Towards an evidence base to support Power-to-X (PtX) decision-making in South Africa

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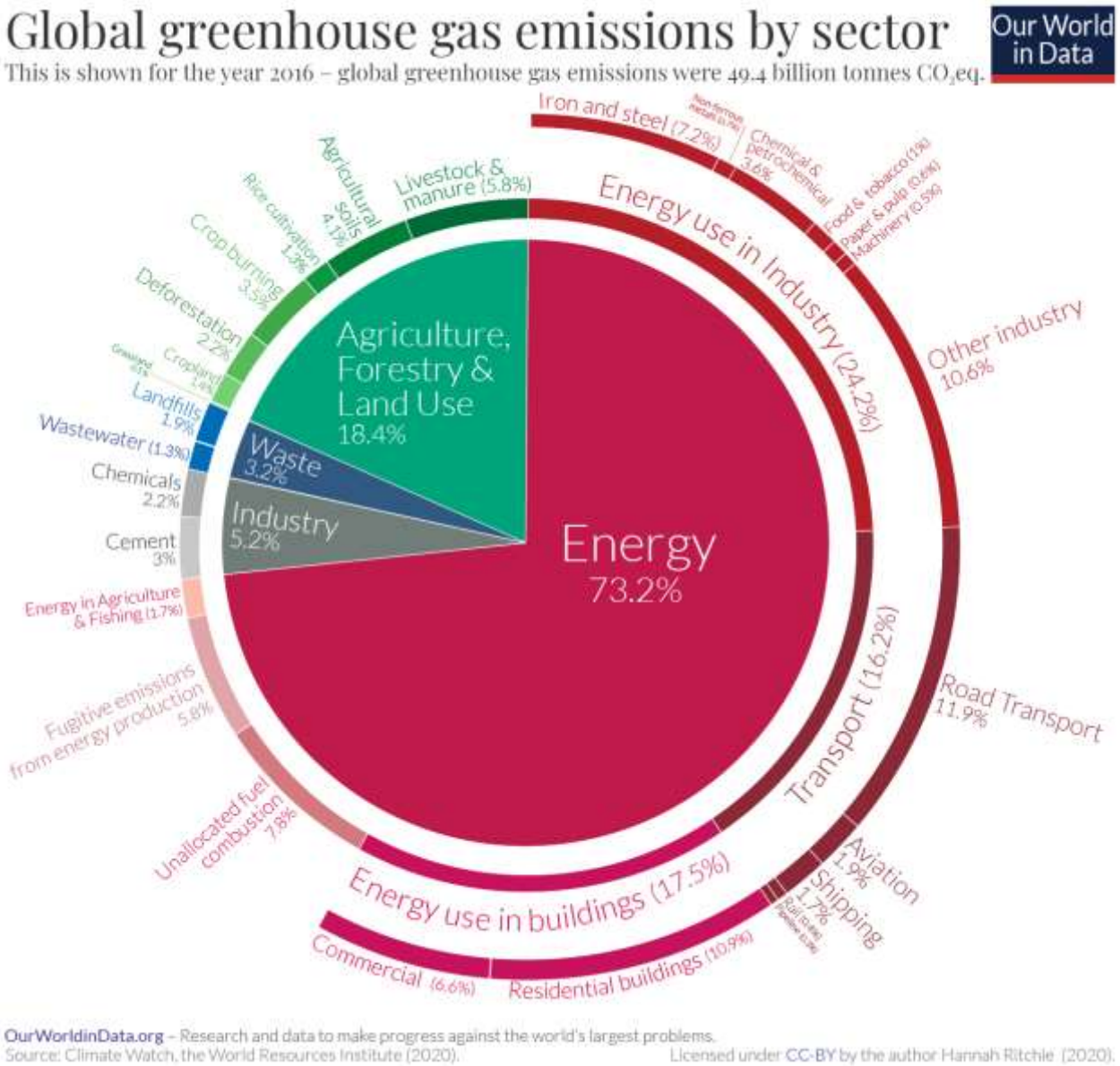
1. Introduction

*"Pathways limiting global warming to 1.5°C with no or limited overshoot would require **rapid** and **far-reaching transitions** in **energy**, land, urban and infrastructure (including **transport** and buildings), and **industrial** systems".*

(IPCC, 2018:15)

- **Solar and wind** → primary source.
- Liquid fuels → **"green" hydrogen-based fuels (Power-to-X)**
- **Transport** and **heat** → mostly **electrified.**
- Reliable electricity → **Batteries** and **chemical-based energy storage technologies .**

(Ives et al, 2021)



Source: Our World in Data - https://ourworldindata.org/emissions-by-sector

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Source: FutureEnergyFund - https://www.futureenergyfund.com/

1. Introduction

- PtX economy, incl. all its different components, stakeholders and applications, is a **complex and far-reaching industry**.

(IRENA, 2020)

- **Vast technologies and infrastructure** are required to create the electricity and water inputs to deliver PtX products.

