Qualitative and Quantitative Robust Decision Making for Water Resources Adaptation

Decision Making Under Uncertainty

Ajay Bhave (Leeds)

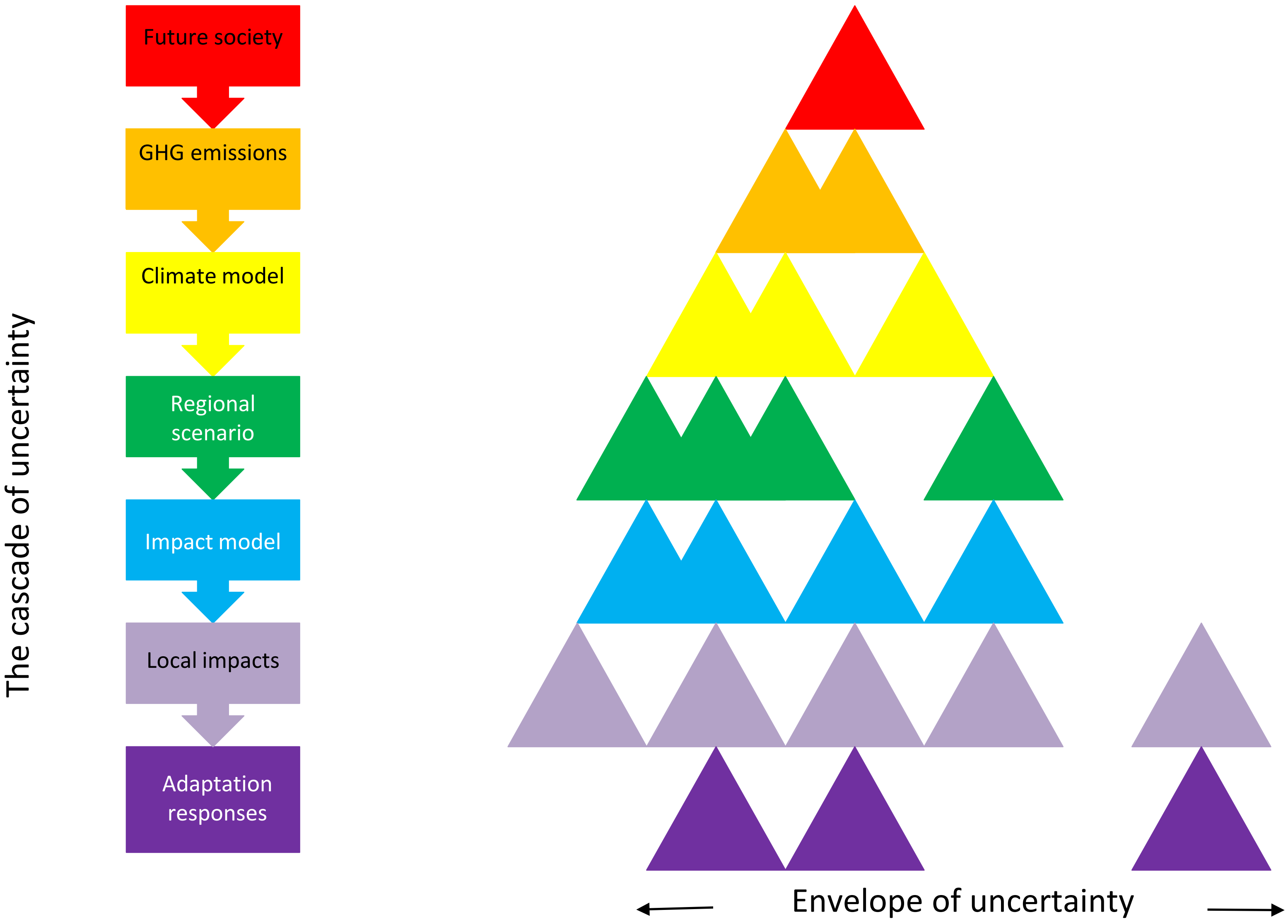
Declan Conway (LSE), Suraje Dessai (Leeds) and David Stainforth (LSE)

