Sustainable Power-to-X development in South Africa

Luanita Snyman-van der Walt
Dr. William Stafford
Dr. Valentina Russo
Dr. Taahira Goga

Council for Scientific and Industrial Research (CSIR)
South Africa

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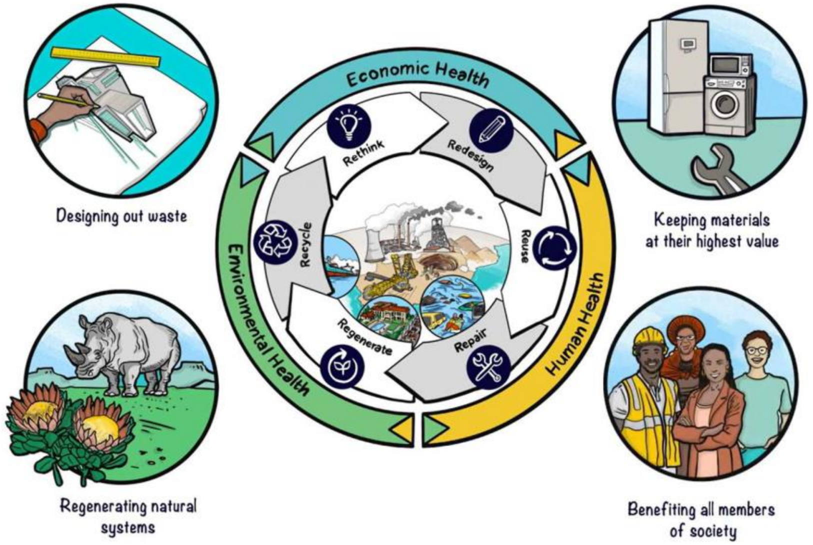
Sustainable Power-to-X development in South Africa
Sustainability, Circularity, Resilience, Social Acceptance

- **H2.SA programme –**
  - **Project:** H2 PtX Market Opportunities for South Africa: Analysis of Lighthouse Projects and Environmental-Social Impact Assessment.
  - **Foundational evidence base** for future planning, assessment, decision-making, and R&D on PtX development in view of social acceptance, circularity, resilience and sustainability.
    - Site selection and landscape modelling.
    - Life Cycle Assessment.
    - Social Life Cycle Assessment.
  - Case study – Saldanha Bay Hub (SBH), South Africa.



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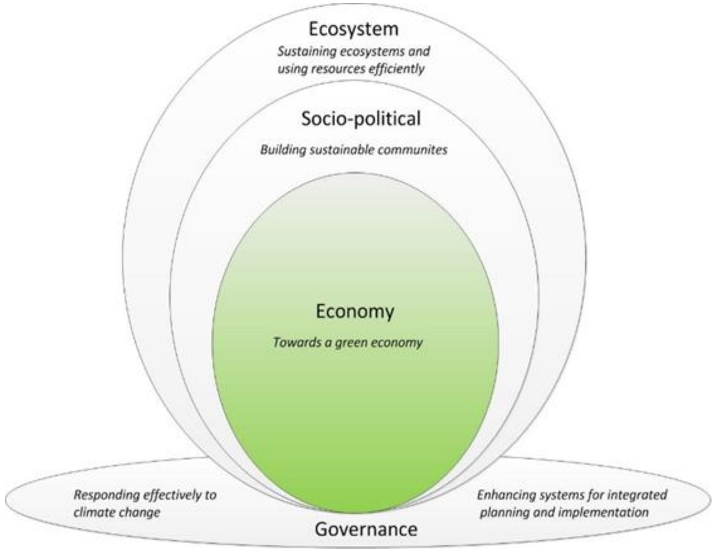

The National Strategy on Sustainable Development (NSSD) view of sustainability (DEA, 2011)

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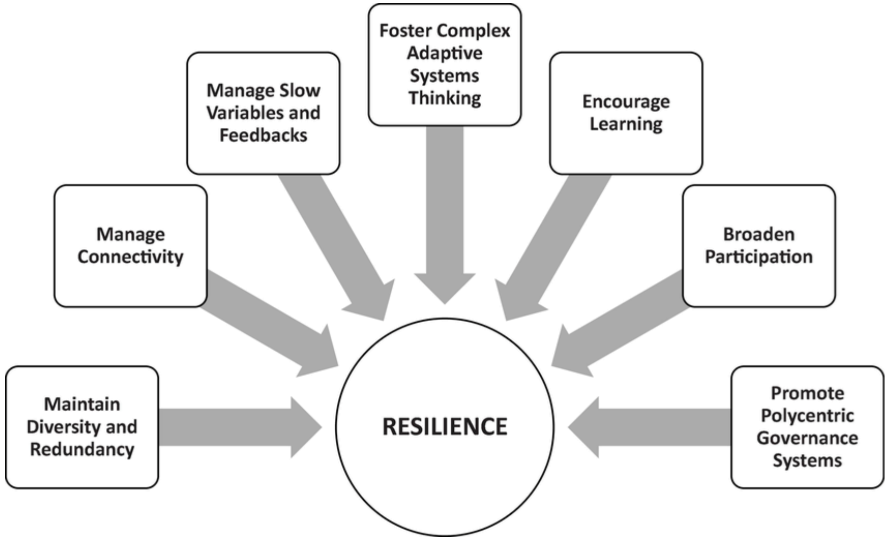

Principles for building resilience (Biggs et al., 2015)

1 Project Title

H2/PtX-Market Opportunities for South Africa - Analyses of Lighthouse-projects & Environmental-Social Impact Assessment

2 Project Timeline

11/2022 - 02/2025

3 Project work packages

WP1: Mapping of suitable sites for H2/PtX production
WP2: Prefeasibility studies for selected H2/PtX lighthouse projects
WP3: E&S impacts of GH2/PtX projects in SA
WP4: Handbook "How to do an EIA for H2/PtX projects"
WP5: Developer's Guide for H2/PtX Projects

4 Project Objectives

- **To improve the conditions for companies to participate in a South African H2 economy**
- **To improve relevant stakeholders' knowledge of the potential E&S impacts of a hydrogen economy**

5 Implementer Consortium

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South African Green Hydrogen Profile

Special Economic Zones / Industrial Development Zones
which present opportunities in the SA GH2/PtX landscape vis-a-vis international competition

Lighthouse selection

Determine criteria and select "lighthouse technologies / applications", i.e. GH2 technologies / applications presenting the best opportunities given the SA GH2 landscape

'Lighthouse' technologies / application selection

Ammonia | Methanol

Saldanha Bay | Richards Bay | Coega | Boegoebaai

GH2 Potentials atlas (export & domestic) (WP1)
Maps showing suitability for selected lighthouse technologies / applications based key spatial criteria e.g. RE potential, proximity to infrastructure, environmental constraints – national extent

Life Cycle Assessment (WP2)
LCA for the green ammonia project

3 Blueprint Pre-feasibility studies (PFS) (WP2)
1) techno-economic PFS green ammonia
2) financial PFS green ammonia
3) techno-economic & financial PFS green methanol

Environmental & social impact and opportunities scoping study (WP3)

Investment Profiles (WP2)

Showcase of GH2/PtX complementary investment opportunities and challenges of selected South African SEZs/IDZs
(in a competing global market)

Audience: investors, SEZ/IDZ, developers

GH2 Cost Model & emission reduction tool (WP1)
LCOE, LCOH, LCOA, LCOM

EIA guideline (WP4)

"How to" / Key considerations for GH2/PtX EIA
Audience: practitioners, specialists, authorities

Developer's Guide (WP5)

"How to" / Key considerations for GH2/PtX project development.
Audience: development proponents, investors, authorities

PtX Scenarios Saldanha Bay Hub (WP4)
1) Spatial footprint and landscape modelling
2) Social Lifecycle Assessment
3) Macroeconomic benefits
4) NDC coherence

Study on share infrastructure (WP2)