- If developed at a sufficient speed, scale, and intensity, it could have **cumulative, unintended consequences.**

- **Methods to handle complexity** and **develop an evidence base** to support Power-to-X (PtX) decision-making in South Africa:

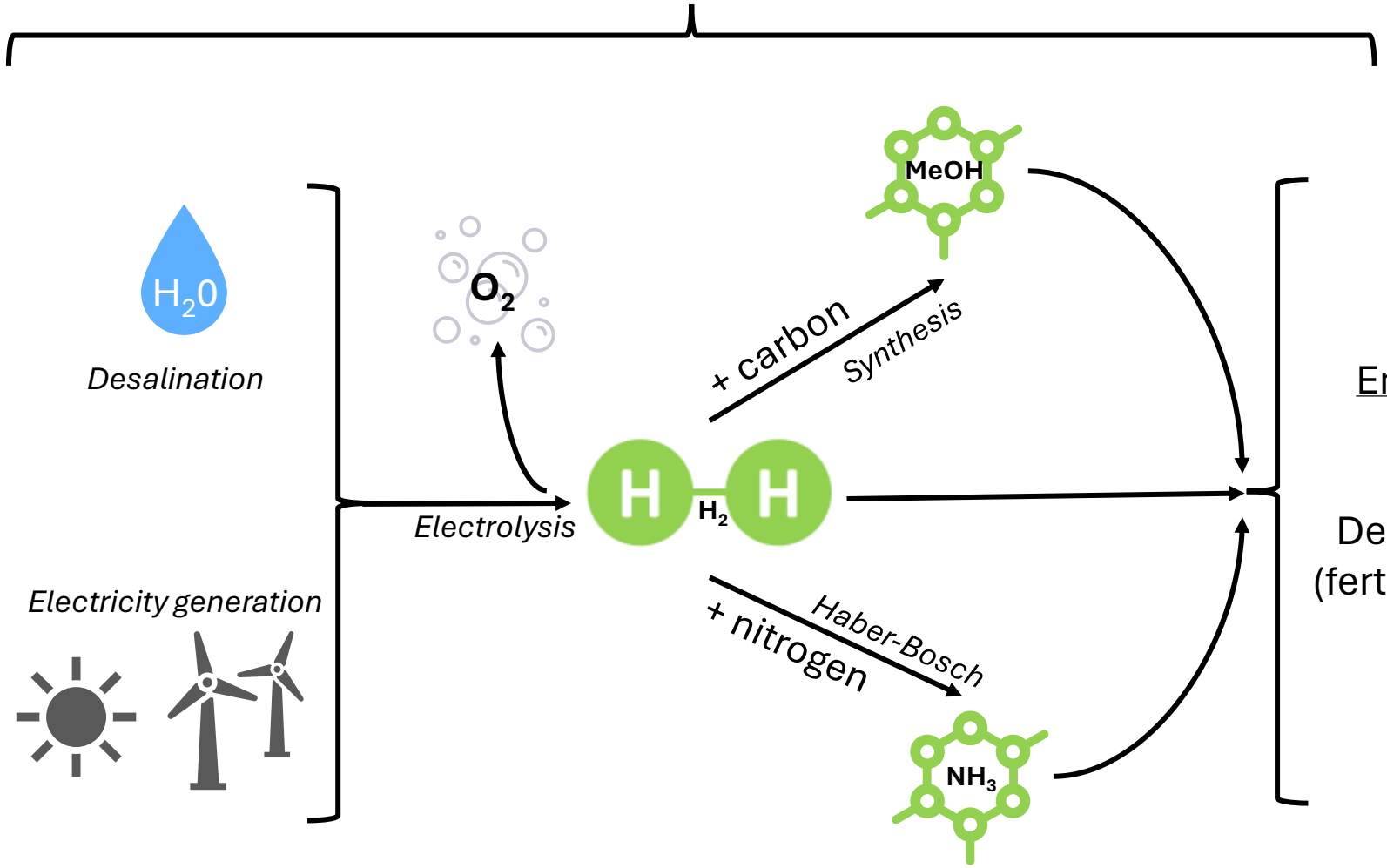
Systems thinking

Spatial analysis

Knowledge co-production

2. Understanding the PtX technological system

Storage, delivery and ancillary infrastructure
Batteries; transmission lines; pipelines; roads; tanks.

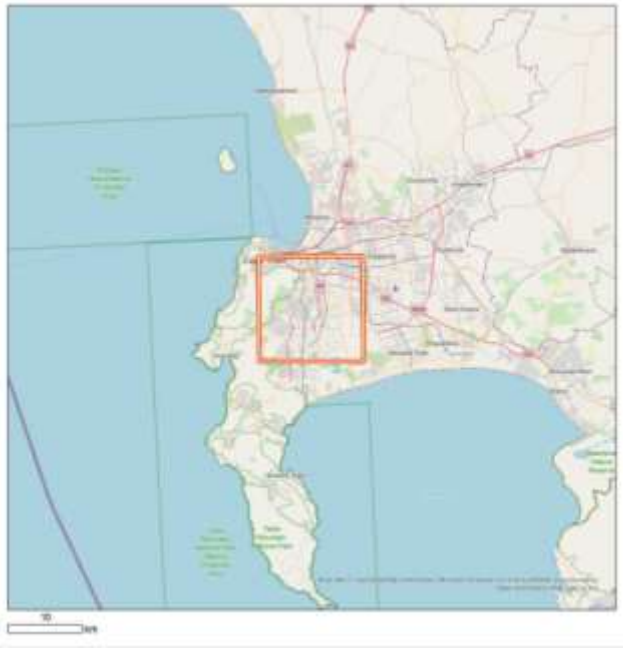


End-uses / markets
Energy carrier;
Heavy mobility;
Defossilise industries (fertilizer, cement, steel, synfuels).