UNIVERSITY OF LEEDS

Centre for Climate Change Economics and Policy

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Uncertain knowledge

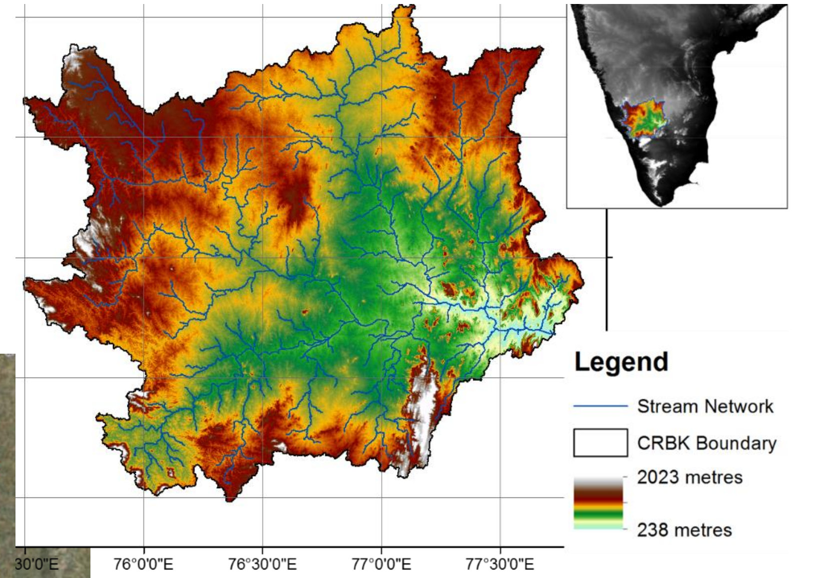


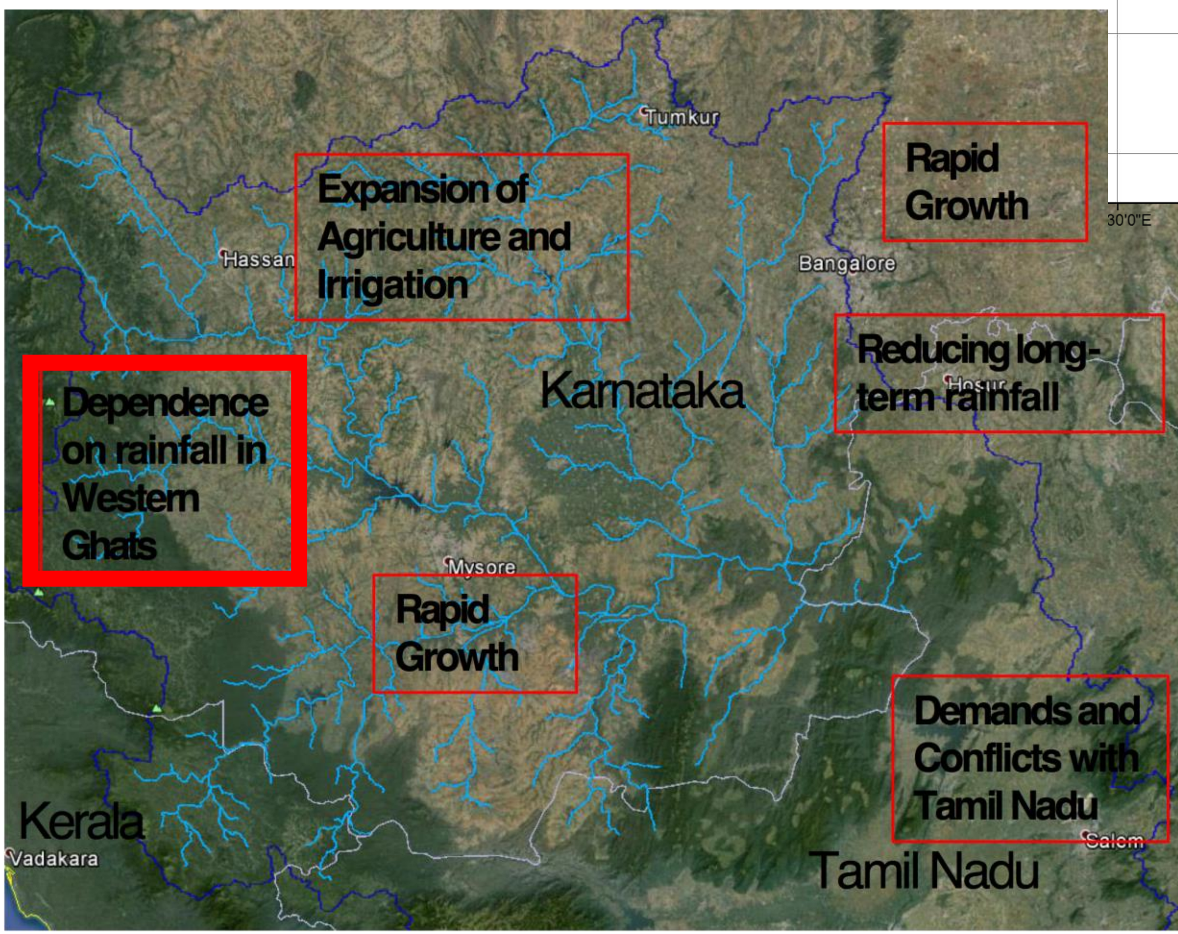
Adapted from Wilby and Dessai (2010)

Adaptation Decision Making Under Uncertainty

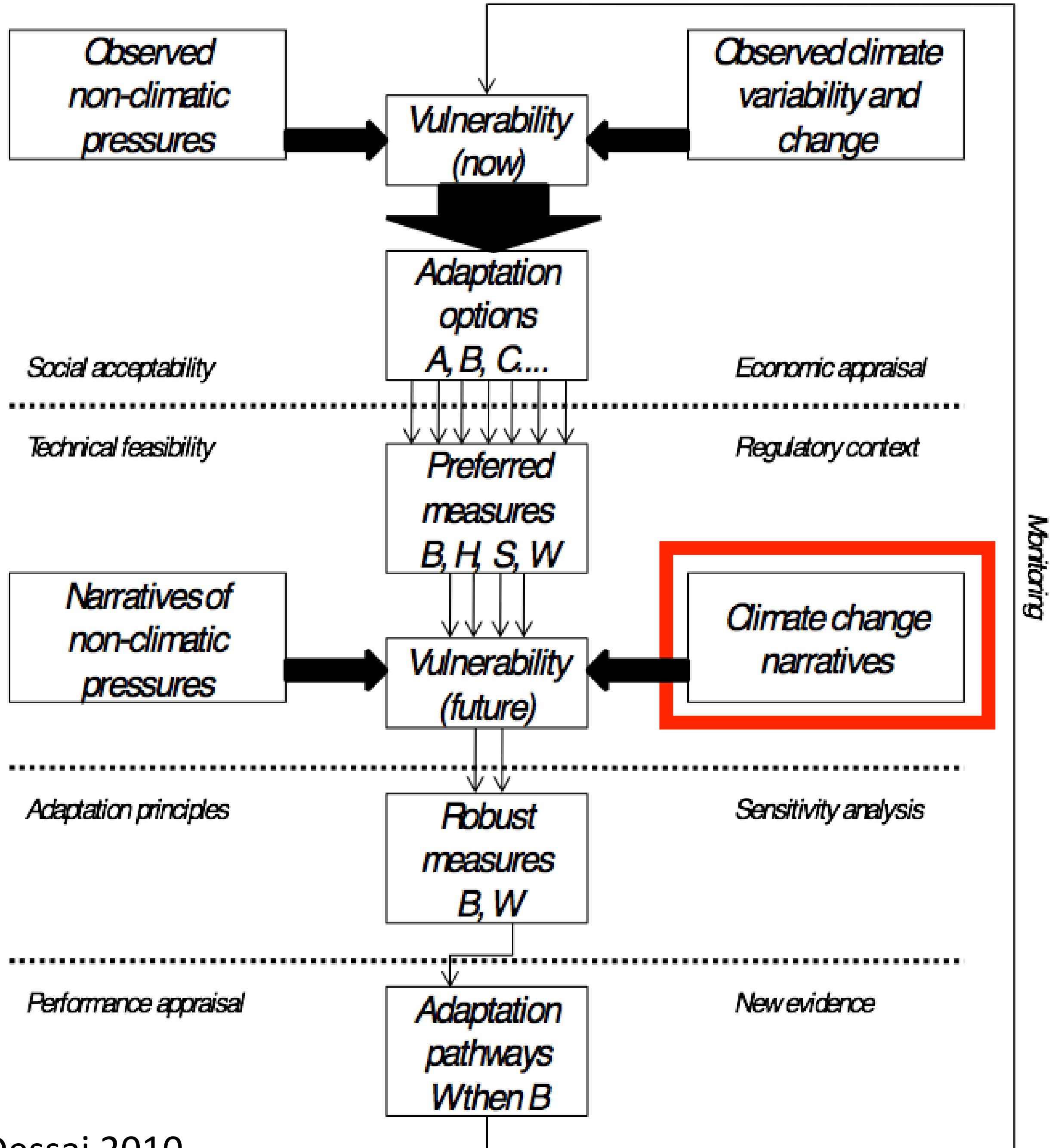
- DMUU approaches are useful for supporting adaptation decision making
- Robust Decision Making analysis helps determine options that provide value against a range of scenarios.
- A study in the Cauvery River Basin in Karnataka
- Focus on long-term thinking
- Focus on developing a relatively less complex model
- Uncertainty in future climate and future water demand
- Combination of qualitative and quantitative approaches

Cauvery River Basin in Karnataka.





What stakeholder-informed water management strategies are robust to a wide range of uncertainty by the 2050s?



