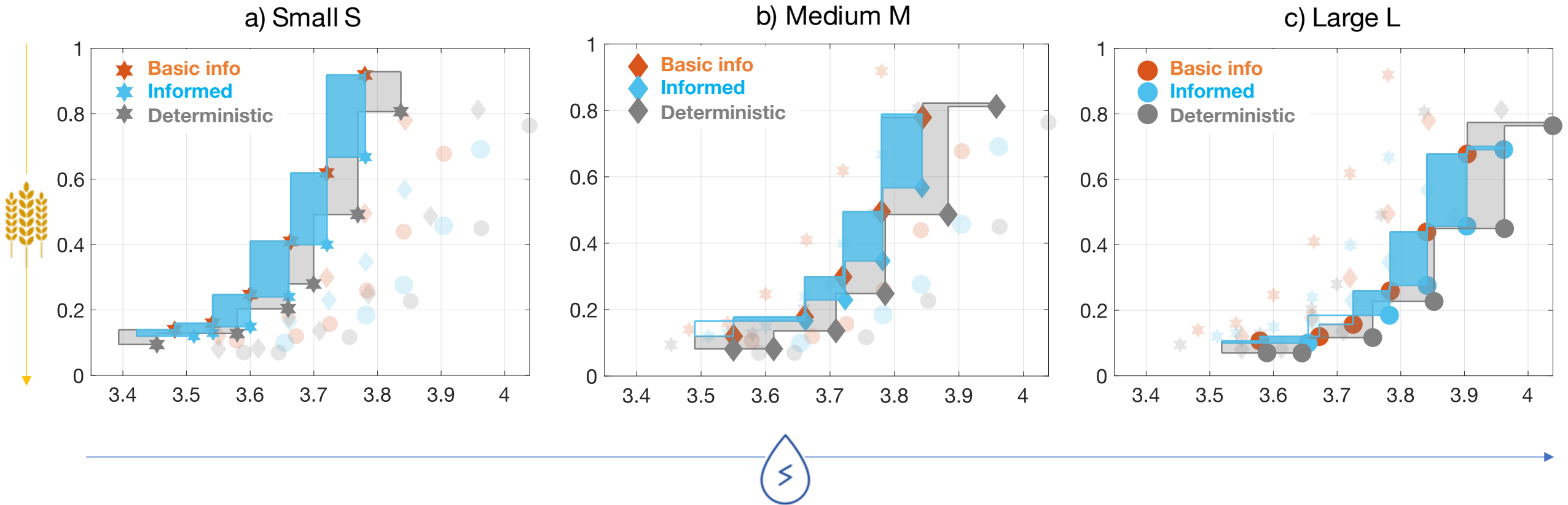


Infrastructure design informed by seasonal forecast lead times

→ Seasonal forecasts → Inter-annual forecasts

