Green Hydrogen For All Namibians

A case study on the drivers and barriers of achieving a hydrogen innovation system that leads to inclusive and just development in Namibia.

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Port of Rotterdam TU Delft INDUSTRIAL ECOLOGY INNOVATIVE BY NATURE

Key Messages

- **Namibia has made great progress** with preparing for the hydrogen projects, by setting up the institutional basis, mobilizing resources, and coordinating research transfer and course development.
- To move forward, it is needed that Namibia increases the level of tertiary education and training focusing on **practical hands-on engineering**, the **awareness and involvement** of the general public, and the **level and variety of local experiments.**
- Acceleration of practical training facilities could be achieved by leveraging **MOUs** to cooperate with vocational training centers in the EU and to upscale the (training department of) GHRI.
- To increase awareness and involvement, Namibia could set up an inclusive **collaboration platform** and leverage **grass-roots communication** actors (e.g., NaYoRE) to reach and inform youth and marginalized groups that have limited media access and little understanding of hydrogen.
- **Local incubators** like Start-up Namibia, could be upskilled and connected to European incubators and an EIF fund, so they can jointly incubate local hydrogen-related start-ups.
- On the long term, it is recommended that Namibia prioritizes knowledge development, education, and experimentations for **scalable solutions that can be adapted to local circumstances** (e.g., agrivoltaics and digital solutions) over solutions for which comparative advantage is hard to achieve in Namibia, (e.g., fuel cells).

Document Context

- The aim of this study was to establish **how Namibia can develop an innovation system** to capture value from hydrogen projects to achieve inclusive and just socio-economic development.
  - This document is an executive summary of the **MSc thesis** of Micha de Roos, as part of the **Industrial Ecology Program at TU Delft and Leiden University**. Financial support and practical supervision was provided by **Port of Rotterdam.**

- The study developed a **theoretical framework** to assess how the joint efforts of key actors and institutions in relation to the hydrogen projects are either **driving or blocking local inclusive development** and discussed energy justice concerns.

- To collect data for the framework, a case study was conducted that included **20 semi-structured interviews with key hydrogen actors** in Namibia and various country reports, governmental documents, academic studies and news articles.

- The insights from the case study were used to provide **key strategies and policy recommendations** on how key stakeholders can **cooperate to leverage drivers and overcome the barriers** towards inclusive and just development.

Key Questions Covered

Why study the hydrogen innovation system in Namibia?

- Introduction of the study
- Theoretical framework

What is the current status of the upcoming hydrogen innovation in Namibia?

- Key actors and institutions
- Drivers and barriers
- Problems

How can stakeholders work together to further develop the hydrogen innovation system?

- Strategies
- Hypothetical local innovation examples
- Recommendations

Why study the hydrogen innovation system in Namibia?

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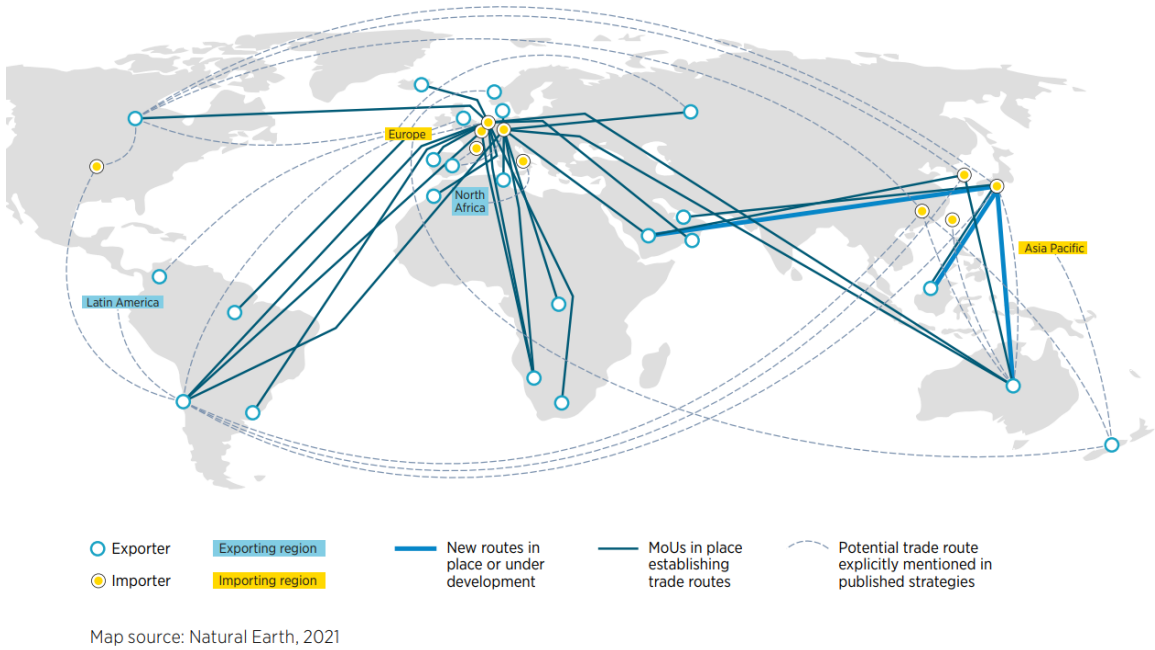
Large momentum for green hydrogen driven by industrialized countries is leading to the development of international supply chains