Wilby and Dessai 2010

Motivation

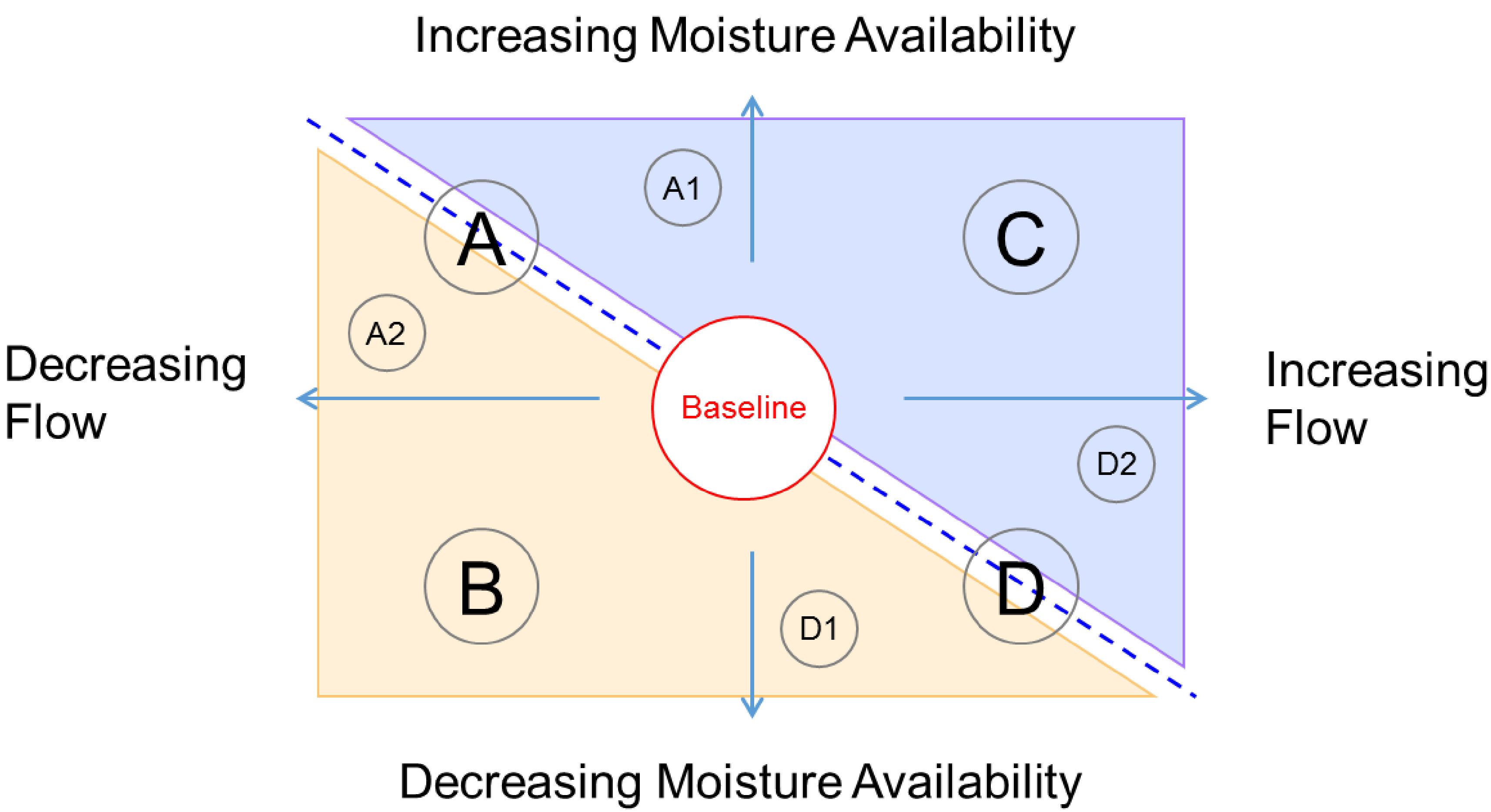
- The growth of multi-model, multi-method and multi-generational data for regional climate projections creates confusion for the Impacts, Adaptation, and Vulnerability (IAV) community (Hewitson et al., 2014)
- Underutilisation of expert judgement for climate change adaptation (Thompson et al. 2016)
- Future climate information has to be salient (decision context relevance) and credible (scientific knowledge)

Climate Narratives

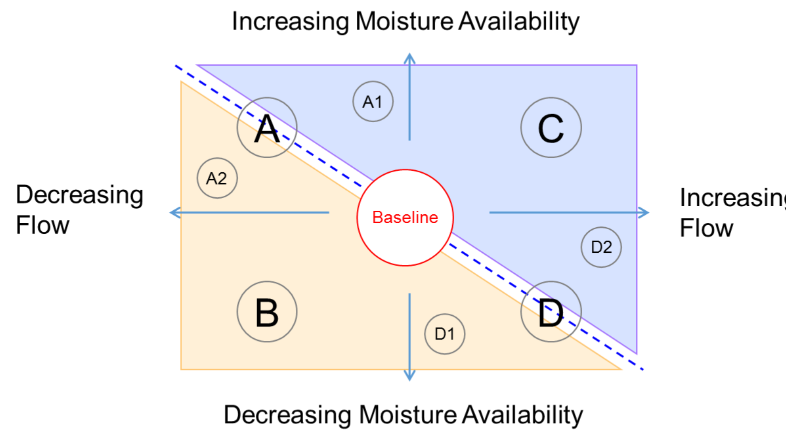
- Climate narratives with Indian Summer Monsoon experts

- Climate narratives development involved
  - **Expert elicitation** of key climate processes with ISM experts
  - Development of **descriptions** of plausible future climatic conditions, focusing on precipitation in the Western Ghats
  - **Establishing relationships** using observations and reanalysis
  - Using relationships to **translate** qualitative narratives into quantitative information

Climatic Narratives

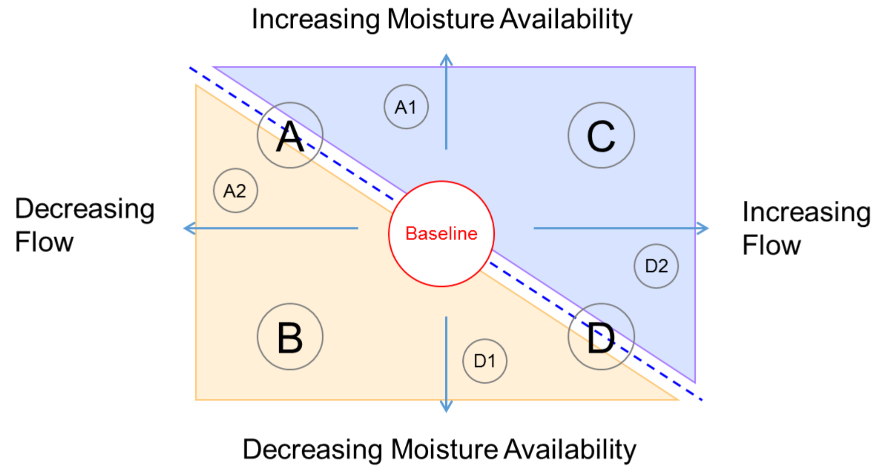


Processes and precipitation



Narrative	Key Processes										
	Arabian Sea/ Indian Ocean SST	Global Warming	Tropospheric Temperature Gradient	Himalayan Snow Cover	Anthro-pogenic Aerosol Forcing	ITCZ movement northwards	Strength of Westerly Jet	Extent of irrigation	Influence of dry Northerlies	Influential Tele - connections	Precipi - tation Change
A1	⇧	⇧	⇧	⇩	⇩	⇧	⇧	⇩	⇩	La Niña	⇧
A2	⇩		⇩	⇧	⇧	⇩	⇩	⇧	⇧	El Niño EQUINOO	⇩
B	⇩		⇩	⇧	⇧	⇩	⇩	⇧	⇧	El Niño EQUINOO	⇩
C	⇧	⇧	⇧	⇩	⇩	⇧	⇧	⇩	⇩	La Niña	⇧
D1	⇩		⇩	⇧	⇧	⇩	⇩	⇧	⇧	El Niño EQUINOO	⇩
D2	⇧	⇧	⇧	⇩	⇩	⇧	⇧	⇩	⇩	La Niña	⇧