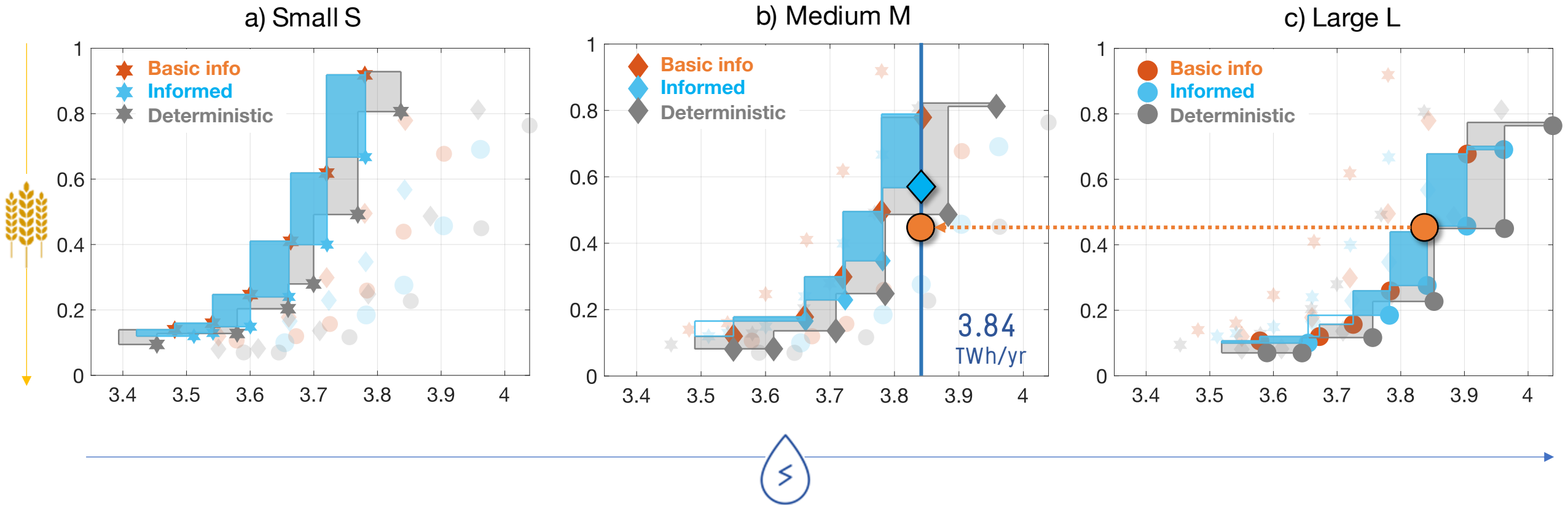


The operational value of perfect seasonal forecasts



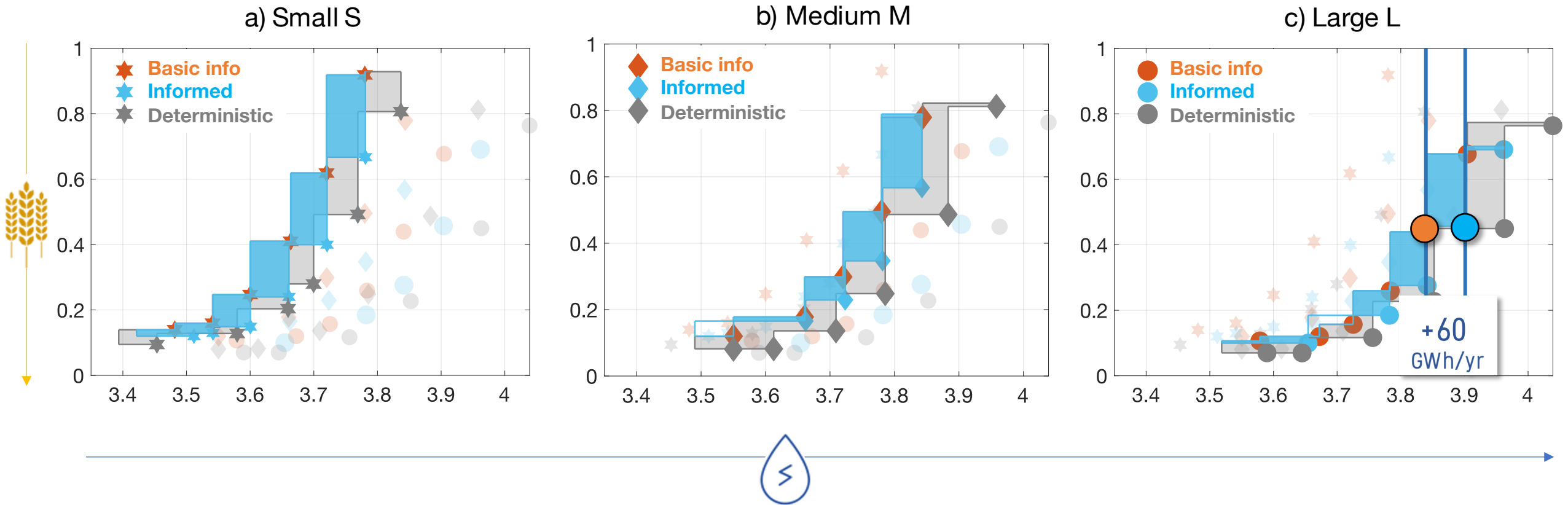
Biggest improvement in the hydropower-prone region

