Combining quantitative techniques for selecting qualitative elements of socioeconomic scenarios adapted to a specific problem

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HOW TO CONSTRUC STORYLINES (scenarios)

- Variables
- States
- scenarios

THE SRES Storylines

Driving forces

Population growth	Economic development	Energy use	Land-use change	Resources availability	Tech-nological change	Future energy system
Low (0)	Medium (0)	Low (0)	Low (0)	Low (0)	Slow (0)	Coal, oil, gas
Medium (1)	High (1)	Medium (1)	Low-medium (1)	Medium (1)	Medium (1)	Balanced
High (2)	Very high (2)	High (2)	Medium (2)	High (2)	Rapid (2)	Non-fossils
		Very high (3)	Medium/ high (3)			Regional
			High (4)			Efficiency
						”Dynamics as usual”

States

A2

A1B

9720 possible scenarios and
10^{21} possible sets with six sceanrios

The problem:

How to identify a small number of scenarios from the (often very large) set of possible scenarios?

CRITERIA FOR SCENARIOS

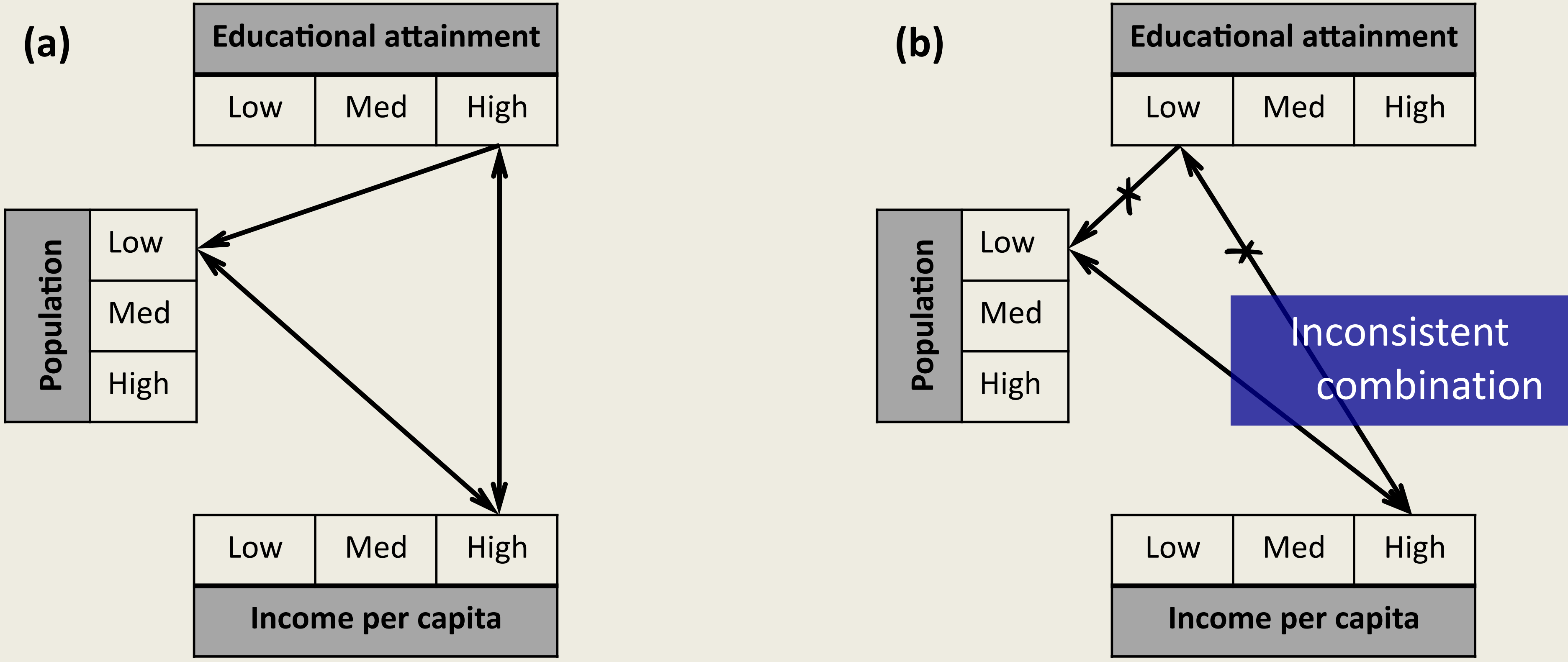
	Property of… Individual scenario	Set of scenarios
Relevance	X	
Plausibility	X	
Representative		X