Power (P) ----- to (t)---------- X

2. Understanding the PtX technological system

- South Africa's PtX ambition = **4 Mt GH_2** per annum (DTIC, 2022)
  = new-build RE in the order of **40 GW**,
  = land-take requirement in the order of **200 km²** * *(assume 2 MW/ha)*
  * only to power the electrolyser subsystem of the PtX technological system.



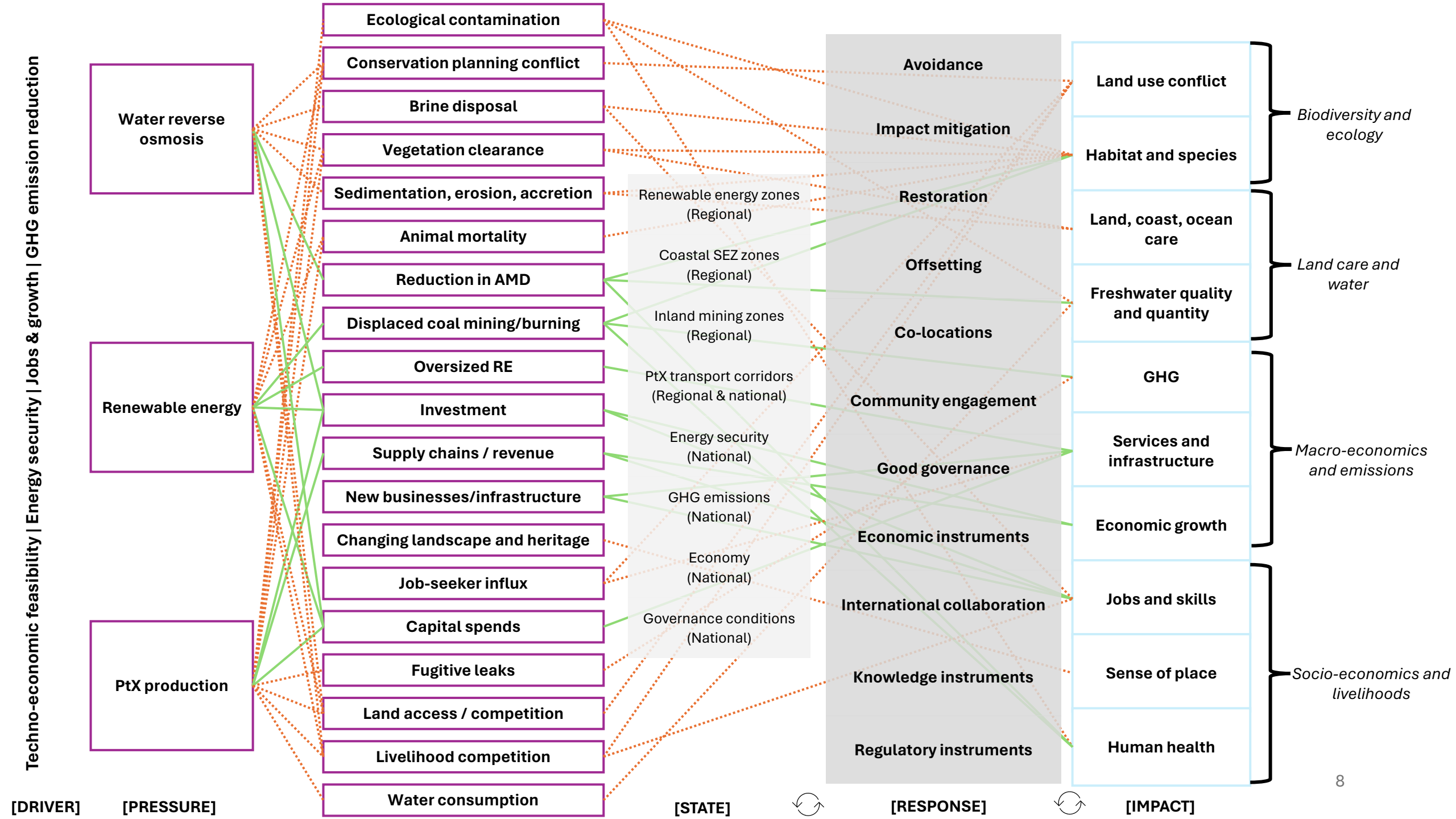
- **Land availability and conflict** may well be a main constraint facing PtX development.
- **Cumulative ecological and social footprints** could rapidly approach or exceed limits of acceptable change and thus undermine progress towards SDGs.