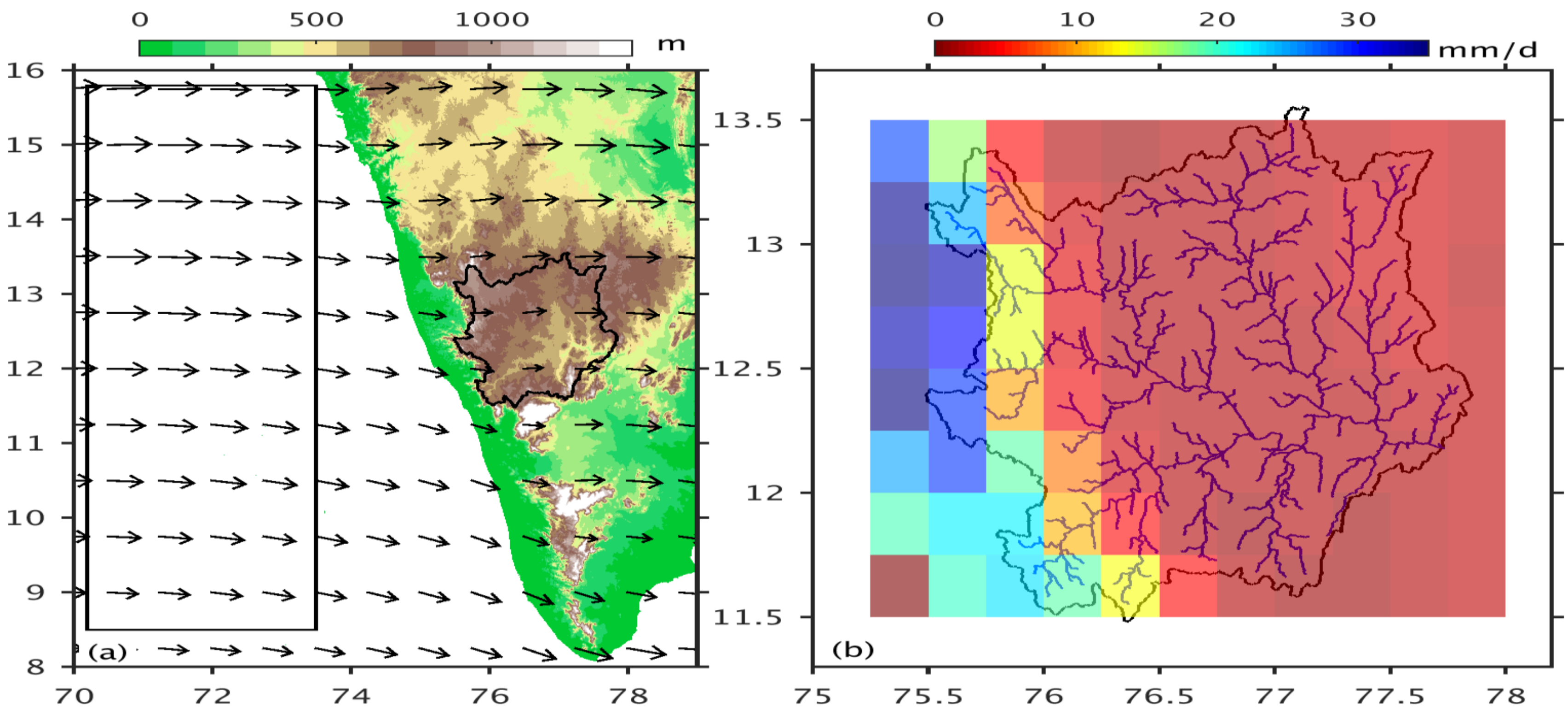
Narrative description



Narrative B

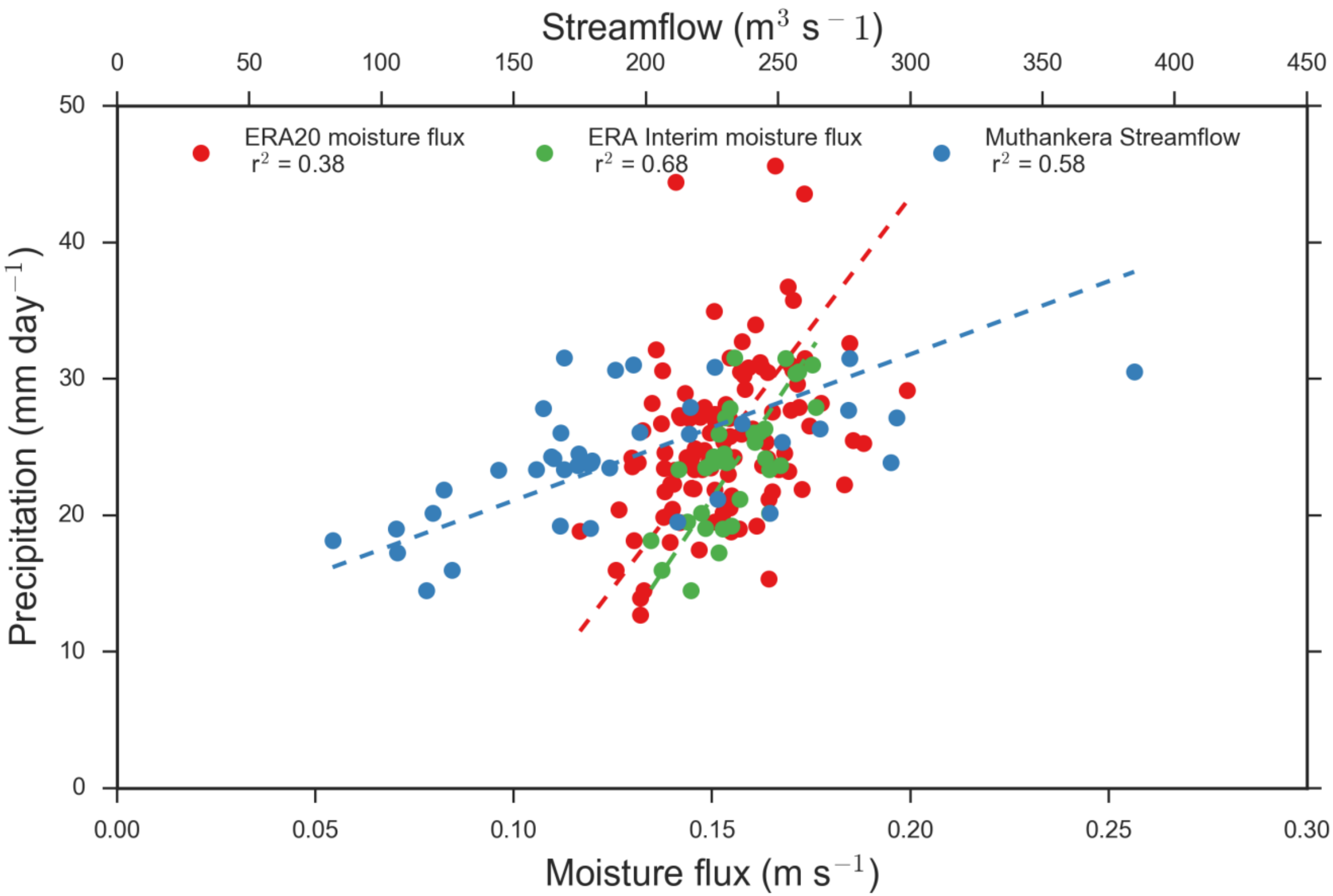
Narrative B describes **future evolution** of the Indian Summer Monsoon for a scenario of decreasing moisture availability and decreasing strength of flow coming towards southern India. Under these conditions, **precipitation is expected to decrease due to the underlying plausible processes** of cooling of sea surface temperatures of the Arabian Sea, weakening of the Westerly Jet, increase in anthropogenic aerosol forcing in the northern hemisphere (particularly in northern India), **increase in irrigation in the Indo-Gangetic Plain** which cools the land surface and decreases overall monsoon circulation, and greater influence of the El Niño and Equatorial Indian Ocean Oscillation teleconnections. **Land use change** and its effect on soil moisture content and evapotranspiration are expected to impact the **spatio-temporal distribution** of precipitation, which, although uncertain, is expected to be **different compared to current conditions.**