Self-consistency

Spanning the space of possibilities

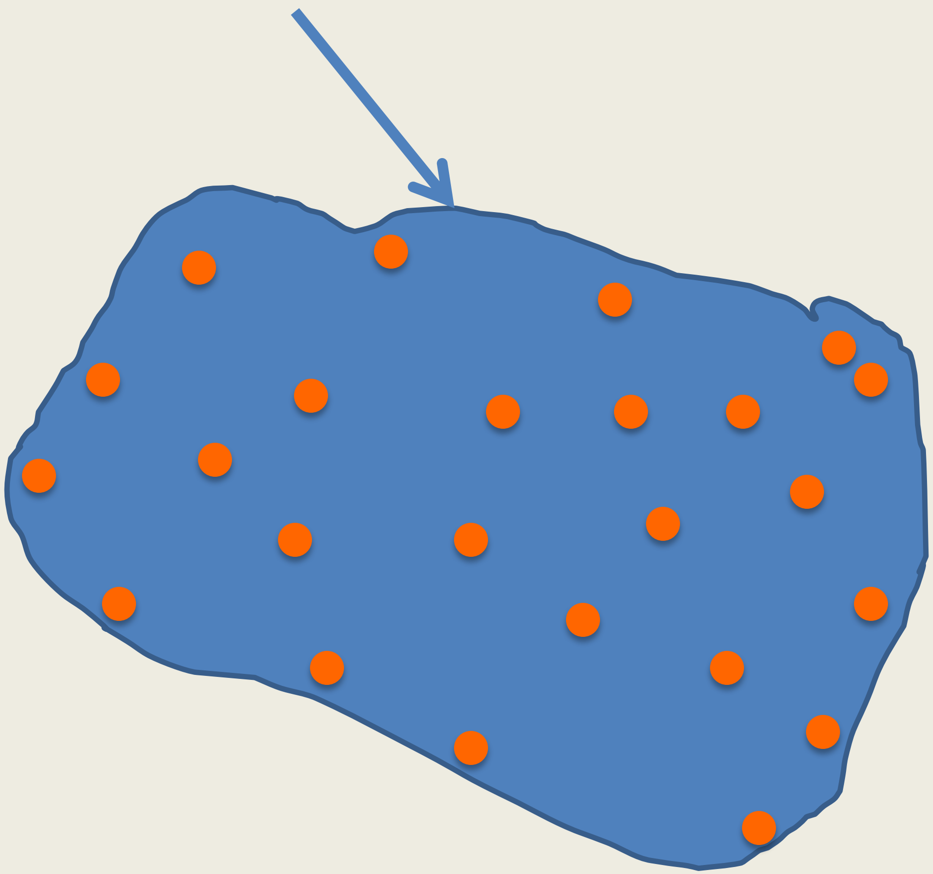
SELF-CONSISTENCY: Cross-Impact Balance (CIB)

Internal consistency determined by **self-consistency**



REPRESENTATVENESS: Scenario diversity analysis (SDA)