Green Box = deliverable

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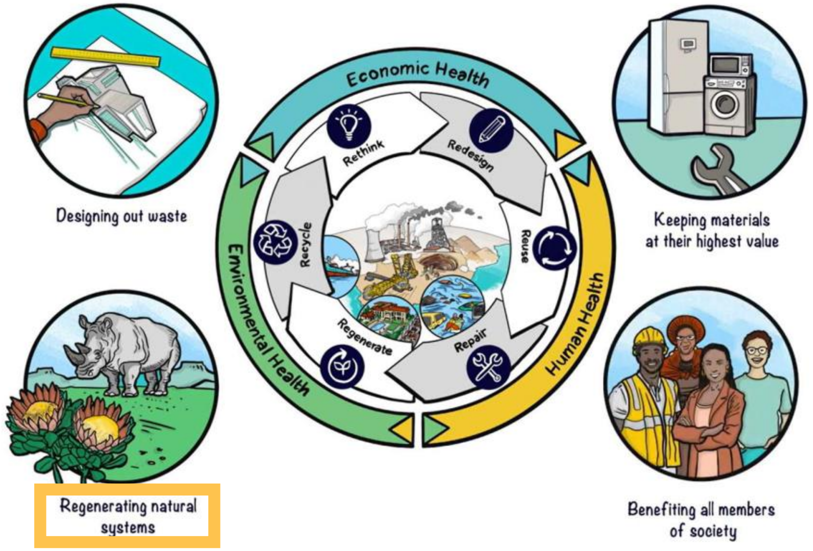

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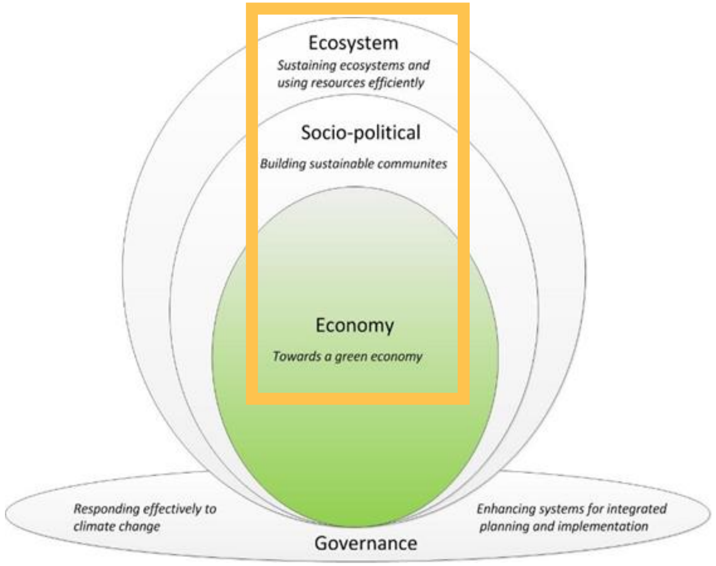
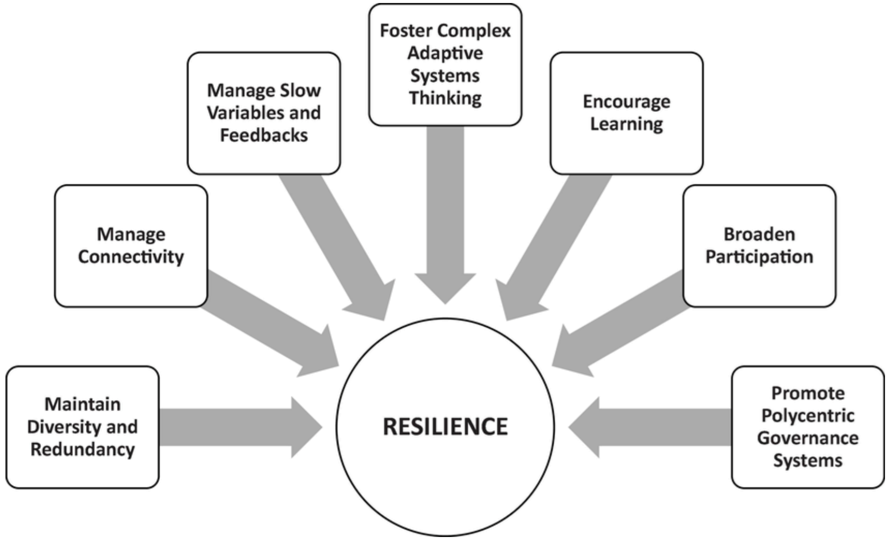


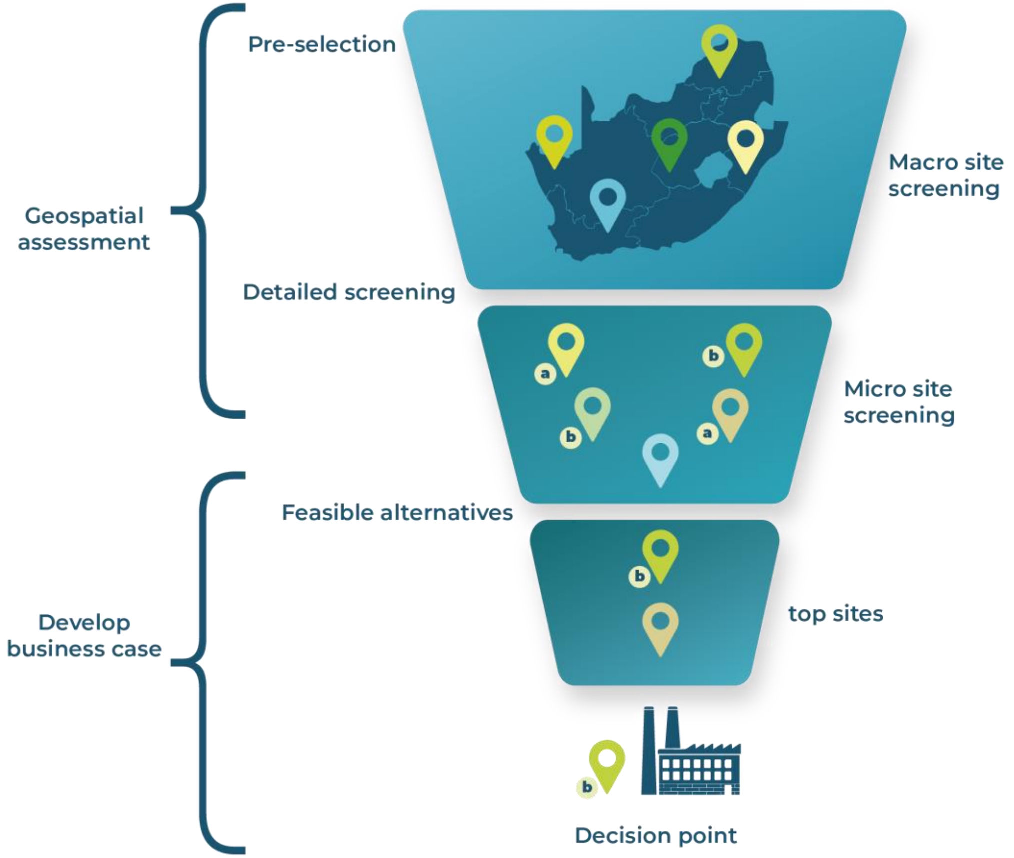
National Strategy for Sustainable Development and Action Plan (DEA, 2011)



Principles for building resilience (Biggs et al., 2015)

Finding space (that promotes sustainability)

- **"Where"** is often driven by techno-economics, but…
- Increasing attention to **environmental feasibility**:
  - **Resilience, social acceptance, sustainability.**
- **Planning PtX development from the point of departure → first, avoid (-) impacts.**



Management action type	Description
Avoidance	**Proactively identifying and steering clear of sensitive areas. Usually includes GIS mapping of areas with fragile ecosystems, or places of cultural and historical importance, so they are identified as early as possible.**
Mitigation or enhancement	In the case of negative impacts, when avoidance is unfeasible, mitigation can minimise effects. Impact enhancement should be sought by the EAP when impacts may result in beneficial outcomes.
Restoration	Aims at returning disturbed or degraded ecological habitats, or social and cultural assets, to their original state post-construction, so they can continue to support humans and nature.
Offsetting	Where residual impacts cannot be avoided or mitigated. Restoration involves creating or enhancing equivalent habitats or areas in other locations to compensate for these impacts.
Technology/design alternatives or colocation synergies	Some PtX technologies may be more environmentally friendly and/or synergistic with existing land-uses or infrastructure. An example is Agrivoltaics, which combines the installation of solar panels with agricultural activities.
Local beneficiation and local contracting	At local scale, applying rules like those required in the enhanced Social and Labour Plans (SLPs) in the mining industry could ensure that socioeconomic opportunities are maximised for local people.
Regulatory / planning instruments	Enforcing regulations and standards, integrating planning strategies like IDPs, EMFs, SDFs to minimise harms or increase benefits of the proposed PtX developments.