- **Decarbonization and energy security** are the key drivers behind the green hydrogen momentum.
- The declining cost of renewables and increase of CO2 prices could make green hydrogen a **viable option in the future.**
- Since the renewable energy (RE) supply is the main cost factor of producing green hydrogen, importing from **low populated areas with high solar and wind capacities** is chosen as a key strategy by the EU.

Figure S.2 **An expanding network of hydrogen trade routes, plans and agreements**

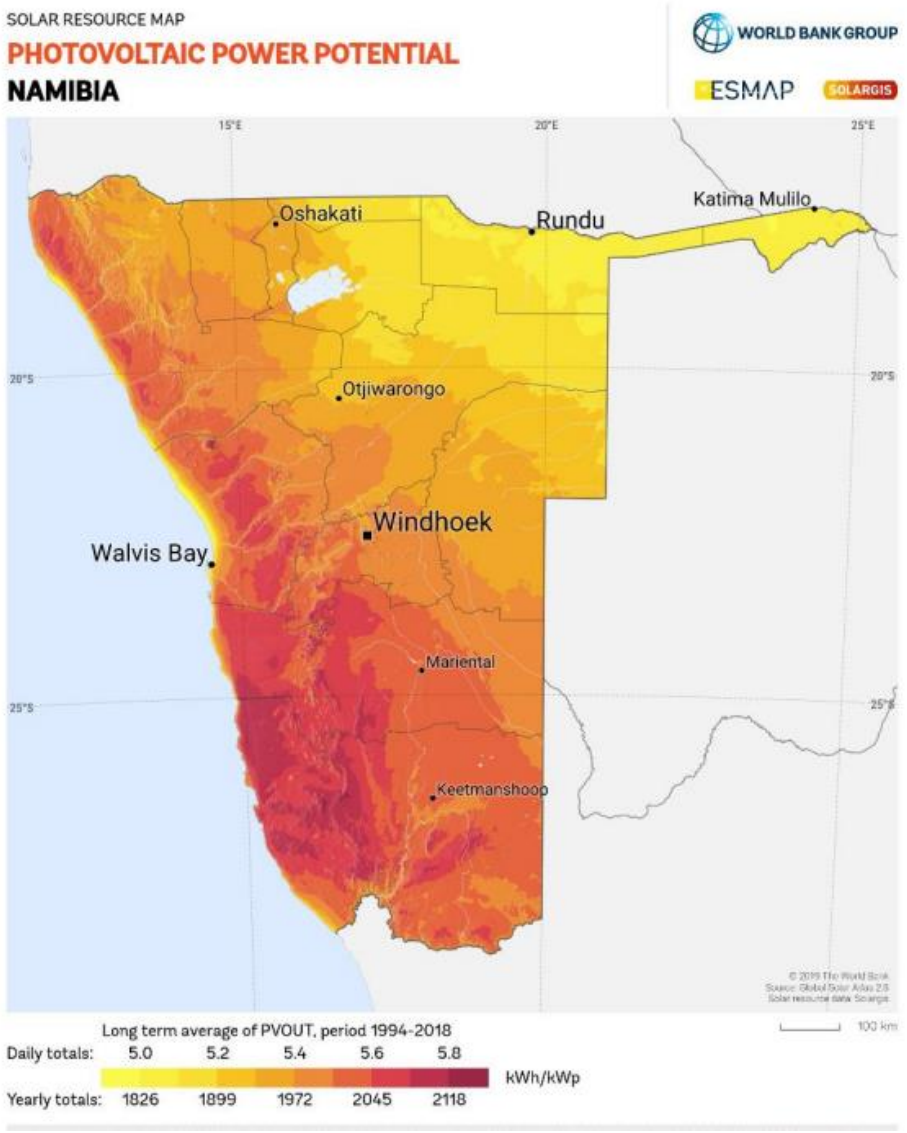


Map source: Natural Earth, 2021

(Collins, 2022; IPCC, 2022; European Commission, 2022)

Multiple studies have concluded that Namibian hydrogen could be highly competitive on the European market

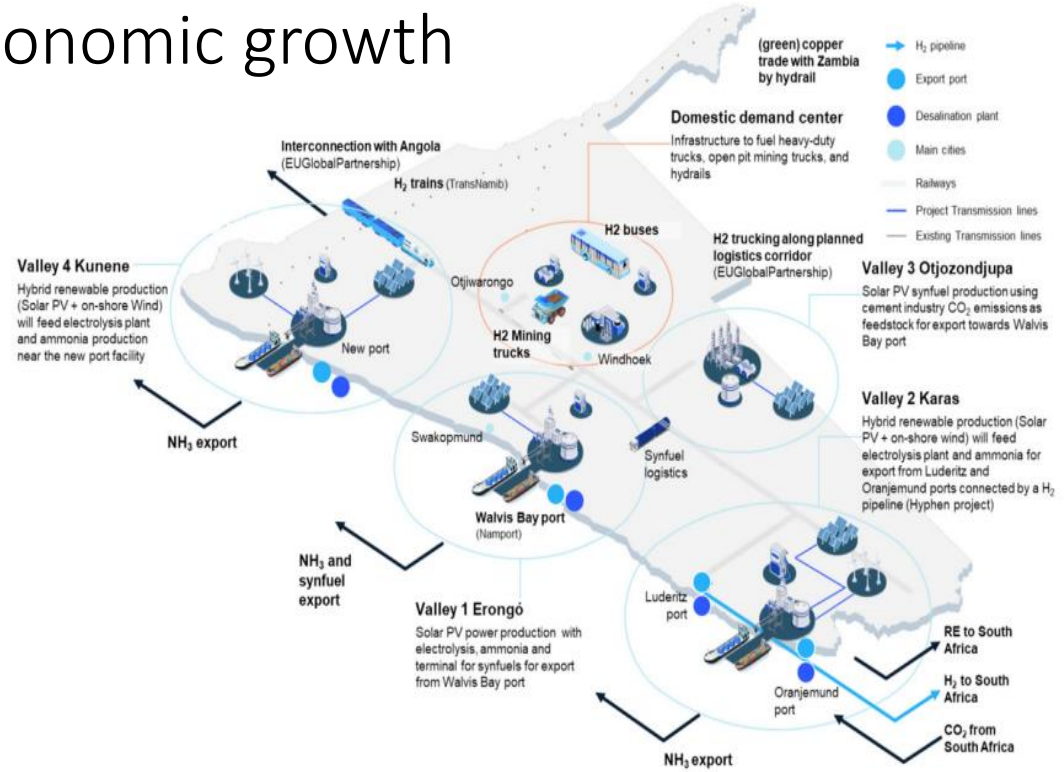
- 20 times the size of the Netherlands but only 2.6 million inhabitants.
- Vast open areas with **high irridation values and wind speeds.**
- **Stable politics,** modern financial system and relatively good infrastructure.



(Port of Rotterdam, 2021; World Bank 2021)

Namibia aims to invest in green hydrogen projects to generate inclusive and just socio-economic growth

- Initial investment of **9.4 billion USD** by Hyphen; **feasibility studies** should confirm competitiveness.
- Small pilot projects by French HDF and Belgium CMB.tech working with **Namibian O&L.**
- **<u>Opportunities</u>** for FDI, job creation, and socio-economic spill-overs.
- **<u>Threats</u>** for negative distributional effects, environmental damage, and resource curse.