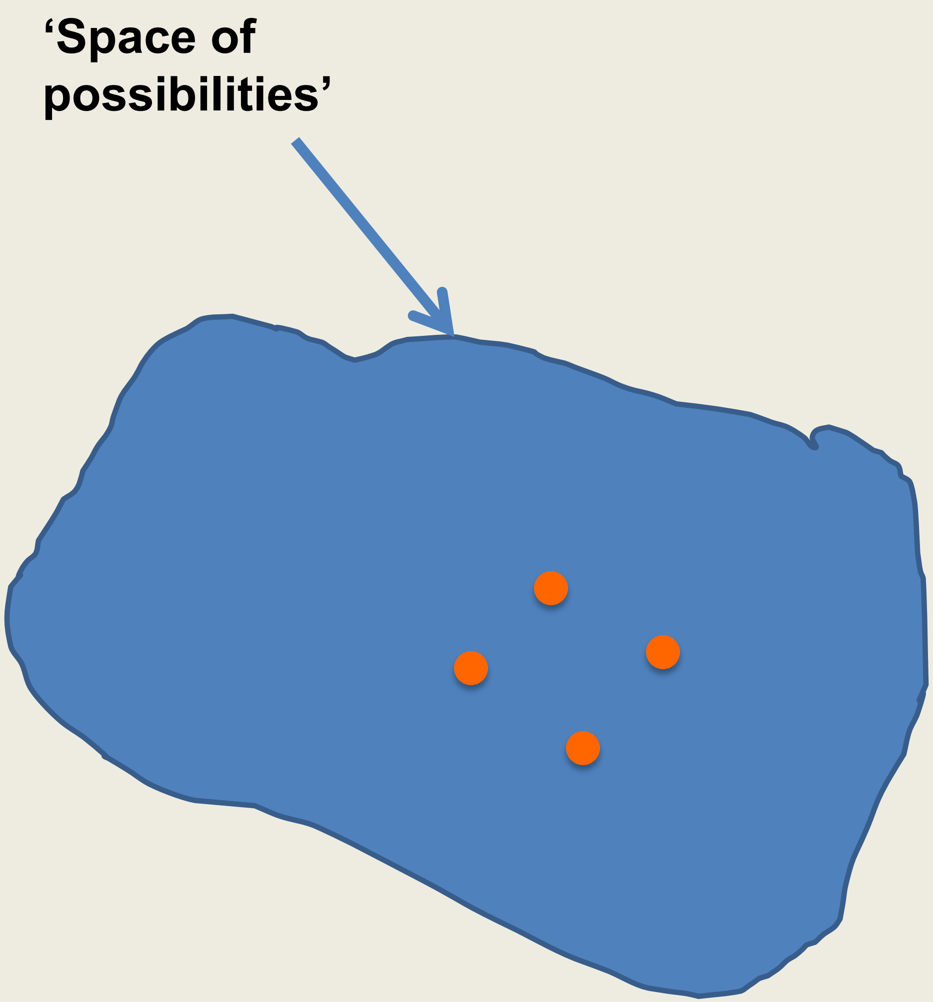
‘Space of possibilities’