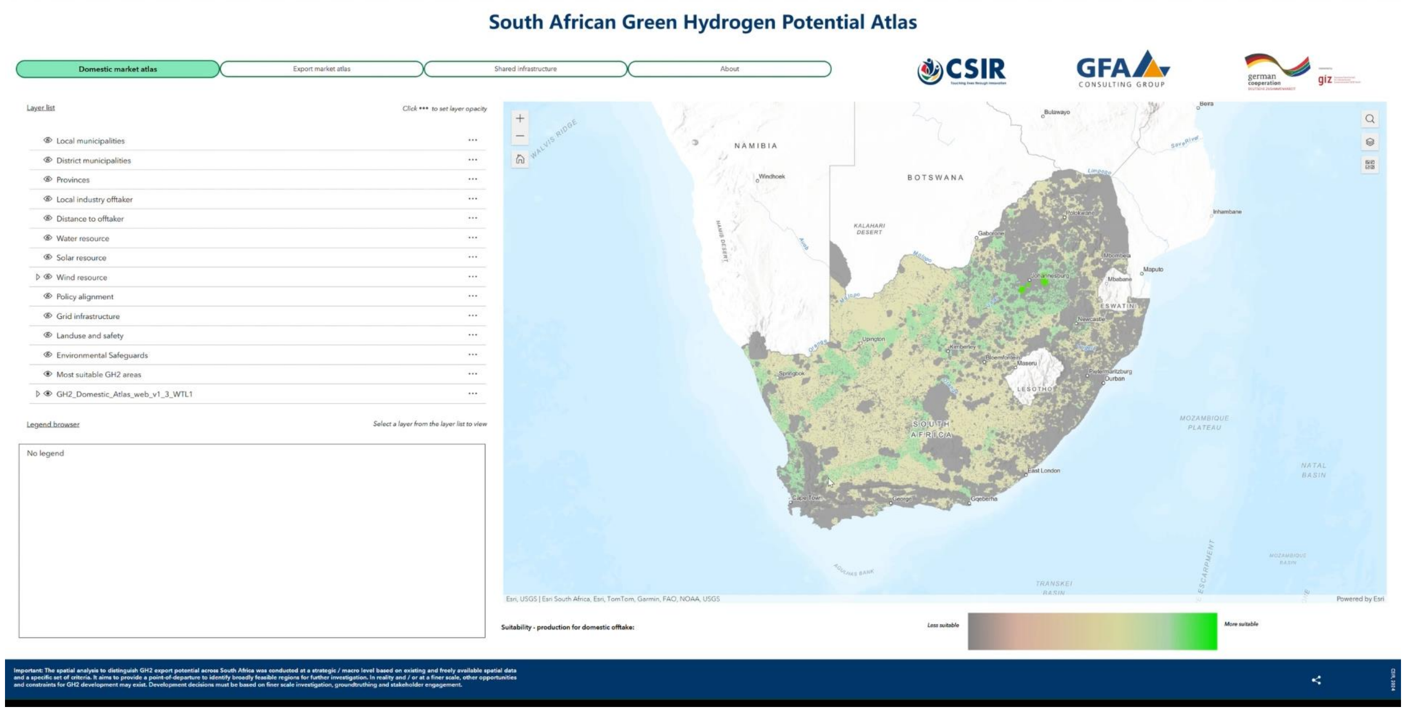
Finding space: data-driven decision support

- **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).

https://bit.ly/SAGH2atlas

- 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 consultations with a multidisciplinary Working Group.
  - 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.

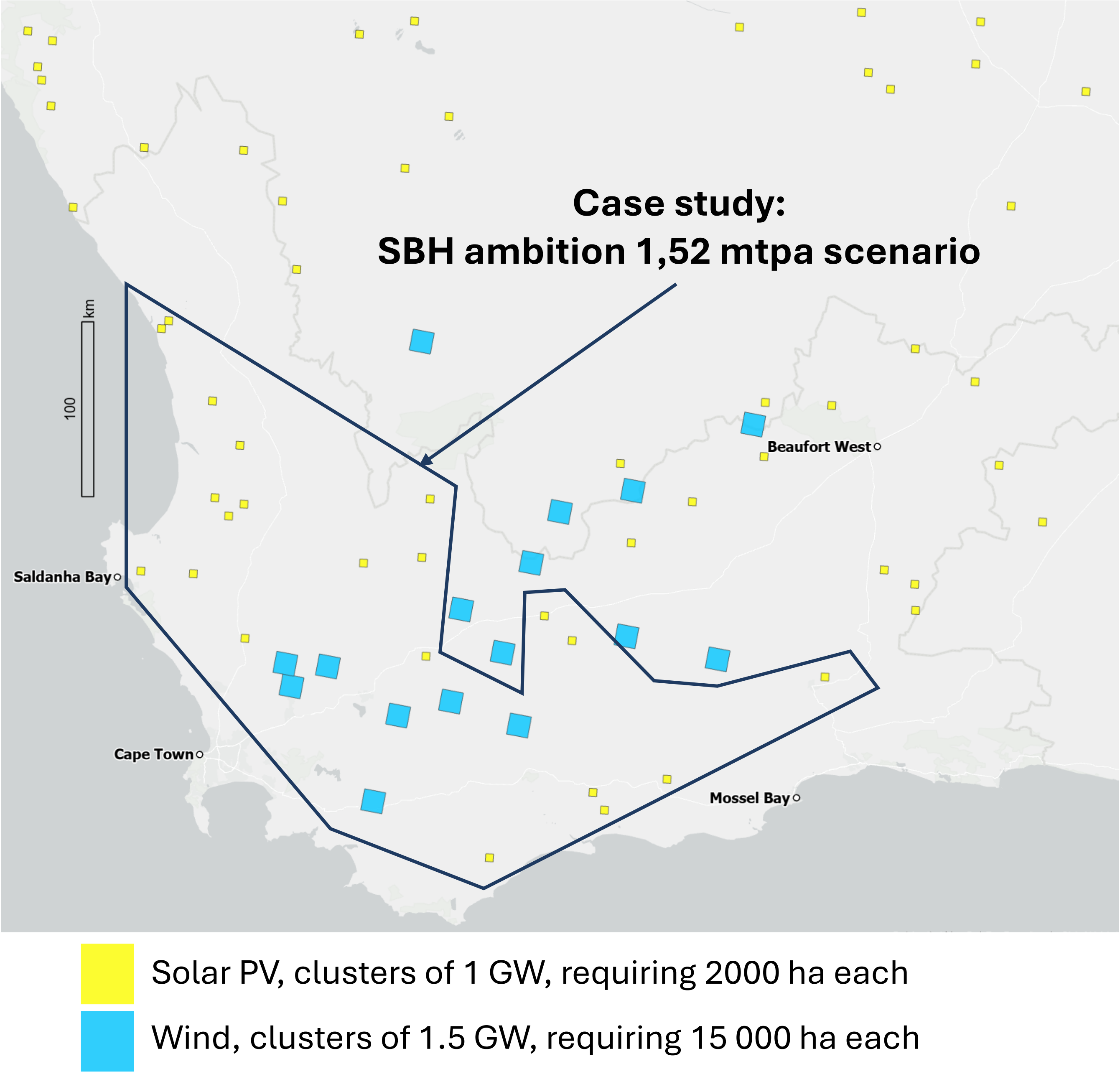
		Domestic Market	Export Market
Increasing relative importance →	**Environmental safeguards (restricted)**	Protected Areas <>	
		Heritage features <>	
		Watercourses and wetlands <>	
	Landuse and safety (restricted)	Population density <>	
		Built-up areas (urban) <>	
		High-value agriculture <>	
	Offtaker	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 ><	

Finding space: understanding scale

- Assume:
  - National ambition = **4 Mt GH_2** per annum
  - 1 mtpa of H2 needs 10 GW electrolyser, powered by 20 GW
  - new-build RE in the order of **80 GW**,
  - 70% solar @ 0,5 MW/ha, 30 % wind @ 1MW/ha
  - land-take requirement in the order of **350 000 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.
- Need for **landscape approach to planning** and robust **implementation of the mitigation hierarchy (avoidance first)**.