Quantitative information on climate narratives



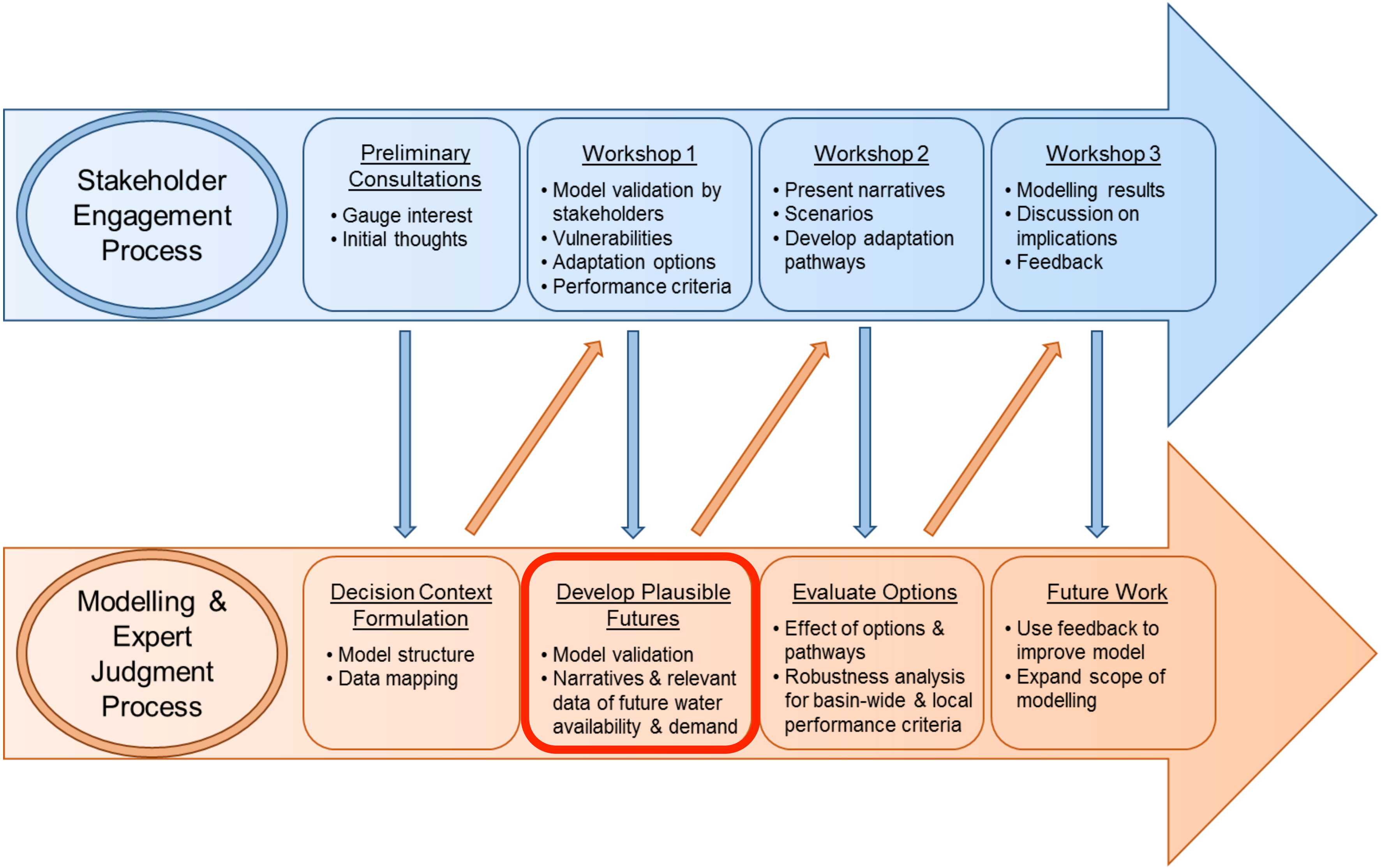
- Observations: Global Precipitation Climatology Centre (GPCC) (1901-2010) + streamflow at Muthankera (1973-2012)
- Reanalysis: ERA20 (1901-2010) and ERAInterim (1979-2015) moisture flux (Specific humidity*U wind) over the Arabian Sea

- Relationship between moisture flux and precipitation
- Apply change factor based on observed standard deviation to create time series of plausible future precipitation change