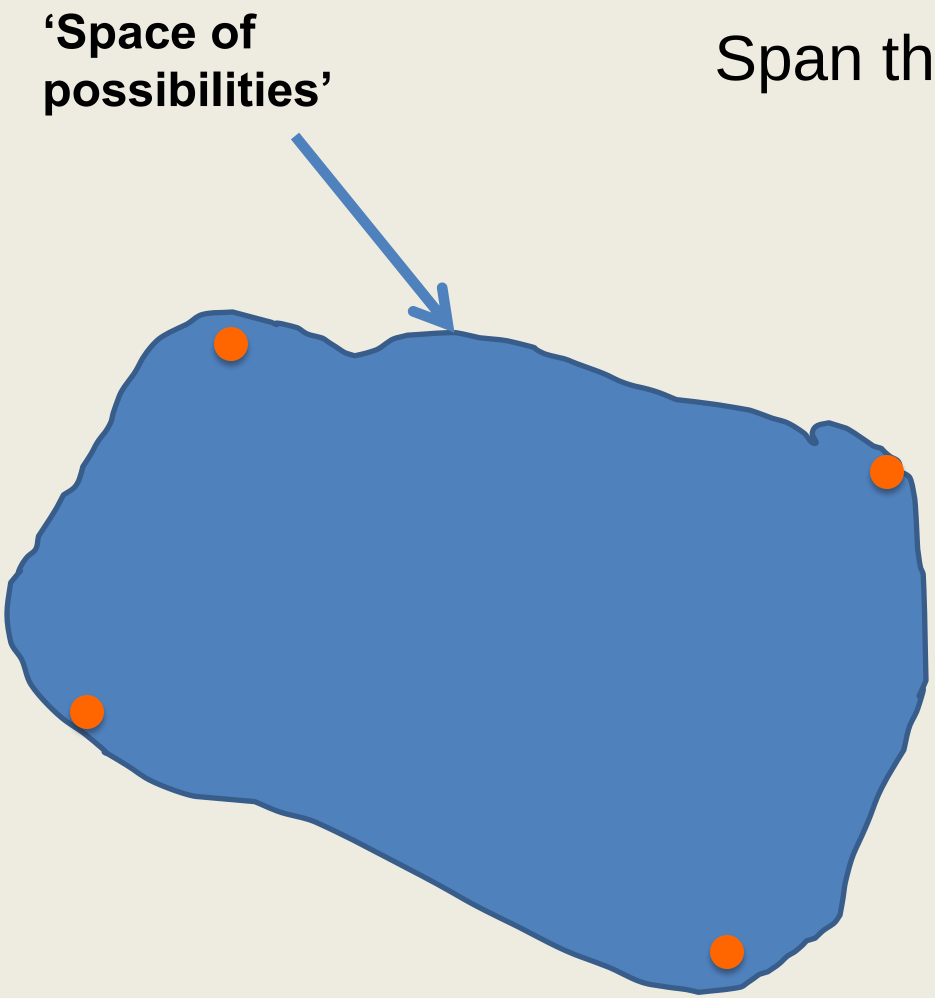
Would like to populate the whole space

However, for analytical tractability a selection is often made.

How to make the selection?



The same ‘world logic’ applied to all feasible scenarios risk getting a set with lack of balance.



Span the space!

In higher dimension, i.e. more drivers, this is a tricky problem.

We have therefore developed an algorithm for finding maximally spanning sets.

Carlsen et al. (2014), under review

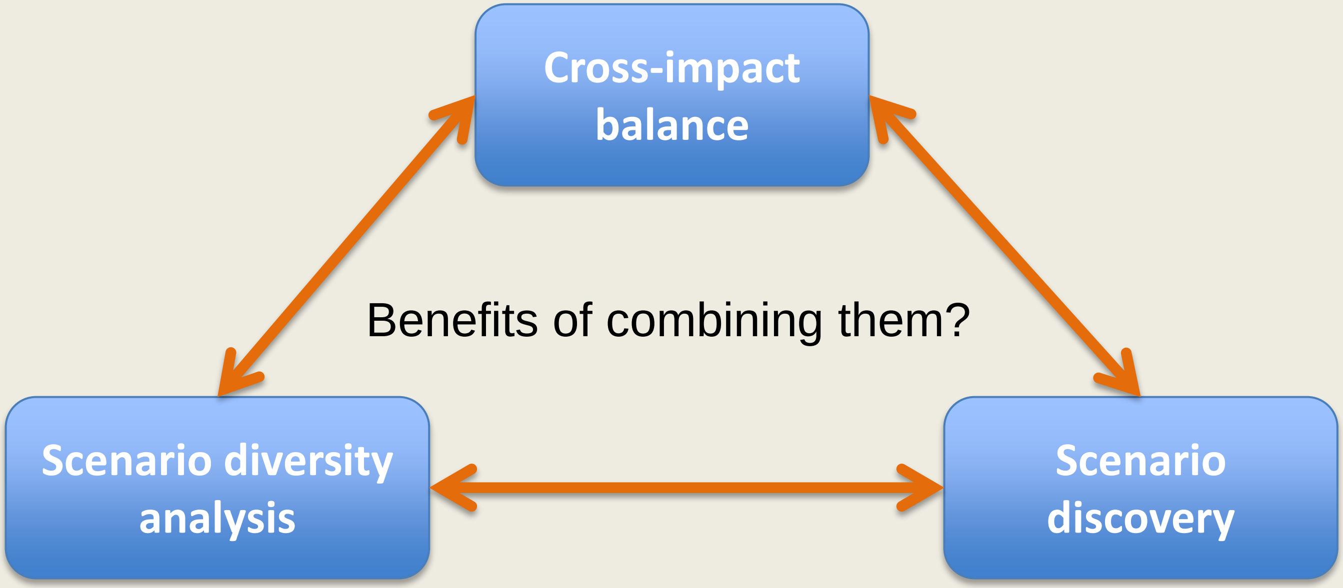
Analysis of different SRES scenario sets relative to calculated optima.