3. Contextualising potential benefits and risks

- Driver-Pressure-State-Impact-Response (DPSIR) causal framework to present a high-level synopsis of the key environmental and social impacts (+ −)

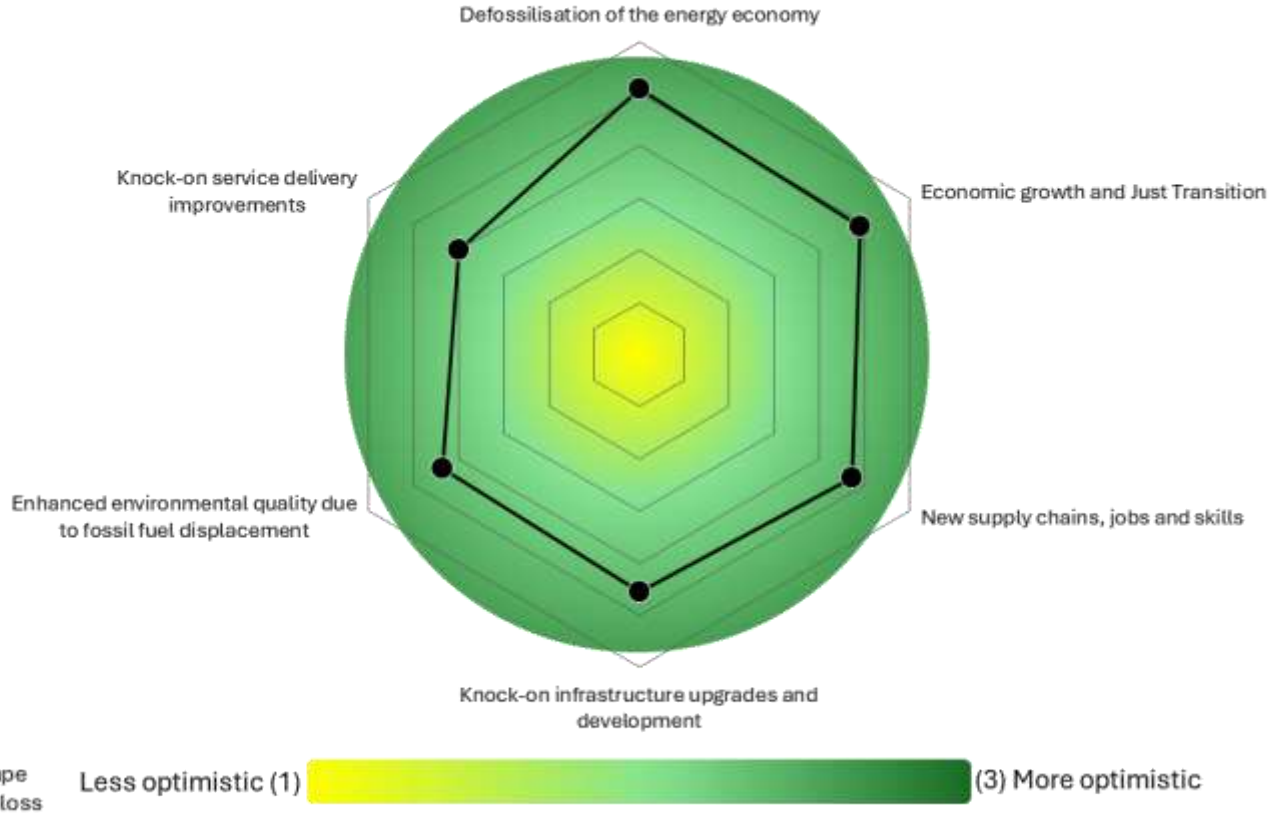
(Cooper, 2013; OECD, 1993)