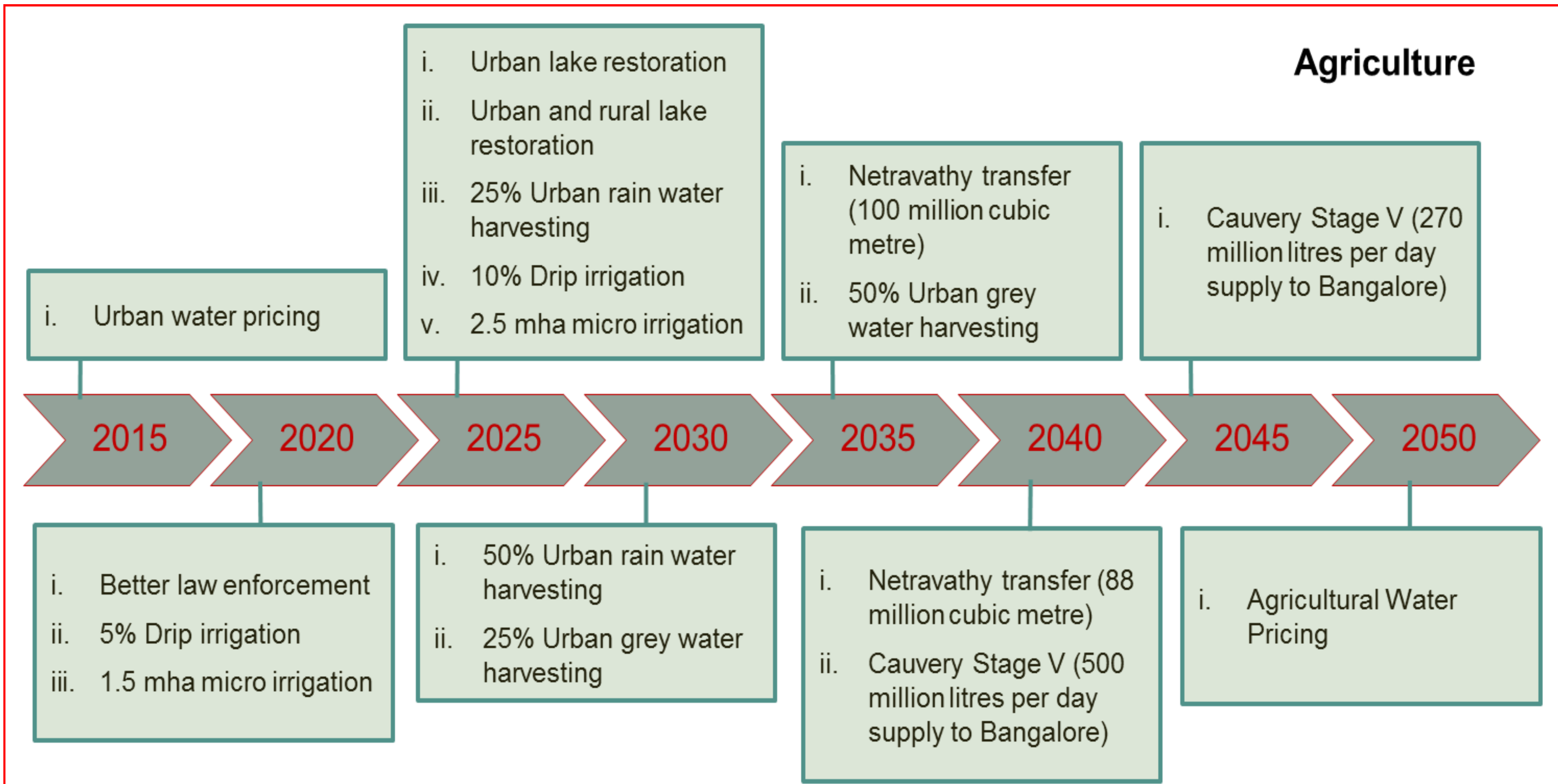
Relationship between monthly moisture flux (product of surface humidity over the Arabian Sea and wind component) in reanalysis ERA datasets and corresponding monthly precipitation for July and August in the Western Ghats (GPCC) and streamflow at Muthankera

