Reliable adaptation policies to sea-level rise require incorporating complexity in economic models.

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The Urgent Challenge of Sea-Level Rise (SLR)

- Coastal adaptation is a massive economic challenge, involving hundreds of billions of USD per year to protect trillions in assets and about a billion people.
- Coastal adaptation could avoid potential damages ramping up to 10% of global GDP by 2100.
- Adaptation is vital due to committed SLR from climate inertia, even if global warming is stabilized.
- Substantial gaps remain in modelling the coupled biogeophysical and socio-economic dynamics of coasts.
- Multiple **issues with mainstream economic models** applied to adaptation to SLR

Methodology

- Knowledge co-production approach with an expert participants' workshop
- We collected, ordered, and linked key ideas discussed during the workshop "**Challenges in Modelling the Economics of Sea Level Rise**" held at San Servolo island (Venice, Italy) on 15th-16th May 2023. The first day of the workshop was designed to brainstorm about known problems, new ideas and possible solutions related to the theme of the workshop. The second day of the workshop was designed to follow a "convergent" approach, identifying avenues for methodological developments and integration.
- The key ideas raised during the discussion were collected into two groups: 1) Questions and Issues, and 2) Avenues for Solutions. The links between the elements of these groups were recorded and a map of linked concepts, reprojected into Sankey diagram and into two networks of (i) issues and (ii) solutions.

Limitations of Current Economic Approaches

- Assume rationality; ignore learning and behavioural responses.
- Overlook inequality and distributional impacts.
- Poorly account for indirect socio-economic losses (!)
- Make over-optimistic assumptions about adaptation proactiveness and effectiveness.
- Ignore trade-offs (e.g., protection exporting risk to nearby areas) and uncertain interlinkages between planned and autonomous adaptation.
- Omit systemic financial and geopolitical risks.

Specific Critiques of Dominant Models

Cost-Benefit Analysis (CBA):

- Focuses on aggregated expected values, omitting tail risks from extreme events.
- Ignores dynamic interactions and masks inequality between regions, actors, and generations.

Computable General Equilibrium (CGE) Models:

- Have coarse spatial resolution and omit complex dynamics.
- Underestimate damages due to:
  1. Assumptions of linearity and averaging, ruling out nonlinear tail risks.
  2. Ignoring responses of complex adaptive systems and tipping points.
  3. Poorly quantifying indirect damages, which can be an order of magnitude higher at a granular level.
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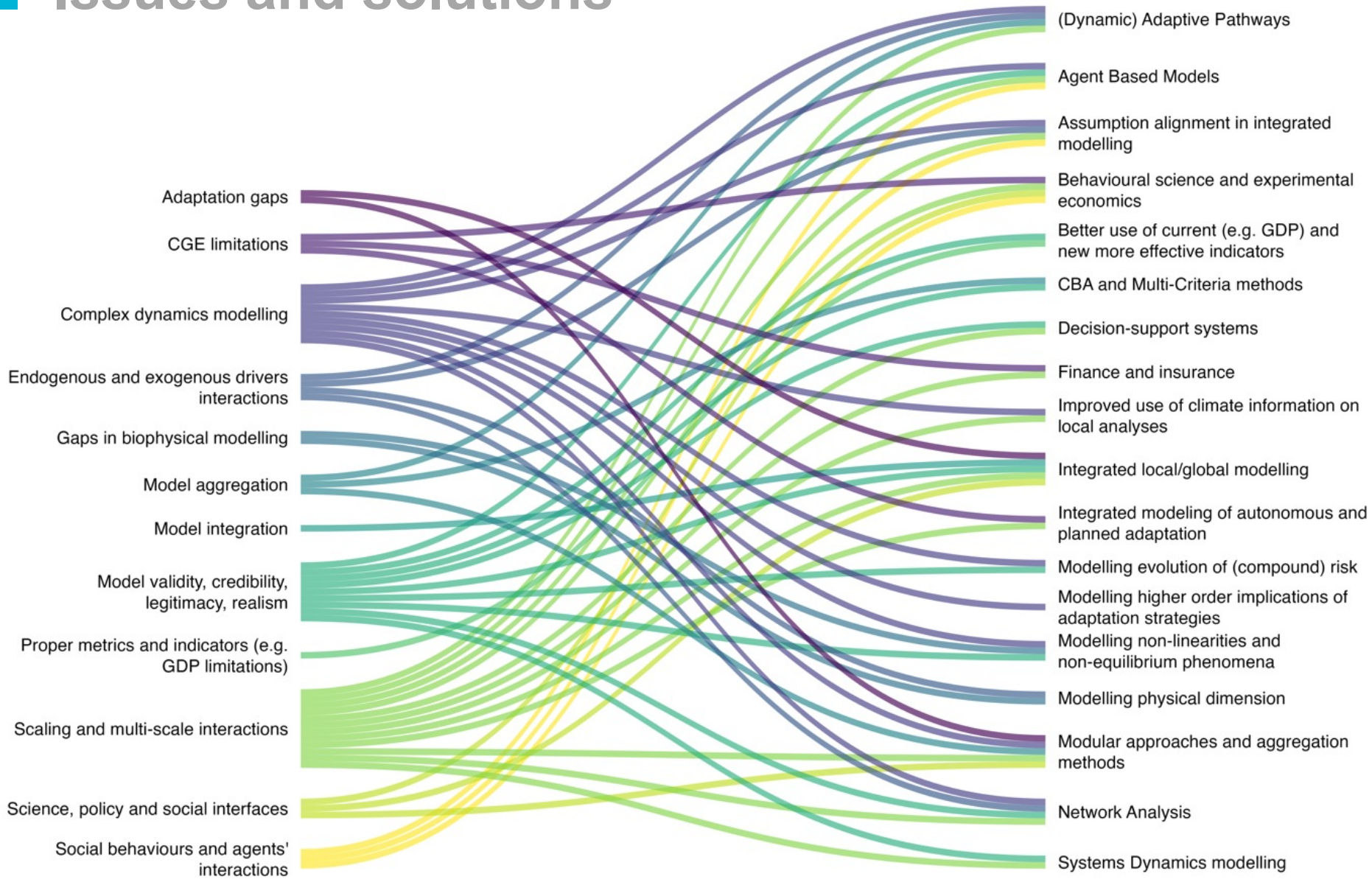
Issues and solutions



Solutions (1/3): A Complex Systems Approach

- **Key Challenge**: Better connect macro-level (sectoral investment) and micro-level models.
- Complex systems methods are essential to capture nonlinearities from multi-scale dynamics.
- Core **Solution 1**: Agent-Based Models (ABM)
  i. Simulate boundedly-rational agents
  ii. Improve representation of local adaptation constraints and distributional impacts
  iii. Can identify socio-economic tipping points
  iv. Improved depiction of emergent processes across scales

Solutions (2/3): Integrating Finance & Networks

Core **Solution 2**: ABM with Stock-Flow Consistent Finance

i. Captures effects of large-scale floods on bank credit risk (financial stability).

Core **Solution 3**: Complex Network Analysis

i. Fills the micro-to-macro gap.

ii. Models systemic risks (e.g., port disruptions) and individual behaviour.