Scenario set	Number of possible scenario sets	Minimum distance	Mean distance
A1B, A2, B1, B2	$\sim10^{14}$	58%	82%
A1T, A2, B1, B2	$\sim10^{14}$	58%	80%
A1FI, A2, B1, B2	$\sim10^{14}$	58%	84%
A1B, A1T, A1FI, A2, B1, B2	$\sim10^{21}$	24%	88%
A1B, A2, B1	$\sim10^{10}$	79%	95%

Adding policy to the picture: Scenario discovery (cf. Key note)

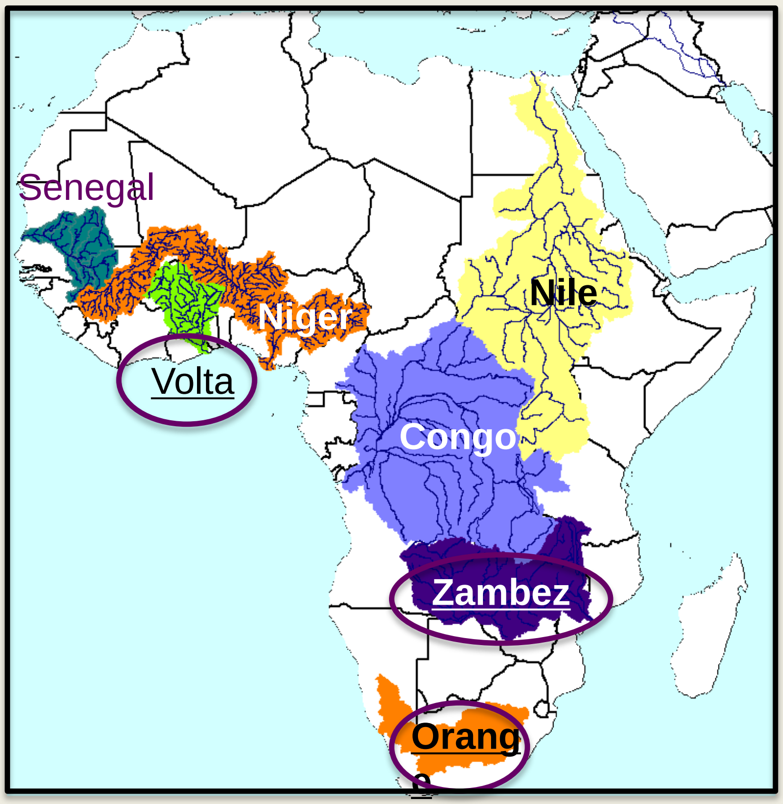
- Policies are *external* to CIB and SDA: Develop scenario and policies independently
- Scenario Discovery, on the other hand, *internalise* policies for developing scenarios that illuminates vulnerabilities of the policies.

Three quantitative techniques



World Bank Project Provides Example Testbed

Project examines **climate resilience** of long-term water and energy infrastructure **investment plans** in river basins across Africa



- Analysis considered here considers a wide range of climate futures
  - (22 in this test case; 121 in overall project)
- **Scenario discovery** identifies clusters of futures where these proposed investment plans do not meet their economic goals
- Project then seeks to calculate "perfect foresight" and "robust" adaptations for these scenarios
  - **How might a diversity analysis identify a small number of representative futures from each cluster to use in further analysis?**
  - How might a CIB analysis identify self-consistent combinations of other uncertainties (e.g. crop prices) used by the optimizers that inform the choice of adaptations?

The model set-up

- Using a model (WEAP - Water Evaluation and Planning System) to generate data on irrigation (I) and hydropower (H) for the three river basins.
- The model's output were mapped onto one of three possibilities:

Dry	if	$I < t_I^{Dry}$ and $H < t_H^{Dry}$
Wet	if	$I > t_I^{Wet}$ and $H > t_H^{Wet}$
Historical	if	neither of these conditions hold.