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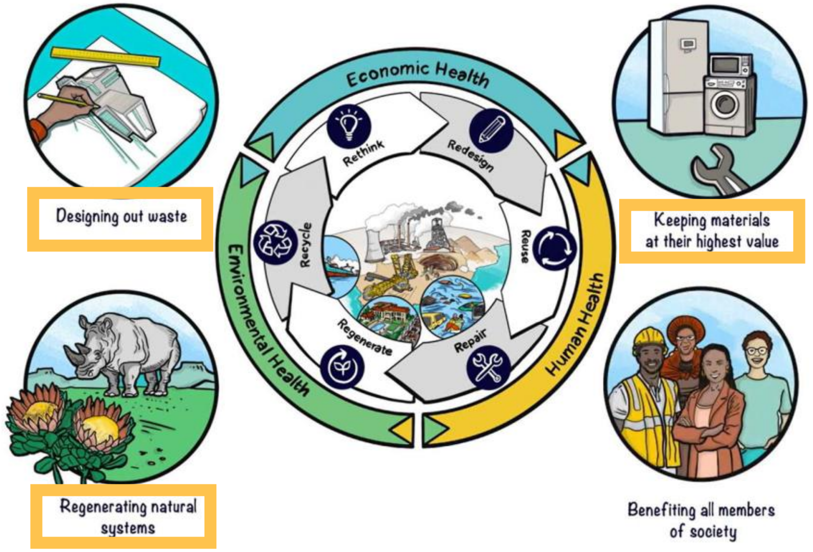

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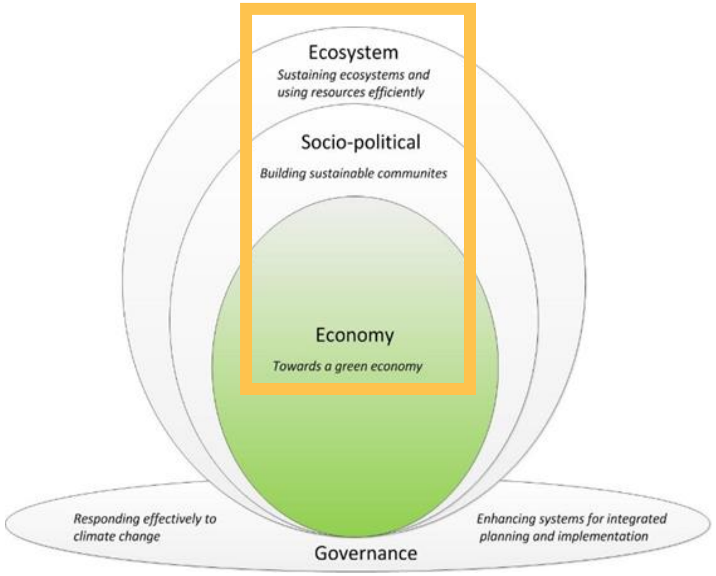

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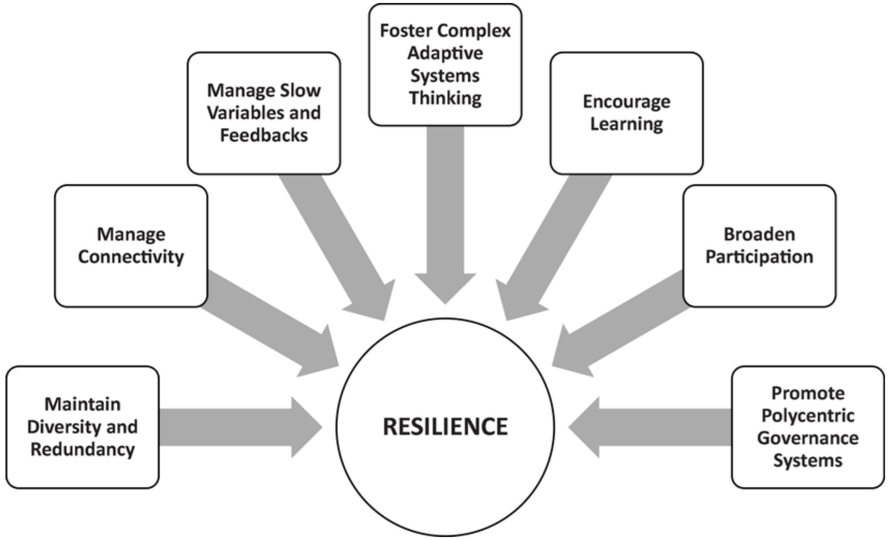
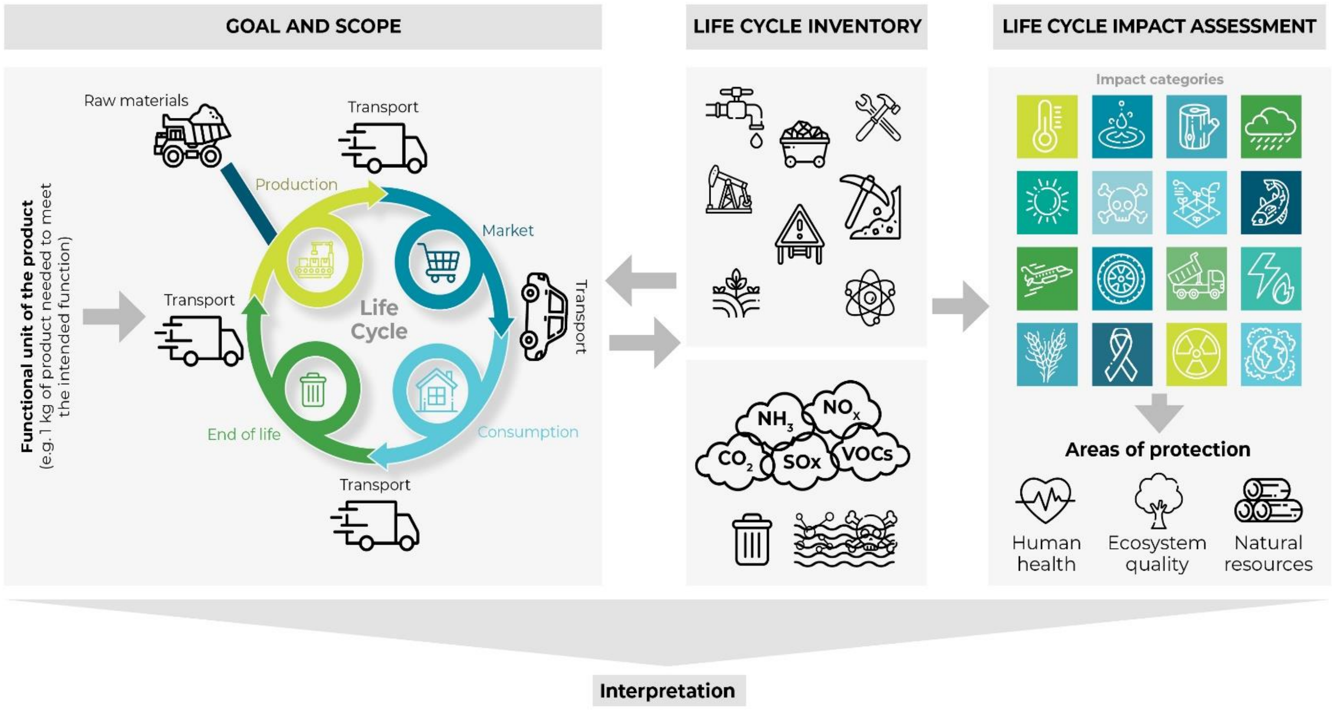