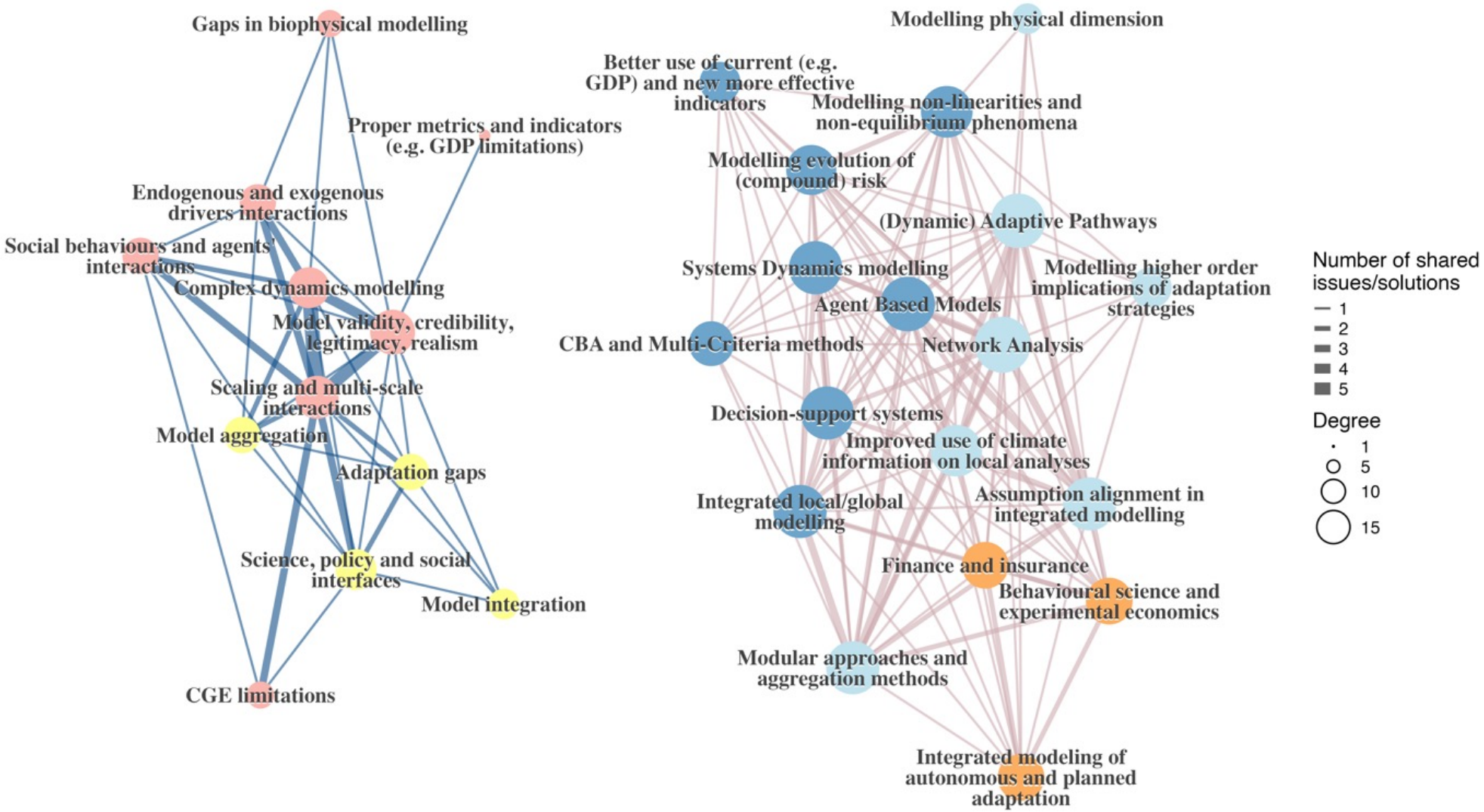
iii. Models cascades across regions and sectors

Solutions (3/3): Linking Physical & Social Dynamics

- Core **Solution 4**: Link Biophysical & Social Models
  i. Integrate probabilistic coastal models with simulations of social dynamics.
  ii. Enhances socio-economic equity assessments.

- Core **Solution 5**: Dynamic Adaptive Policy Pathways
  i. Assess interaction between autonomous and planned adaptation.
  ii. Account for future learning and the costs of switching pathways.

Visual summary



Conclusion

Improved models will:

- Mitigate **risk underestimation** and maladaptation.
- Avoid costly **lock-ins** and actions that exacerbate inequalities.
- Facilitate reliable decision-making from the near to the **long term**.
- Capture crucial interconnected **nonlinear dynamics** across domains and scales

Economic models for SLR must evolve and incorporate complexity for **effective and equitable adaptation policies.**

Thanks!

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