The thresholds were based on an analysis of Min and Max of I and H

The "input/output" morphological field

Model	Emission	Volta	Orange	Zambezi
bccr_bcm2_0	A2	Dry	Dry	Dry
cccma_cgcm_3_1	A1B	Hist	Hist	Hist
…	B1	Wet	Wet	Wet
…				
ukmo_hadgem1				

Inputs (Model, Emission) — Outputs (Volta, Orange, Zambezi)

The task is identify a set with 6 scenarios that diversely represent this structure.

We consider two types of diversity:

i) within a scenario

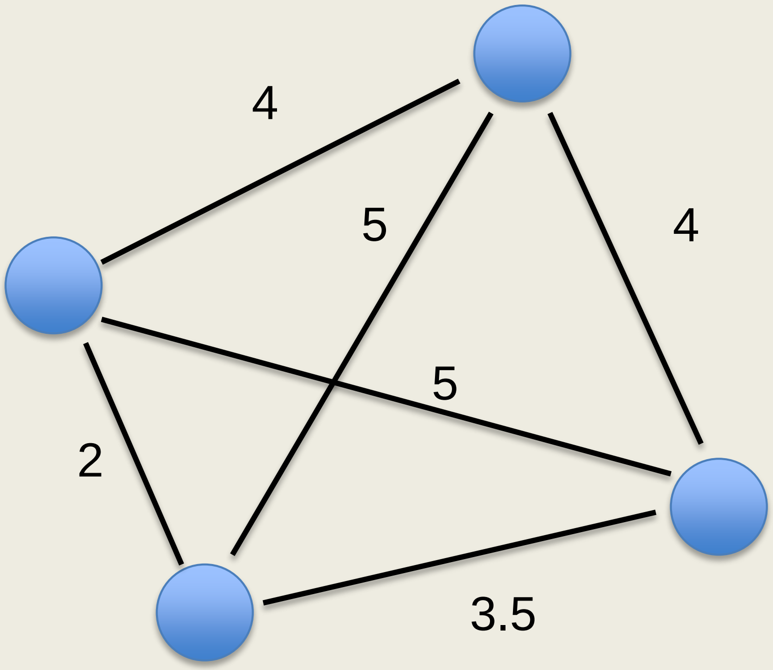
ii) between scenarios

- Within (D_w)
  (A2, Dry, Dry, Dry) has low D_w
  (A2, Dry, Wet, Hist) has high D_w

- Between (D_b)
  (A2,Dry, Dry,Dry) and (A1B,Dry, Dry,Dry) are close
  (A2,Dry, Dry,Dry) and (B1,Wet, Wet,Wet) are diverse

		D_w	
D_b		Small	Large
	Small		(A2, D, W, H) (A2, W, D, H)
	Large	(A2, D, D, D) (B1, W, W, W)	?

Two possible measures of diversity between scenarios (D_b)



Would like to have large values both for the minimum distance (D_b^{min}) and mean distance (D_b^{mean}), need to strike a balance:

$$\alpha * D_b^{min} + (1- \alpha) * D_b^{mean}$$

Strike a balance also between D_w and D_b

$$ß*D_w + (1- ß)* D_b =$$

$$ß*D_w + (1- ß)* [\alpha* D_b^{min} + (1- \alpha)* D_b^{mean}]$$

So, find the set with six scenarios (of the 163 350 possible sets) that maximises this function and subject to the boundary conditions:

(A2, ?, ?, ?) (A2, ?, ?, ?)

(A1B, ?, ?, ?) (A1B, ?, ?, ?)

(B1, ?, ?, ?) (B1, ?, ?, ?)