The planning value of perfect seasonal forecasts



20% reduction in capital costs with same hydropower production

+60 GWh/yr more hydropower under seasonally informed large dam sizes



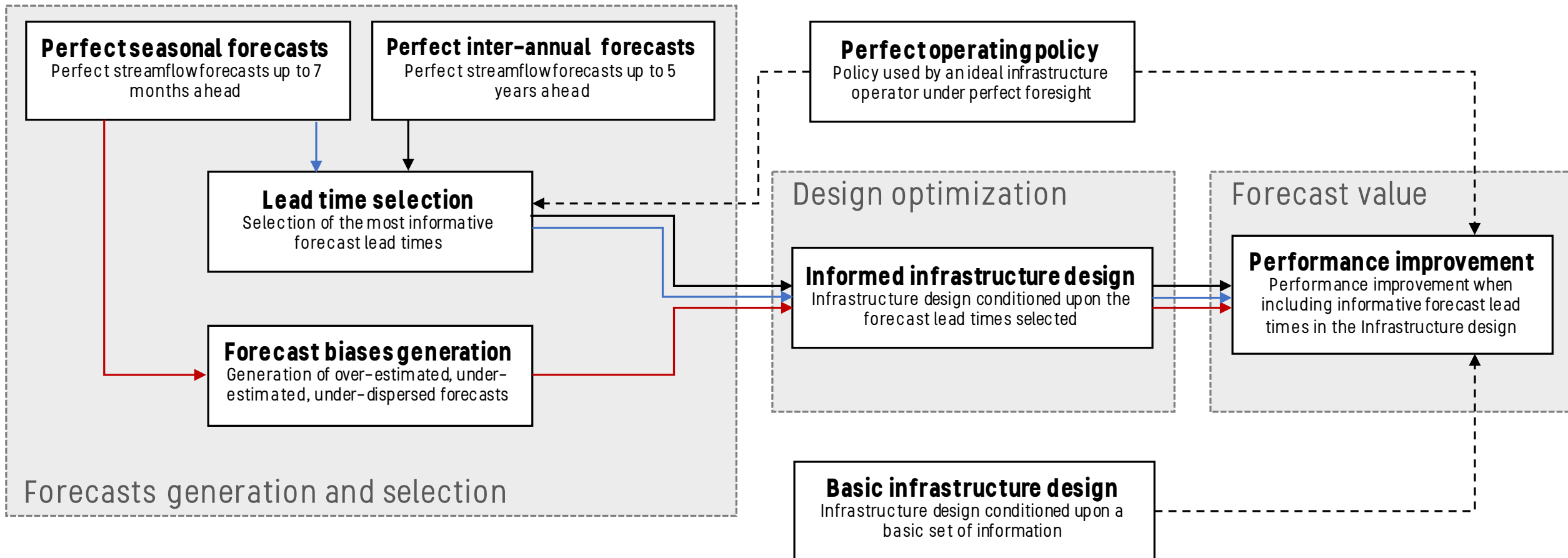
More than 25% of yearly mean electricity consumption by agriculture in Zambia*