Principles for building resilience (Biggs et al., 2015)

Life Cycle Assessment (LCA)

- Estimates the **environmental impacts of a product throughout its life cycle.**
- **Lifecycle** considers raw material extraction, manufacturing, packaging and distribution, use, and end-of-life disposal.
- Quantifies the **inputs** of materials and energy, as well as **outputs** of emissions and waste
- ISO Standard- **Principles and framework** (**ISO 14040**) **Requirements and guidelines** (**ISO 14044**)



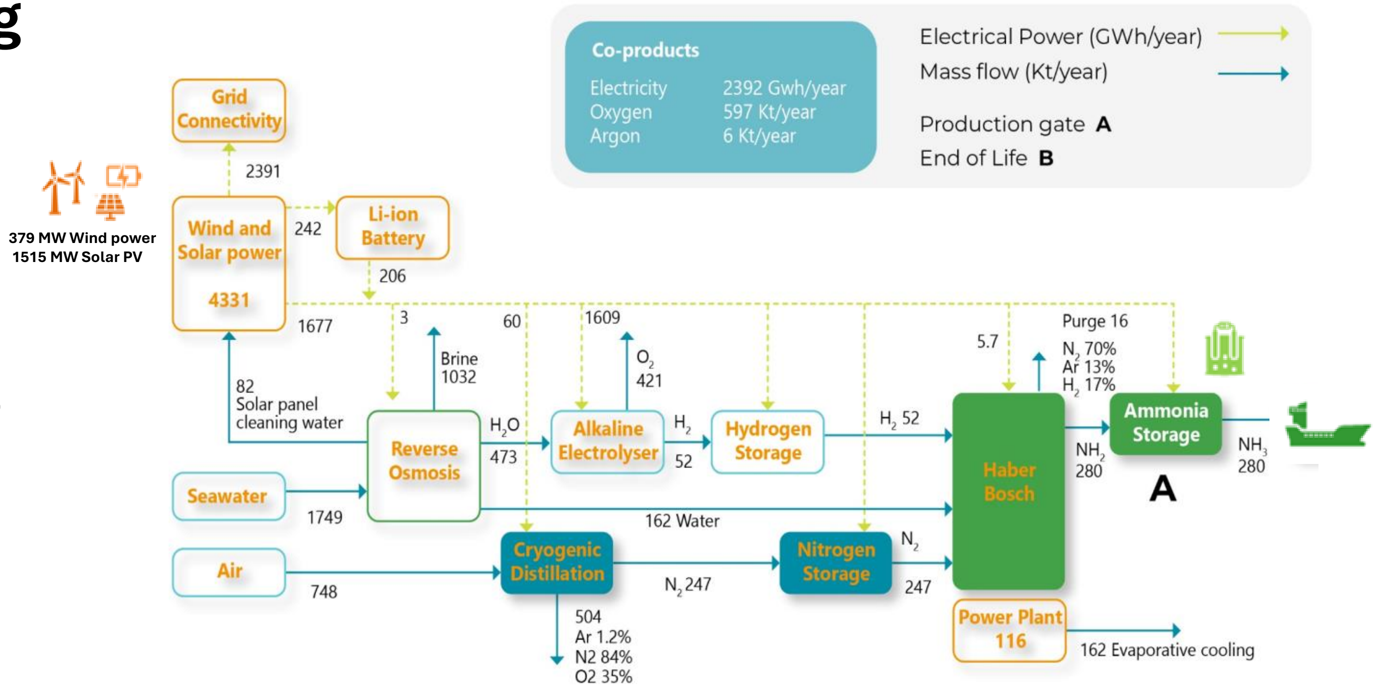
Application in product design, certification, eco-labelling policy making

LCA most established for environmental impacts, but complemented by social and economic impacts- social LCA (sLCA) and Lifecycle costing (LCC)

LCA from cradle-to-production gate

Green ammonia production: Prototype plant @ Saldanha Bay, South Africa

- **Green ammonia production using 100% Renewable energy in islanded mode** (only grid export)
- **Renewable from PV+Wind hybrid with oversizing** of 200% relative to the electrolyser
- Possible **co-products** of **purified water, electricity, oxygen and argon**



Renewable energy used to desalinate seawater, produce Hydrogen and synthesize Ammonia

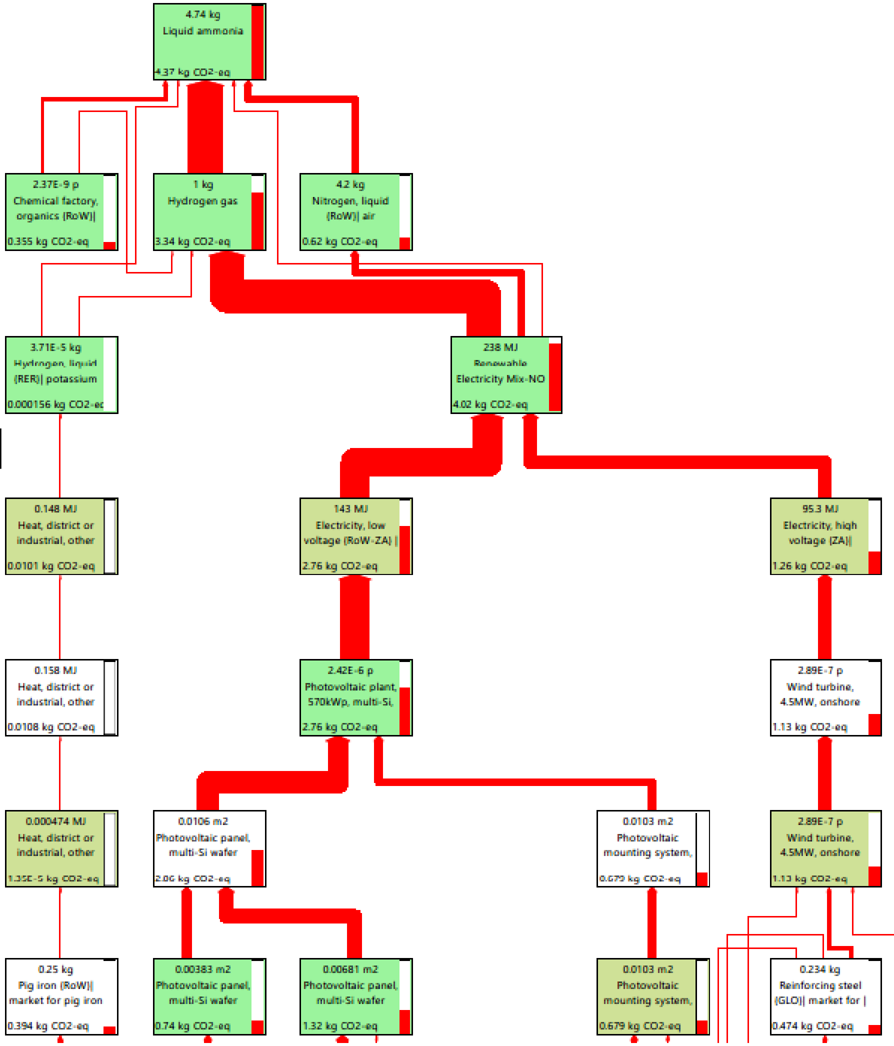
LCA from cradle-to-production gate:
Carbon intensity of Green ammonia production

Carbon intensity of Green ammonia production (ISO/TS19870) is **0.105 kg CO_2-eq/kg ammonia (0.598 kg CO_2-eq/kg hydrogen) well below threshold for green hydrogen certification** (GHO, EU-REDII)

Green ammonia carbon emissions related to the **energy used for manufacturing infrastructure** (solar PV and wind power components).