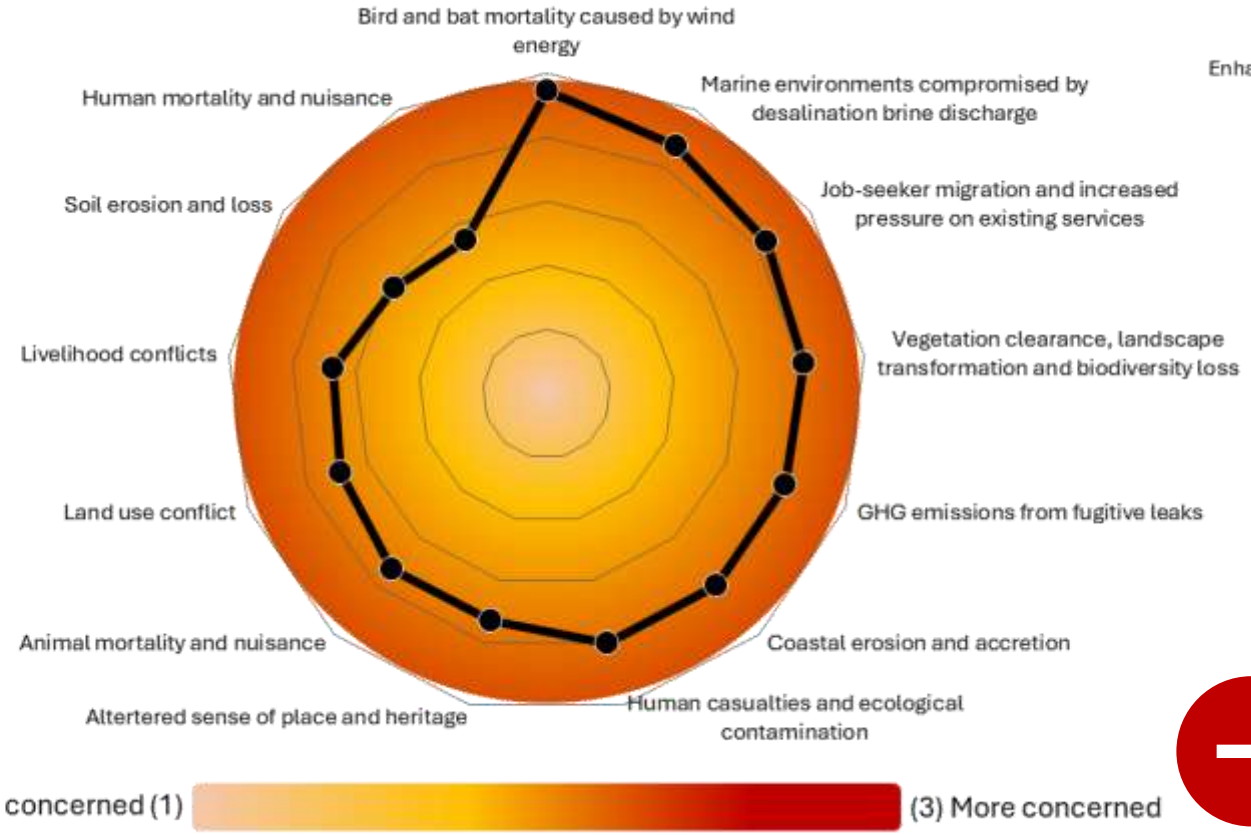
- **Driving forces** - global and domestic **trends** pushing forward a South African PtX economy.
- **Pressures** - direct mechanisms through which PtX activities and infrastructure will **positively and/or negatively affect** people and the environment.
- **States** - likely **baseline receiving environments** that will be affected.
- **Responses** - **options available for society to mitigate negative impacts and enhance positive ones** (implemented in anticipation of changing states or in reaction to changes that have manifested as impacts).
- **Impacts** are **net positive or negative effects** on biophysical and social environments that may arise from PtX activities.


Techno-economic feasibility | Energy security | Jobs & growth | GHG emission reduction
Water reverse osmosis
Renewable energy
PtX production
Ecological contamination
Conservation planning conflict
Brine disposal
Vegetation clearance
Sedimentation, erosion, accretion
Animal mortality
Reduction in AMD
Displaced coal mining/burning
Oversized RE
Investment
Supply chains / revenue
New businesses/infrastructure
Changing landscape and heritage
Job-seeker influx
Capital spends
Fugitive leaks
Land access / competition
Livelihood competition
Water consumption
Renewable energy zones (Regional)
Coastal SEZ zones (Regional)
Inland mining zones (Regional)
PtX transport corridors (Regional & national)
Energy security (National)
GHG emissions (National)
Economy (National)
Governance conditions (National)
Avoidance
Impact mitigation
Restoration
Offsetting
Co-locations
Community engagement
Good governance
Economic instruments
International collaboration
Knowledge instruments
Regulatory instruments
Land use conflict
Habitat and species
Land, coast, ocean care
Freshwater quality and quantity
GHG
Services and infrastructure
Economic growth
Jobs and skills
Sense of place
Human health
Biodiversity and ecology
Land care and water
Macro-economics and emissions
Socio-economics and livelihoods
[DRIVER]
[PRESSURE]
[STATE]
[RESPONSE]
[IMPACT]

3. Contextualising potential benefits and risks

- Statements on impacts were distributed to a multi-disciplinary WG (n=18).
  - positive impacts (⊕) - rate level of optimism,
  - negative impacts (⊖) - rate level of concern.





- Integrated & multidisciplinary perspective.
- Highlight **perception** of which negative impacts posed the greatest risks, and which positive impacts may present the greatest opportunity.