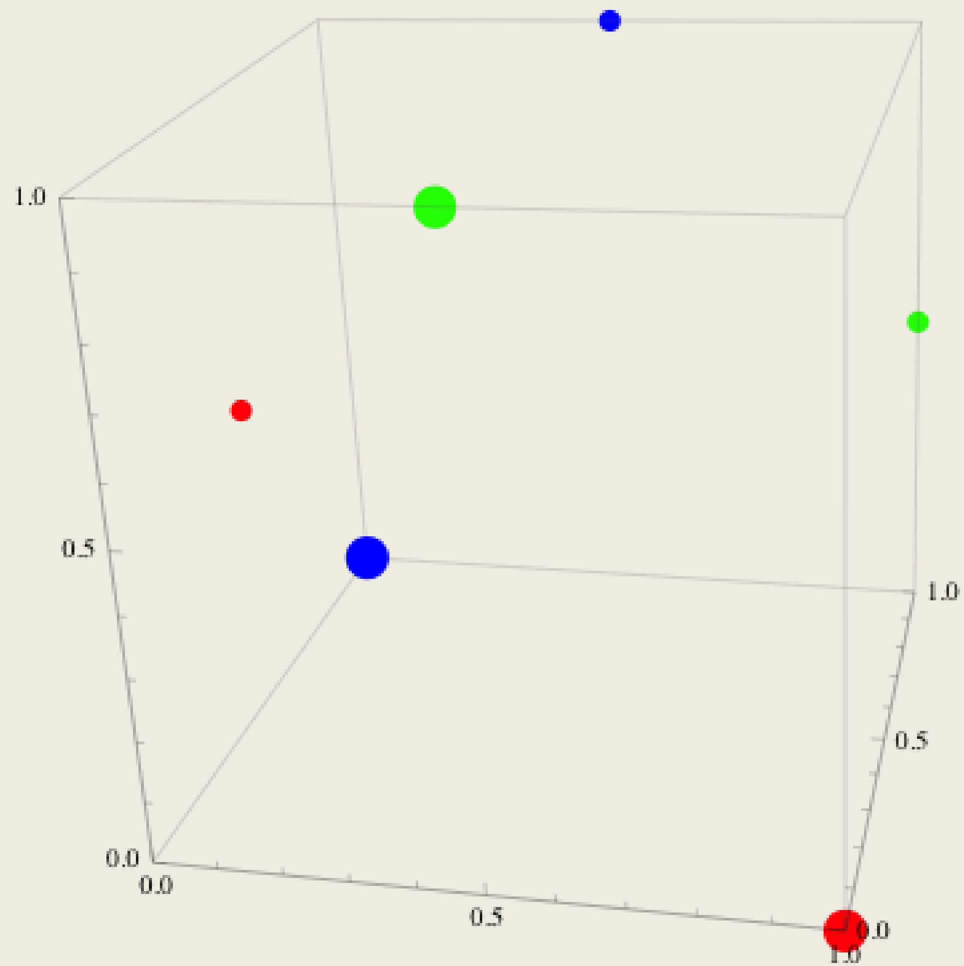
Results

Beta (alpha= 0.5)	#of sets	D_b mean	D_b min	D_w mean	Obj
0	1	2.233	1.5	1.33	1.861
0.25	3	2.1667	1.5	1.5	1.75
0.5	1	2.1667	1.5	1.5	1.667
0.75	1	2	0.5	2	1.813
0.99	3	2	0.5	2	1.993
1	3	2	0.5	2	2