Need for a **rapid transition of manufacturing** countries to a have a **high percentage of renewable energy** in the country energy supply mix

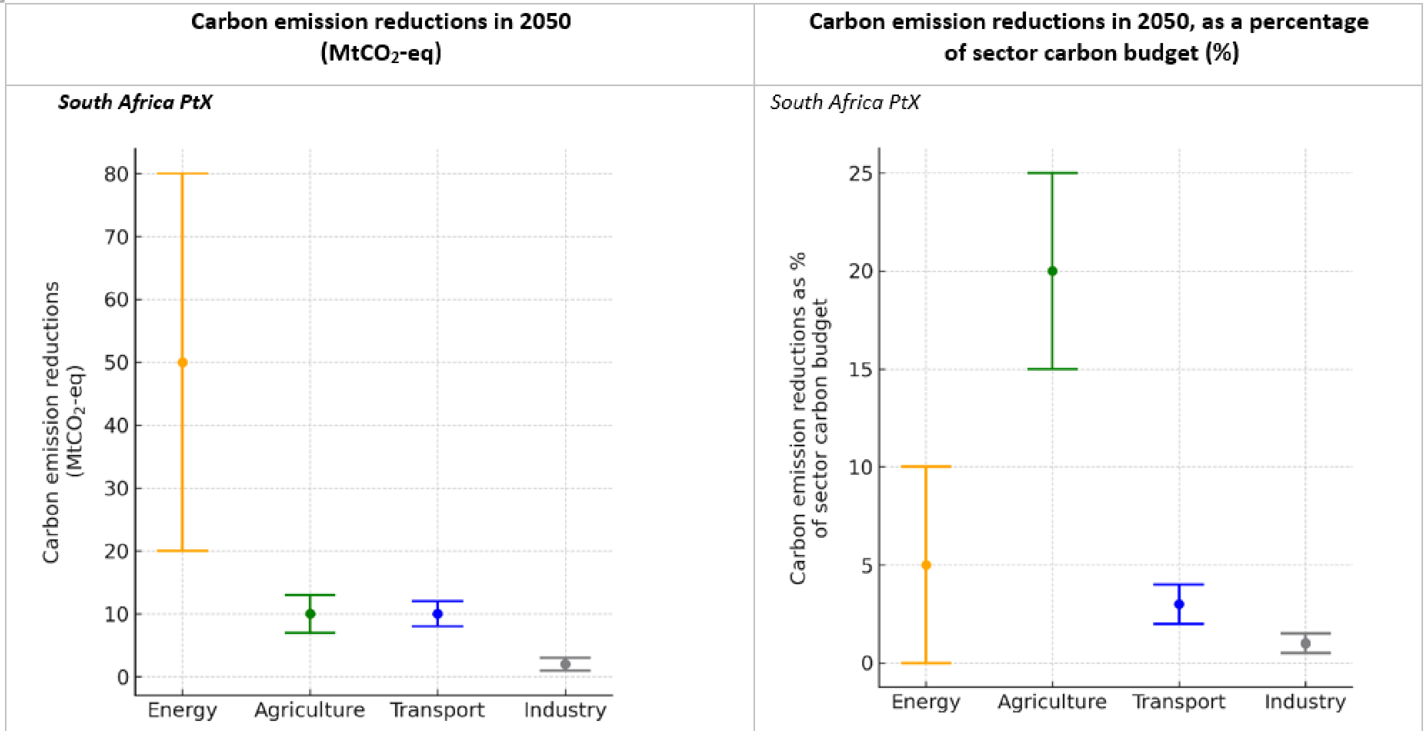
Recycling of infrastructure can also **reduce embodied carbon emissions and avoid resource depletion.**



PtX carbon mitigation potential for South Africa in 2050

Upscaling Saldanha prototype plant design **to South Africa Hydrogen Roadmap** target of up to 4.7 Mt Hydrogen in 2050

Mitigation potential: Reduce National carbon emissions by up to 112 $MtCO_2$-eq in 2050

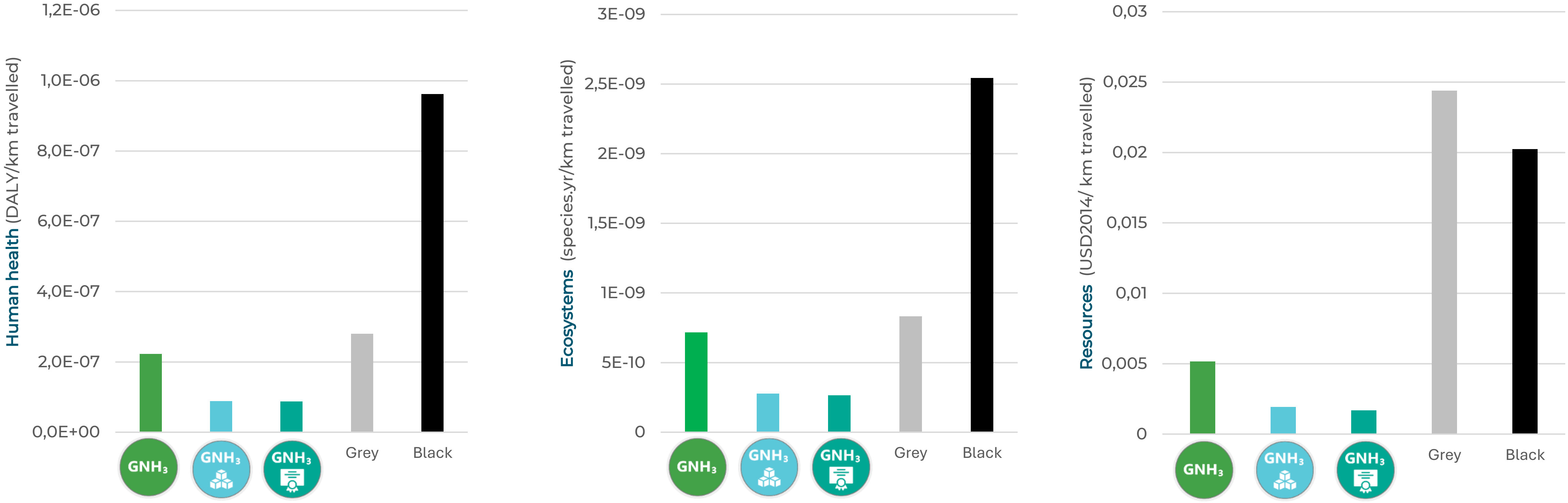


Sector reductions in carbon budget : Agriculture (28.50%); Transport (9.81%); Energy (7.70%), and Industry (0.71%).

A 30% **oversizing of desalination beyond that required for PtX production** has a minimal impact on the levelised cost of Green ammonia production and provides up to 32 ML per day **potable water for local communities** (sufficient for 133 333 persons)

Green ammonia production

LCA with ReCiPe method: *Damage to Areas of Protection*



Green ammonia has 20 % to 97**% reduced damage to Human health**, 13% to 96% **reduced damage to Ecosystems** and 79% to 98% **reduced damage to Resources**, when compared to grey and black ammonia, respectively.

Summary: LCA of Green ammmonia

- **Carbon intensity of Green ammonia production @Saldanha bay well below threshold for certification** (ISO/TS 19870). Most of the carbon intensity is related to the **embodied emissions in manufacturing infrastructure** (solar PV and wind)
- **Co-products** share impacts, so less impacts attributed to green ammonia. Co-production of **electricity, pure water (desalination), gases** (oxygen, argon) **can diversify product revenues and deliver local benefits while increasing business resilience**.
- **Recycling of infrastructure** can **reduce embodied emissions and the risks of resource scarcity/critical raw material depletion.** Recycling of Renewable energy infrastructure is a **requirement of South Africa's** recent **extended producer responsibility (EPR) legislation** that aims to increase the **circularity of the economy**
- **The environmental Life Cycle Assessments** should be **complemented by socio-economic assessments** to inform the adoption of green hydrogen and associated energy carriers and in the **Just Energy Transition.**