4. Data driven decision-support

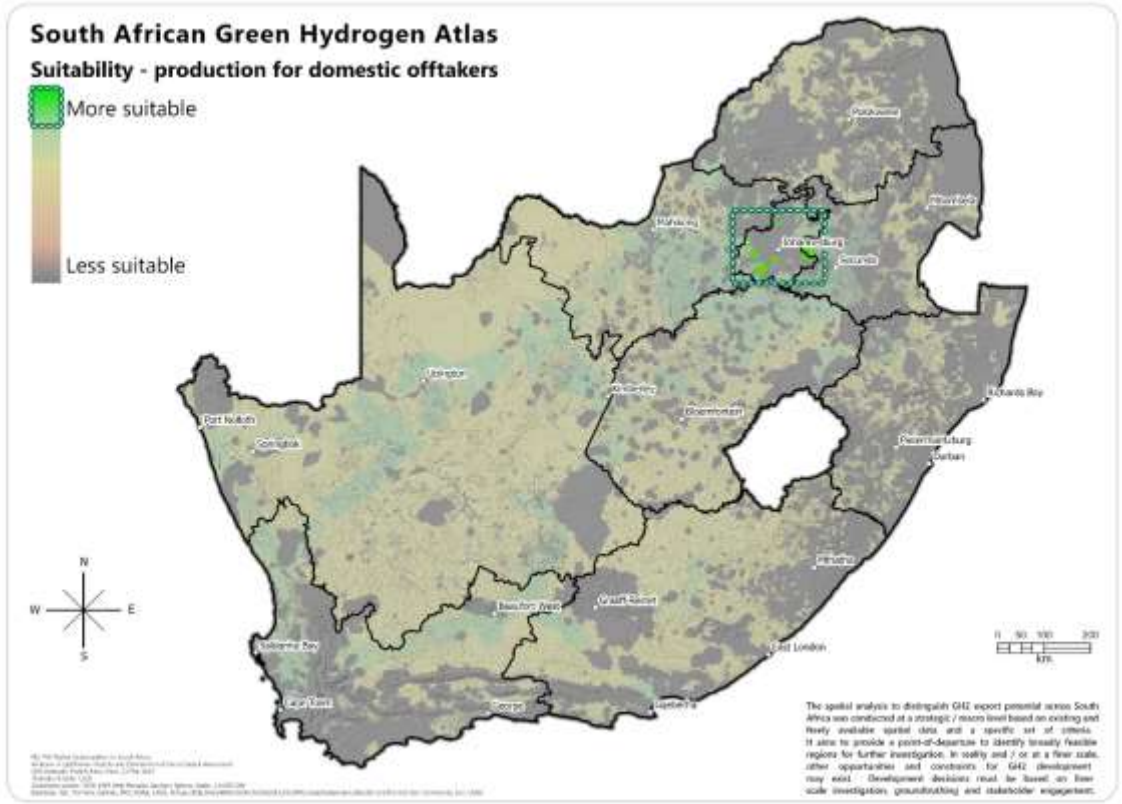
- **Spatial analysis →identifying suitable and optimal areas**, based on a range of environmental, economic, and social parameters, for important infrastructure developments.

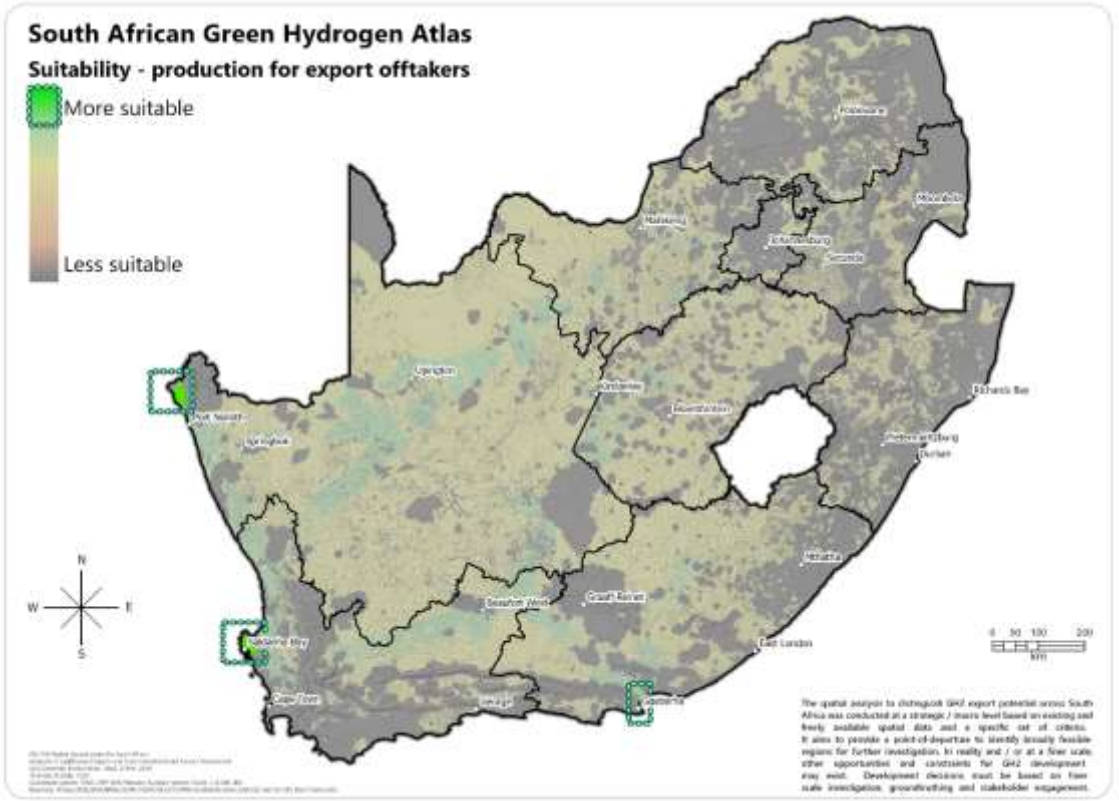
(DEA, 2015; Latinopoulos & Kechagia, 2015; Sánchez-Lozano et al., 2014; Messaoudi et al., 2019).