RDM approach in the CRBK

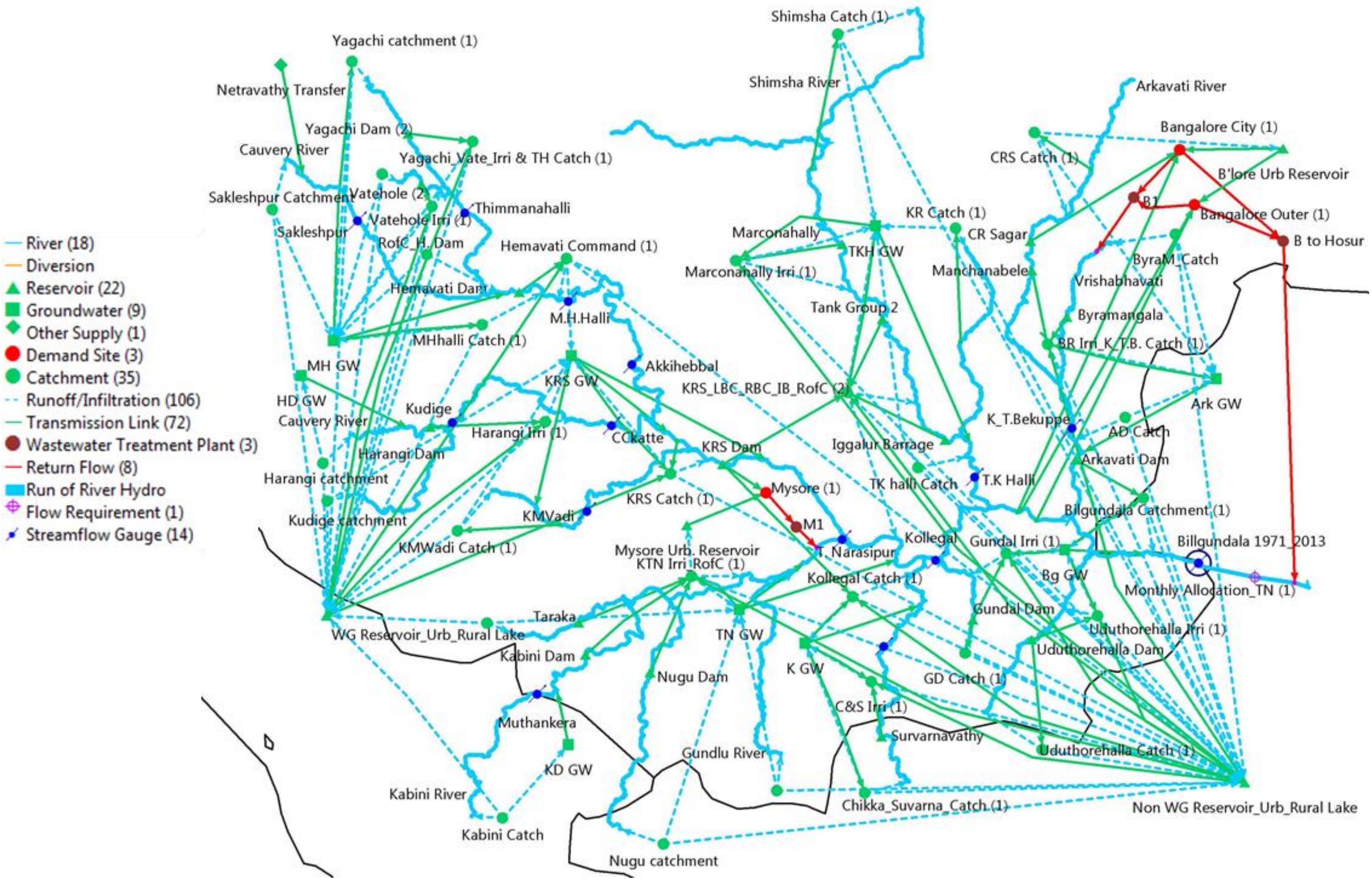


Adaptation Pathways of Agriculture stakeholders

Sequences of 17 adaptation options



WEAP model


River (18)
Diversion
Reservoir (22)
Groundwater (9)
Other Supply (1)
Demand Site (3)
Catchment (35)
Runoff/Infiltration (106)
Transmission Link (72)
Wastewater Treatment Plant (3)
Return Flow (8)
Run of River Hydro
Flow Requirement (1)
Streamflow Gauge (14)
Yagachi catchment (1)
Netravathy Transfer
Yagachi Dam (2)
Cauvery River
Yagachi_Vate_Irri & TH Catch (1)
Sakleshpur Catchment
Vatehole (2)
Vatehole Irri (1)
Thimmanahalli
Sakleshpur
RofC_H. Dam
Hemavati Command (1)
Hemavati Dam
M.H.Halli
MHhalli Catch (1)
MH GW
HD GW
Cauvery River
Kudige
KRS GW
Akkihebbal
Harangi Irri (1)
CCkatte
Harangi Dam
Harangi catchment
Kudige catchment
KMVadi
KMWadi Catch (1)
KRS Catch (1)
KRS Dam
Mysore (1)
M1
T. Narasipur
Mysore Urb. Reservoir
KTN Irri_RofC (1)
WG Reservoir_Urb_Rural Lake
Taraka
Kabini Dam
Muthankera
KD GW
Kabini River
Kabini Catch
Nugu Dam
Nugu catchment
Gundlu River
TN GW
K GW
Kollegal Catch (1)
Kollegal
C&S Irri (1)
Survarnavathy
Chikka_Suvarna_Catch (1)
Shimsha Catch (1)
Shimsha River
Marconahally
Marconahally Irri (1)
TKH GW
KR Catch (1)
CR Sagar
Manchanabele
Tank Group 2
KRS_LBC_RBC_IB_RofC (2)
Iggalur Barrage
TK halli Catch
T.K Halli
K_T.Bekuppe
Arkavati River
Bangalore City (1)
CRS Catch (1)
B'lore Urb Reservoir
B1
Bangalore Outer (1)
B to Hosur
ByraM_Catch
Vrishabhavati
Byramangala
BR Irri_K_T.B. Catch (1)
Ark GW
AD Catch
Arkavati Dam
Bilgundala Catchment (1)
Gundal Irri (1)
Bg GW
Billgundala 1971_2013
Monthly Allocation_TN (1)
Gundal Dam
Uduthorehalla Irri (1)
Uduthorehalla Dam
GD Catch (1)
Uduthorehalla Catch (1)
Non WG Reservoir_Urb_Rural Lake