Research questions

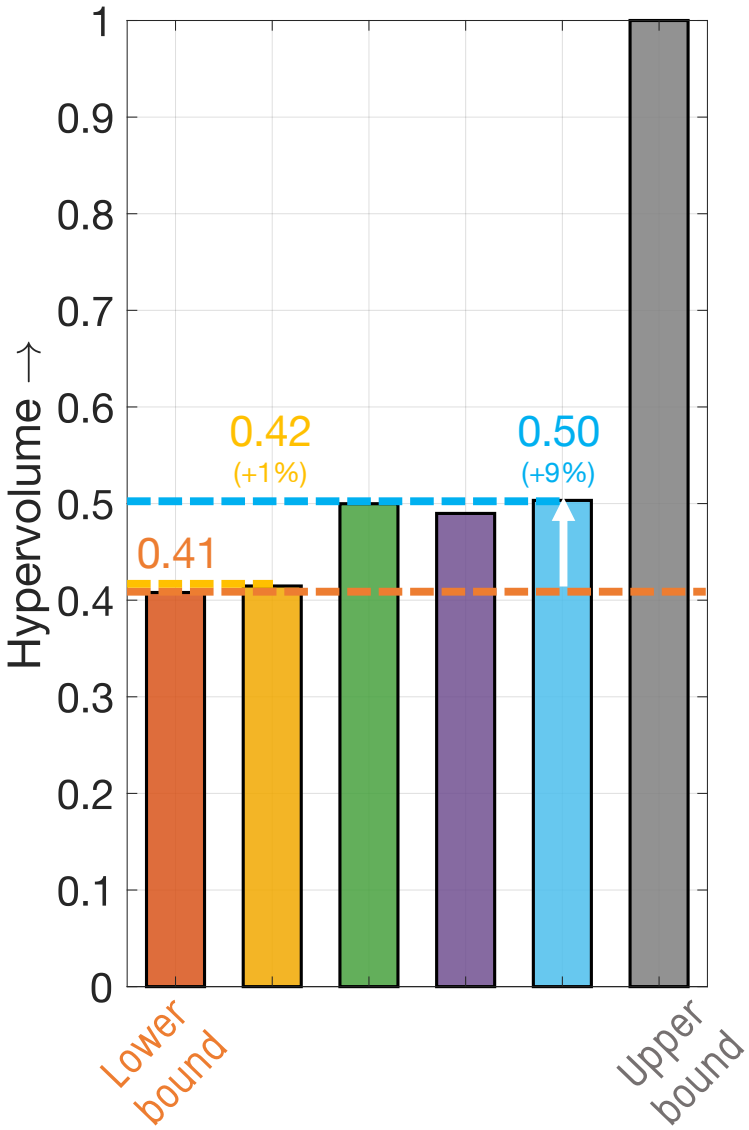
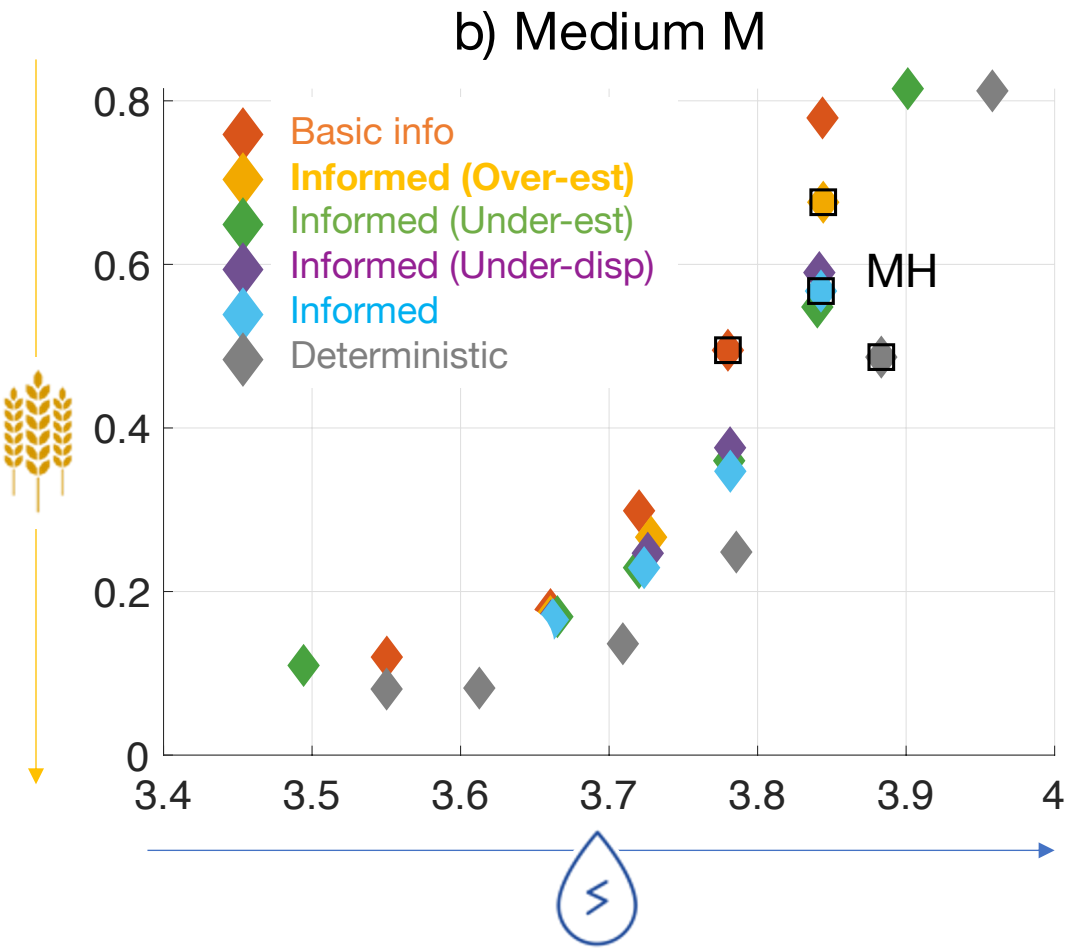
- a. Assess how the space for improvement estimated under perfect knowledge of the future changes with dam size and operational trade-offs
- b. Analyze potential benefits when including forecasts in dam design
- c. Assess the sensitivity of the informed dam design to different forecast accuracies

Sensitivity of informed infrastructure design to forecast accuracies

→ Seasonal forecasts → Inter-annual forecasts → Realistic forecasts



Informed infrastructure design is most sensitive to over-estimated forecasts



Take home messages

- a. Space for improvement increases with dam size and from irrigation to hydropower operational trade-off
- b. Informing dam design with valuable seasonal streamflow forecasts allows to attain a 20% reduction in capital costs
- c. Dam design is more sensitive to forecast over-estimation



Thank you

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