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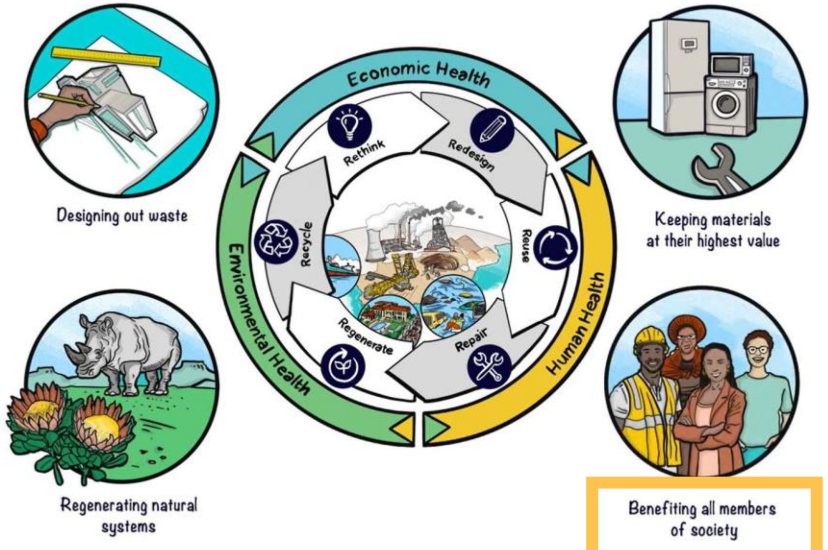

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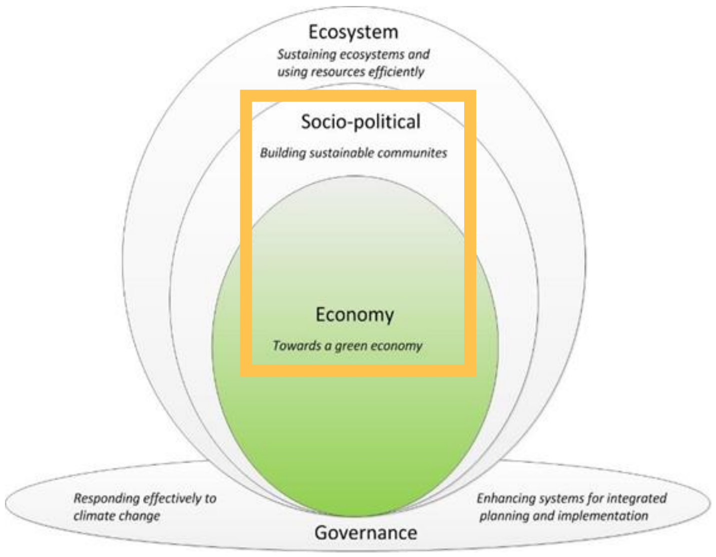

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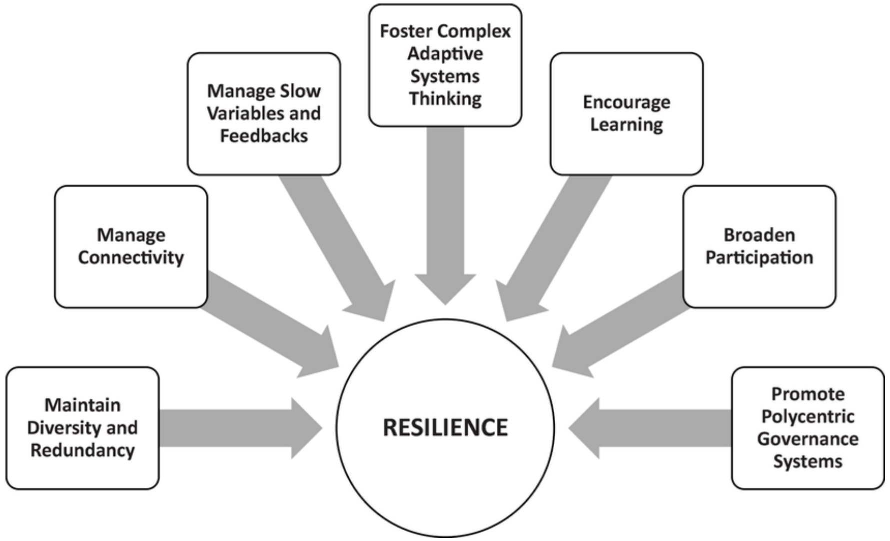

Principles for building resilience (Biggs et al., 2015)

Social Life Cycle Assessment of Potential of Power-to-X products at Saldanha Bay Hydrogen Hub

CONTEXT

Addressing climate change → improve the resilience to immediate events with a particular focus on **vulnerable groups**
<u>Just Energy Transition</u> is not just an environmental concern; it is more directly **an economic and social issue** with great implications for the future competitiveness of the South African economy as well as the livelihoods of its people (Presidential Climate Commission, 2022)

Study Aim

A prospective Social LCA (S-LCA) of possible future scenarios of green hydrogen production in South Africa using a local case study (<u>Saldanha Bay Hub</u>)

Social LCA of Green H_2 at Saldanha Bay

Primary and Secondary Data Sources

Quantitative

Based on Ram et al.(2022) Method + LCA SBH plant design & PtX Scenario

- Employment Opportunities

Qualitative

PSIA methodology (incl adapted scoring scale) & PtX Scenario

- Skills Development
- Economic Development
- Access to Material and Immaterial Resources

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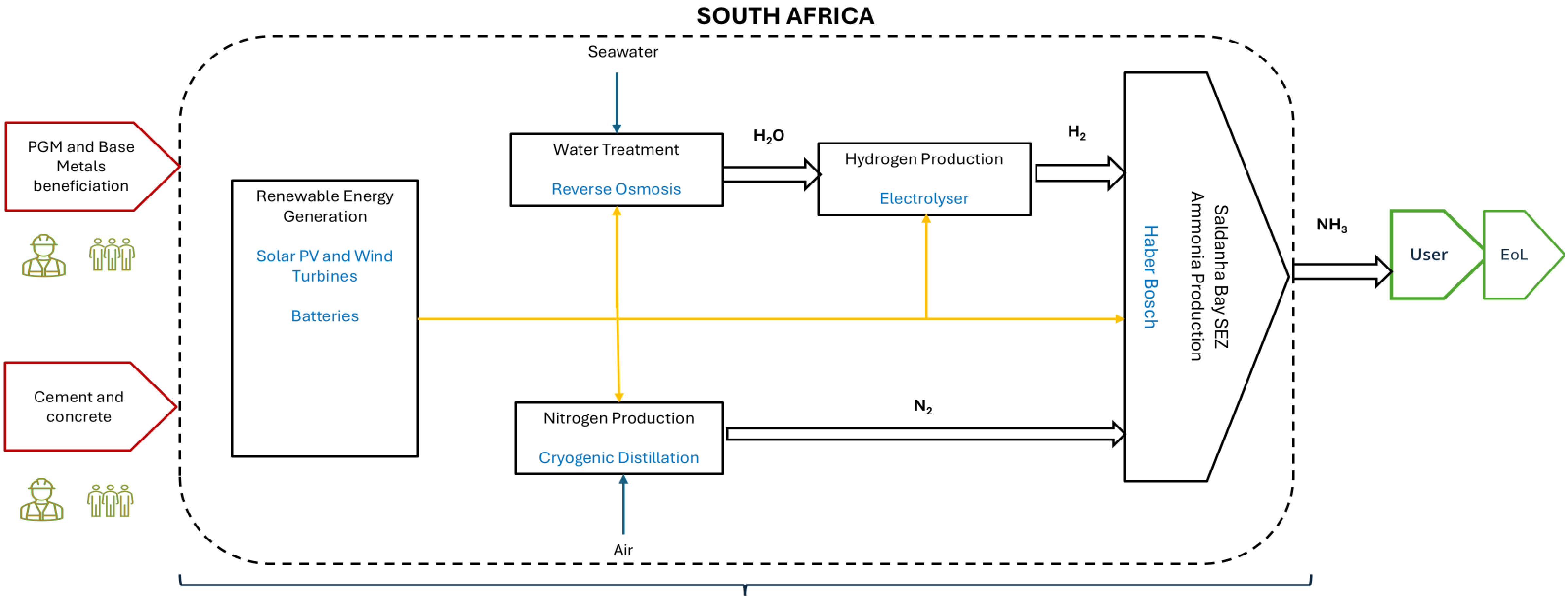
Stakeholder Map (Submitted for review)



Workers

- Equality
- Occupational health and safety
- Remuneration
- Freedom of association
- Work-life balance

Local communities

- Local Employment - Potential Employment Opportunities
- Contribution to skills development
- Contribution to economic development
- Access to material and immaterial resources
- Health and safety
- Community Engagement