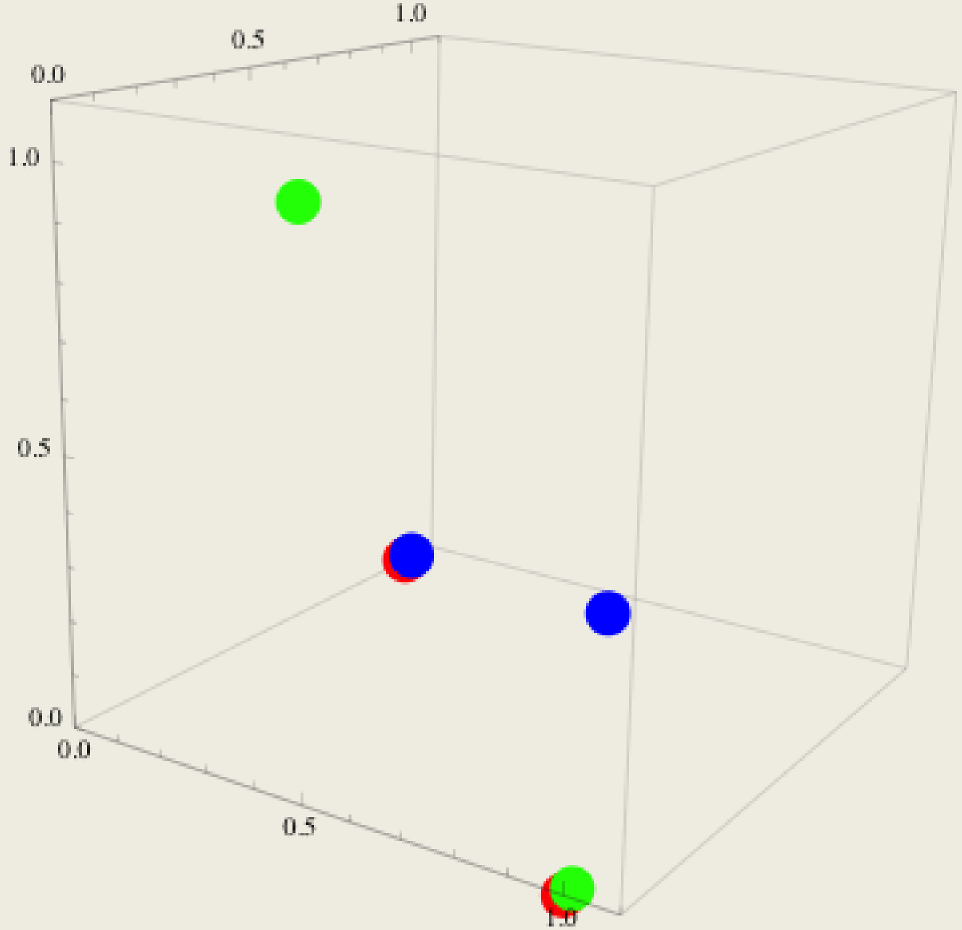
alpha (beta=0.5)	#of sets	D_b mean	D_b min	D_w mean	Obj
0	1	2.2	0.5	1.833	2.01667
0.25	1	2	0.5	0.5	1.8125
0.5	1	2.1667	1.5	1.5	1.667
0.75	3	2.1667	1.5	1.5	1.5833
1	64	2.033; 2.1	1.5	1.5	1.5

α = β = 0.5

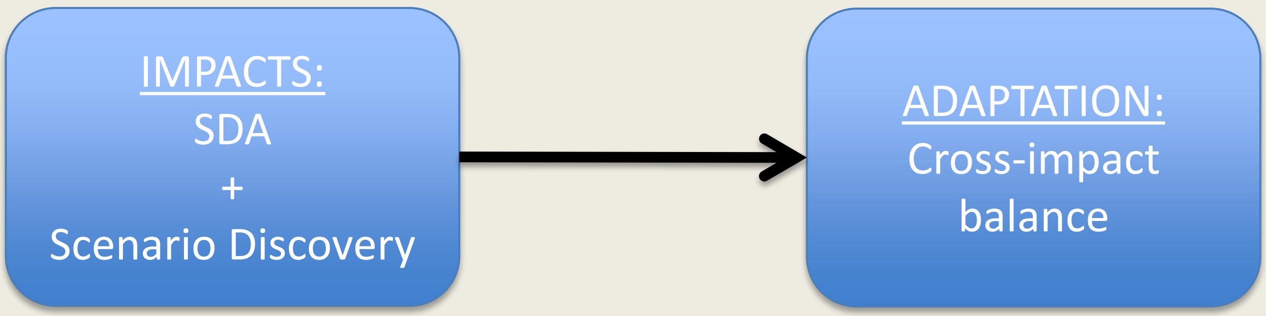
One color for each emssion scenario. The size is proportional to D_w.



α = 0.25 and β = 0.5, i.e. less focus on maximising D_b^{min}.



Bringing in cross-impact balance (Sketchy...)



Identified six representative scenarios

Several socioeconomic factors influence what are robust or optimal adaptation strategies.

Using CIB we'll identify a few consistent scenarios for analysing adaptation strategies.

Integrating SDA and Cross-impact balance

- CIB rank scenarios according to internal consistency.
- However, this method assumes the same consistency measure for all feasible future worlds.
- But, this could stand in contrast to spanning the space of possibilities
- Different scenarios should describe different world logic<u>s</u>
- Not to strike a balance also here!

Thank you!