- South African Green Hydrogen Potential Atlas -
  - Spatially explicit siting variables which constituted 'push'- or 'pull' factors
  - Variables were assigned relative importance (weighted) with scores developed through interdisciplinary consultations within the WG.
  - Weighted overlay Multicriteria Analysis.

Variables considered in a spatial Multi-Criteria Analysis represented 'push' (< >) and 'pull' (> <) factors to determine suitable regions for PtX production in South Africa, considering both domestic and export markets.

Increasing relative importance →		Domestic Market	Export Market
	Environmental safeguards (restricted)	Protected Areas <>	
		Heritage features <>	
		Watercourses and wetlands <>	
	Landuse and safety (restricted)	Population density <>	
		Built-up areas (urban) <>	
		High-value agriculture <>	
	Offtaker	Local industries (cement, steel, synfuel, oil) ><	Export ports ><
	Renewable energy	Solar & wind potential ><	
	Water	Desalinated seawater ><	
		Acid mine drainage regions ><	-
		Coal fired power stations ><	-
	Enabling infrastructure	Electricity grid ><	
	Environmental safeguards (non restricted)	Important Bird Areas (wind) <>	
		Conservation Areas <>	
		Steep slopes <>	
	Landuse and safety (non restricted)	Other agriculture <>	
		Built-up areas (industrial) ><	
	Policy alignment	All Special Economic Zones (SEZs) ><	Export port SEZs ><
		Renewable Energy Development Zones (REDZ) >< and Electricity Grid Infrastructure (EGI) corridors ><	