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Methodological Approach – Qualitative Assessment

+2	best in class, continuous improvement
+1	beyond generally acceptable situation, continuous improvement
0	generally acceptable situation,
-1	unacceptable situation but improving
-2	unacceptable situation, no improvement

Generic scale to assess social performance
Current performance of a product
(Goedkoop et al., 2020)

Adapted scale to assess social performance
Prospective performance of a sector at a municipal level
(Russo and Goga, 2024)

Reference Scale – Saldanha Bay Context

	Definition of the scale level	Performance Indicators
+2	Conditions could substantially improve compared to the Baseline Scenario	Evidence shows initial progress in terms of tangible results with a concrete action plan and short- to medium-term targets
+1	Conditions could marginally improve compared to the Baseline Scenario	Evidence speaking to planned opportunities and initiatives but no concrete overall action plan and/or targets
0	Conditions could remain the same as the Baseline Scenario	No or insufficient evidence to support potential changes in the system leading to either significant improvement or deterioration
-1	Conditions could marginally deteriorate compared to the Baseline Scenario	Evidence speaks to potential deterioration as no or very few mention of planned opportunities for improvementin a historically problematic area of national concern
-2	Conditions could substantially deteriorate compared to the Baseline Scenario	Absence of any positive information where the risk of a negative situation is likely to occur according to generic statistics or data

Methodological Approach – Quantitative Assessment

Potential Employment Opportunities – PtX Saldanha Bay H2 Hub

(Secondary data from publicly available sources)

Employment Factors per Tech

Installed Capacity: Jobs-year/MW

Cumulative/Production Capacity: Jobs-year/GWh

Processing / Treatment Capacity: Jobs/m3

Investment : Jobs / EUR 1 Ml

Jobs Inventory Template

Saldanha Bay Hydrogen prototype plant design to produce:

280 kt of GNH3 pa

Or

50 kt of GH2 pa

Scenarios Jobs Inventory

EFs x Scenarios design requirements:

S0 – 500 MW and RO (3650 ML pa)

S1 – GH2 510 kt pa

S2 – GH2 1520 kt pa

Analysis of the PEO

Construction, Operation and Manufacturing

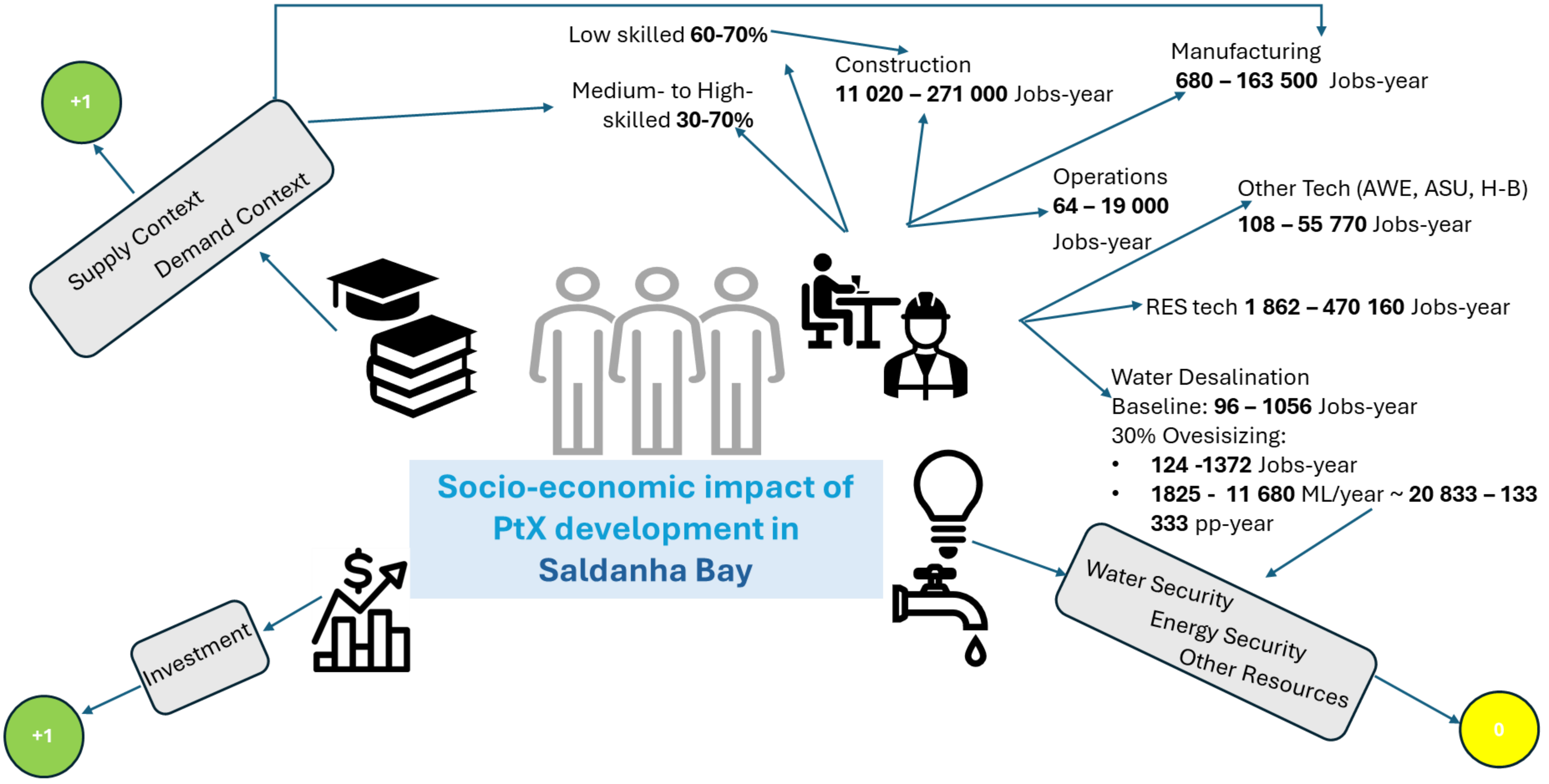
High- , Medium- & Low-skilled

RES and other tech (AWE, ASU, H-B synthesis)

Water Desalination (RO) oversizing opportunities

Localising Manufacturing Jobs opportunities

Preliminary Results: Qualitative and Quantitative of PtX @ SBH



Qualitative Scale: Potential Improvement Potential Deterioration No Significant Change

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Summary of the S-LCA

- The results show the significance of conceptualising clean energy (specifically green hydrogen) and low carbon development pathways **within local contexts** incorporating their own unique socioeconomic factors.

- Additionally, although material topics and indicators have been assessed independently, the analysis highlights **linkages** between the various aspects and emphasises that a **systems-based approach** is required.

- Overall, the Green Hydrogen sector presents a combination of potential significant socio-economic **opportunities and challenges** in South Africa.

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Concluding thoughts

- **PtX projects are far-reaching and complex.**
- **Foundational evidence base** for future planning, assessment, decision-making, and R&D on PtX development towards promoting social acceptance, circularity, resilience and sustainability.
  - **Site selection and landscape modelling.**
    - "Where" is often driven by techno-economics, however, increasing attention to **environmental feasibility**.
    - Need to better understand **scale and extent** to meet PtX development ambitions.
  - **Life Cycle Assessment.**
    - **Carbon intensity** well below threshold for **green hydrogen certification** (ISO/TS 19870).
    - **Co-products** (water, electricity, oxygen and argon) can increase business **resilience**
    - **Recycling** (especially renewable energy infrastructure) to reduces **embodied emissions**, recovers **critical materials** and supports a **circular economy**
  - **Social Life Cycle Assessment.**
    - Importance **of conceptualising low carbon development pathways within local development contexts** incorporating their own unique - factors.
    - PtX development presents a **combination of potential significant socio-economic opportunities and challenges** in South Africa.

Thank you

Dankie

Enkosi

Luanita Snyman-van der Walt LvdWalt1@csir.co.za

William Stafford WStafford@csir.co.za

Taahira Goga TGoga@csir.co.za

Valentina Russo VRusso@csir.co.za

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