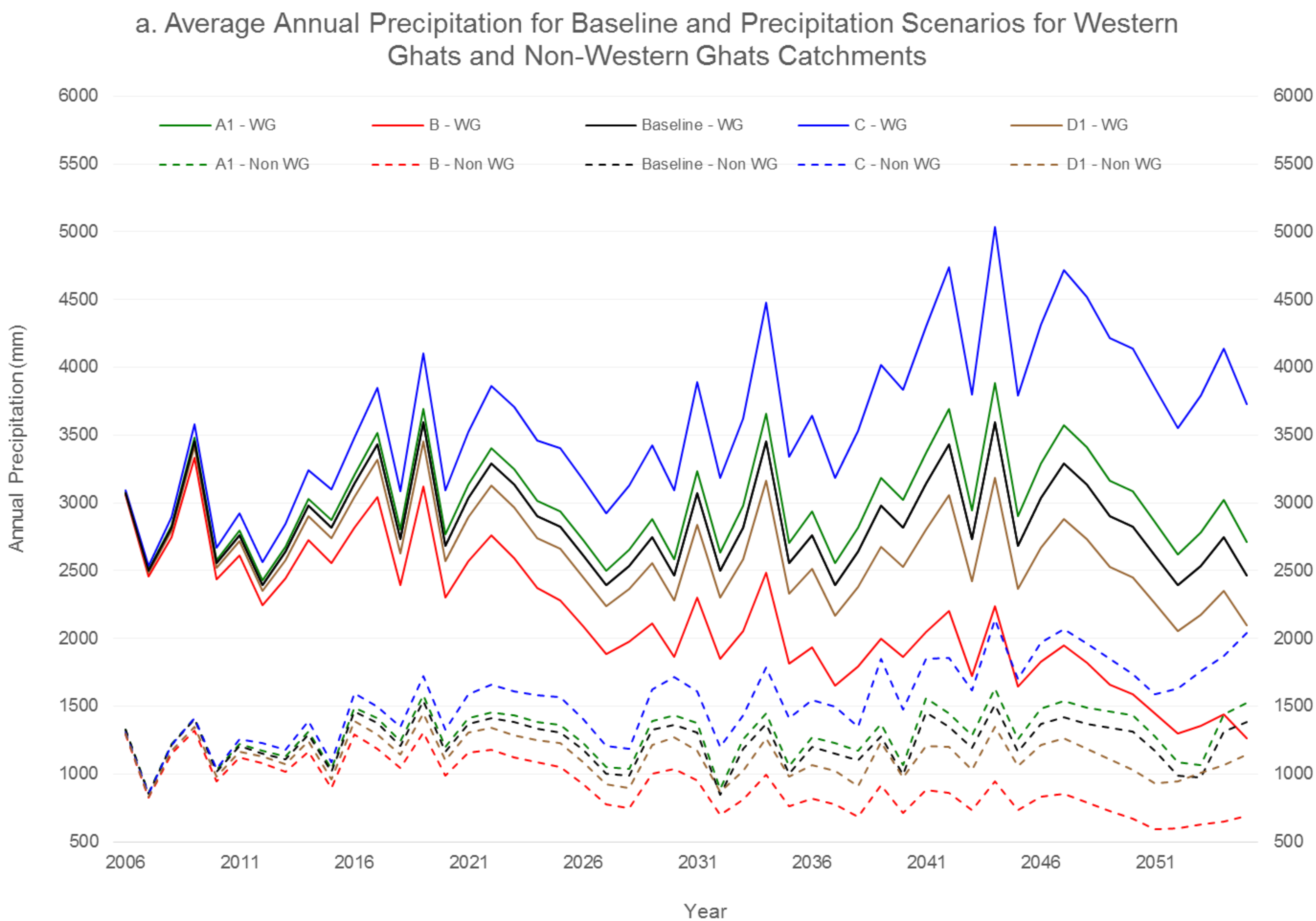
Results

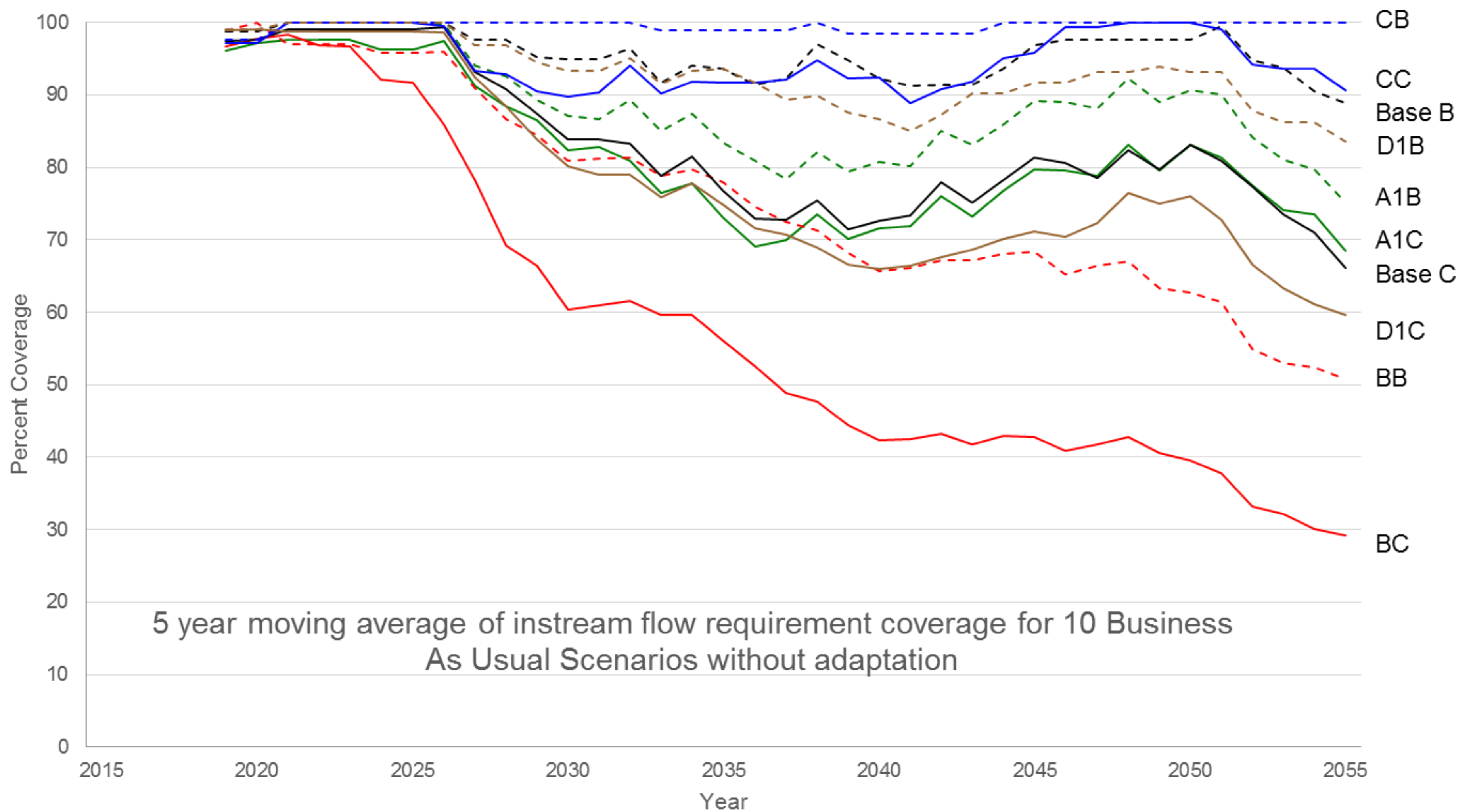
Focus on three metrics

- Basin-wide metric of water allocations for downstream Tamil Nadu
- Water requirement for Bangalore (>50% of Karnataka GDP)
- Water availability for four main irrigated command areas

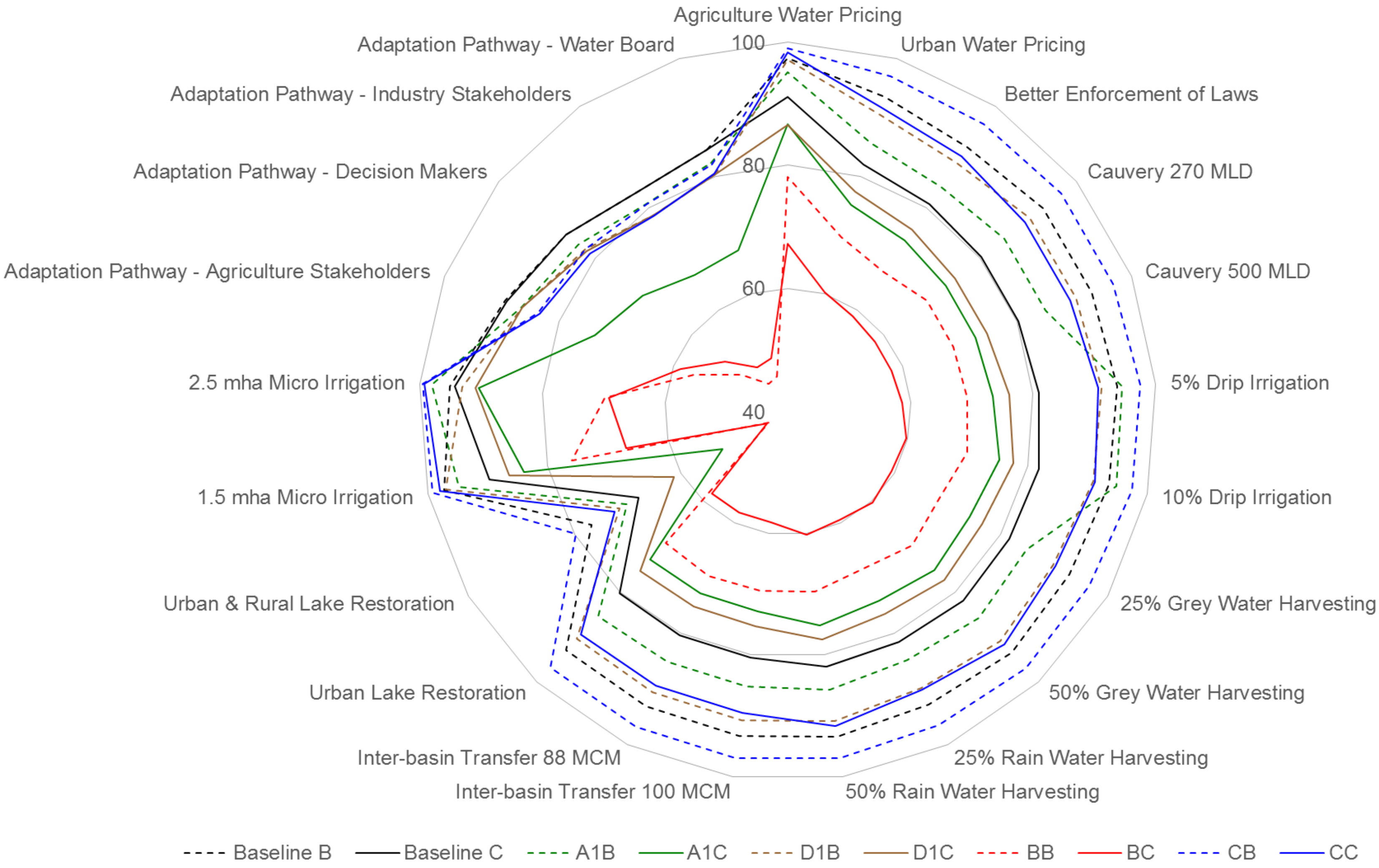
Assessing adaptation options

- Determine the effect of adaptation options by comparing with Business As Usual scenarios


a. Average Annual Precipitation for Baseline and Precipitation Scenarios for Western Ghats and Non-Western Ghats Catchments
A1 - WG
B - WG
Baseline - WG
C - WG
D1 - WG
A1 - Non WG
B - Non WG
Baseline - Non WG
C - Non WG
D1 - Non WG
Annual Precipitation (mm)
Year
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
2006
2011
2016
2021
2026
2031
2036
2041
2046
2051



5 year moving average of annual IFR coverage for the Business As Usual Scenarios. There is a significant difference between scenarios with increasing and decreasing demand for the same climate.



Reliability of flow requirement coverage for each option and pathway for all 10 scenarios. Reliability here denotes the percent of the timesteps in which the was fully satisfied.

Key Messages

- Decision Making Under Uncertainty approach for supporting adaptation decision making
- We applied an iterative RDM approach - modelling and stakeholder engagement
- Expert elicitation of plausible future climate conditions and underlying processes as narratives, focussing on precipitation in the CRBK
- Translation of qualitative to quantitative information
- Information generated relevant to decision context
- Modelled effects of options
- Assessed robustness of options