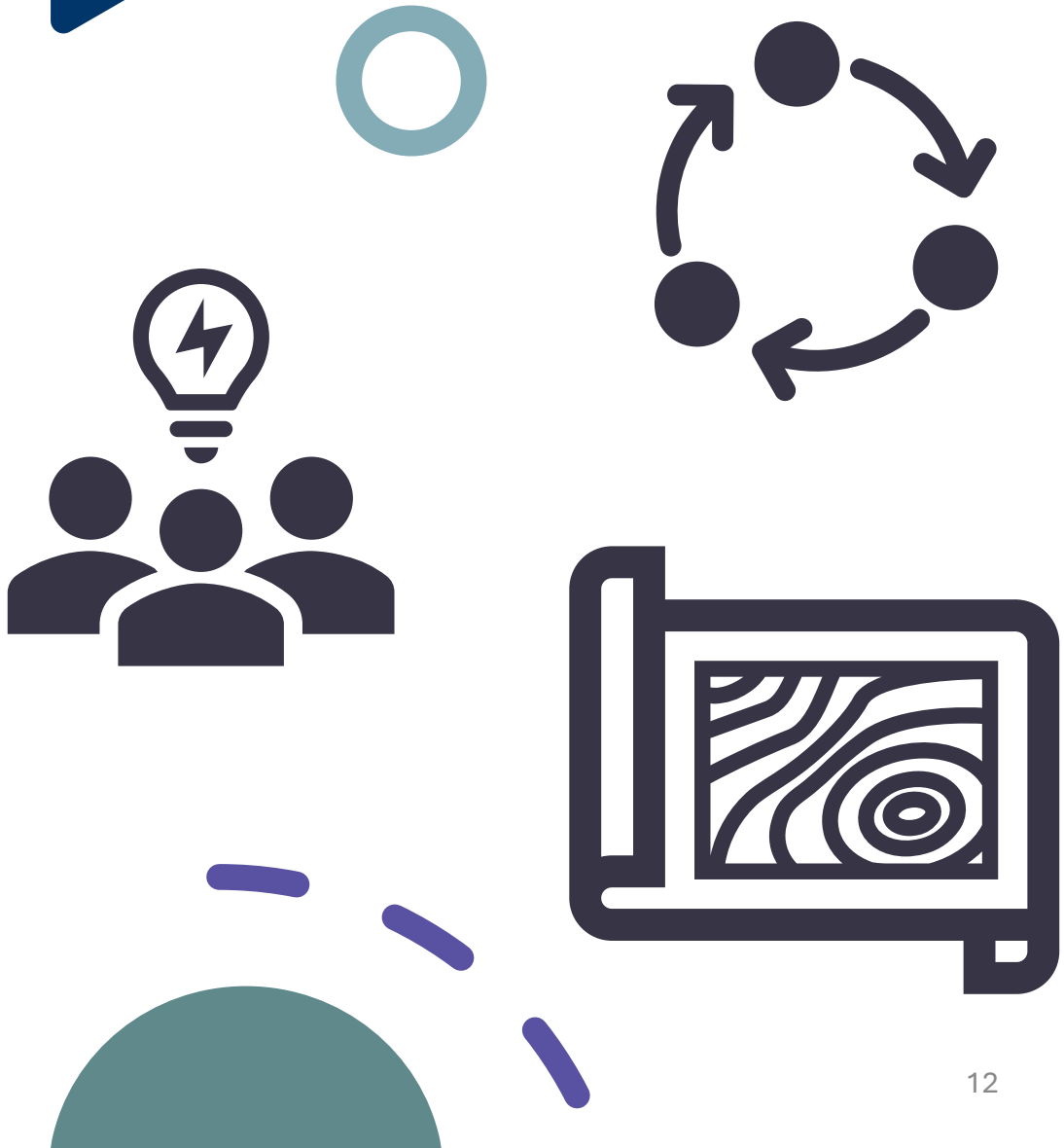




- High-level decision support tool.
- Queryable webmap.
- Understand the underlying attributes driving GH_2 export potential score.

5. Conclusion

- **Foundational evidence base** for future planning, assessment and decision-making on PtX –
  - **Systems thinking,**
  - **Knowledge co-production,**
  - **Spatial analysis.**
- Looking forward - science-policy interfaces:
  - **Strategic Environmental Assessment (SEA), for policy/programme-level guidance.**
    - Integrated, holistic,
    - Development trends,
    - Scenarios,
    - Landscape modelling.
  - **Environmental Impact Assessment (EIA), for project-level guidance.**



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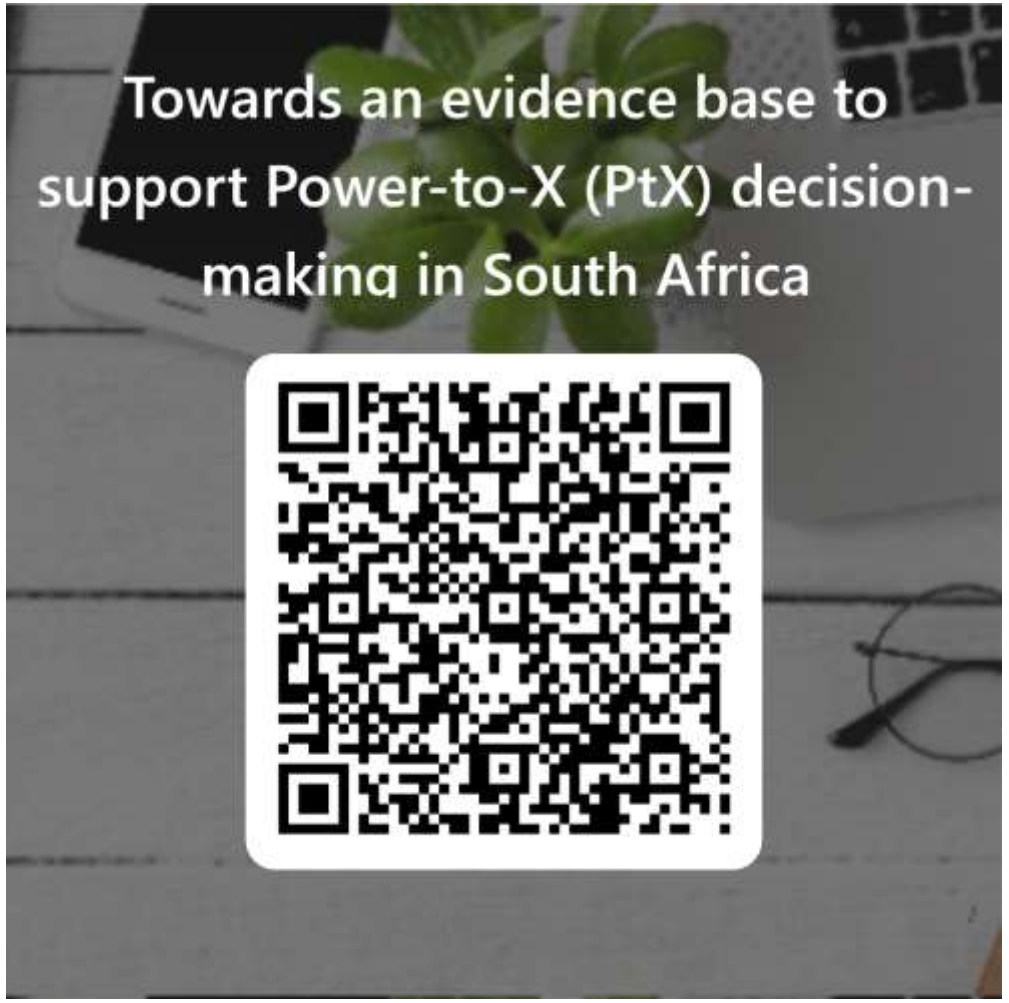
7. Thanks, Acknowledgements and survey

The project Working Group, consisting of representatives from various private and public organisations in engineering, sustainability science and policymaking, provided invaluable input.

Please tell us what you think!

To measure performance / impact of our work, please take a moment to fill out this short survey – thank you!



Let’s continue the conversation!

Post questions and comments in the IAIA24 app.

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