(Republic of Namibia, 2022; van Oertzen, 2021)

However, Namibia has various interrelated development challenges that influence inclusive growth and deserve priority

- Driest country of sub-saharan Africa, **water scarcity** is an increasing problem due to climate change.
- **High inequality** due to Apartheid legacy; unequal access to electricity, sanitation, and quality education.
- **High electricity prices** as Namibia imports over 40% from South African utilities.
- Ongoing **economic recession** and unemployment rates **over 40%**.

Sandwich Harbour in the Namib Desert (Source: Author)

(Nambinga, 2017; World Bank 2021; Hooli & Jauhiainen, 2018)

How can hydrogen projects address these development challenges and lead to inclusive and just socio-economic growth in Namibia?

- Innovation and development studies have shown that a **crucial factor that drives economic growth** is the ability of developing countries to **receive and use the knowledge and resources transferred to them.**
- The presence of a well-functioning **Innovation System (IS)** is believed to **facilitate the process of knowledge and technology transfer** into a country as it considers many important socio-economic, organizational, and political factors that influence the adoption, diffusion, and use of technologies.
- **Research Question:** What should a hydrogen innovation system in Namibia look like, so that it allows for successful and just transfer and diffusion of hydrogen technologies into their country?

(Lundvall et al., 2009; van Alphen et al., 2008)

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Theory behind Innovation Systems: Evolutionary Economics and System Thinking

- Economic growth is an **evolutionary process,** where the market equilibrium is being perpetually destroyed through variation and selection.
- The function of the market is to **create competitive pressure** for selection to take place.

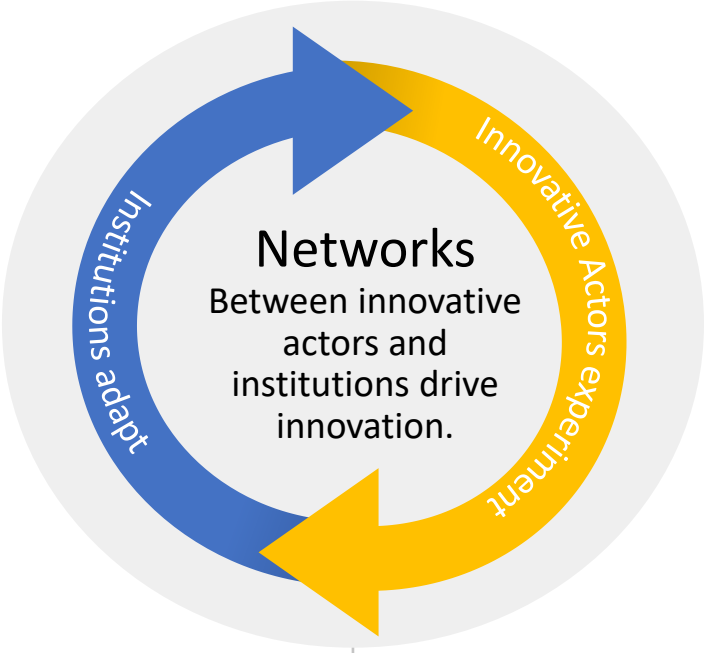
- Interactions between actors, institutions, and technologies lead to **emergent system behaviour**, i.e., economic growth.
- **Interactive learning** between actors, institutional alignment, and capabilities drives innovation.

(Lundvall et al., 2009; Sharif, 2006; Schumpeter & Opie, 1934; Meadows, 2008)

(Image Source: Pixabay.com)

Conceptually, the Innovation System is comprised of a set of actors, institutions and the networks between them

Cooperation
to tackle joint problems and to align technology, innovative actors, and institutions



Knowledge
and skills are developed and shared in these networks

Network strength

Determines the level of coordination, experimentation, and learning

Technological capabilities

Are needed to invest in, use, or develop new technologies

Contextual influences

Have a large influence on the development of an emerging IS

(Bergek et al., 2015; Lundvall et al., 2009; Edquist, 2011)

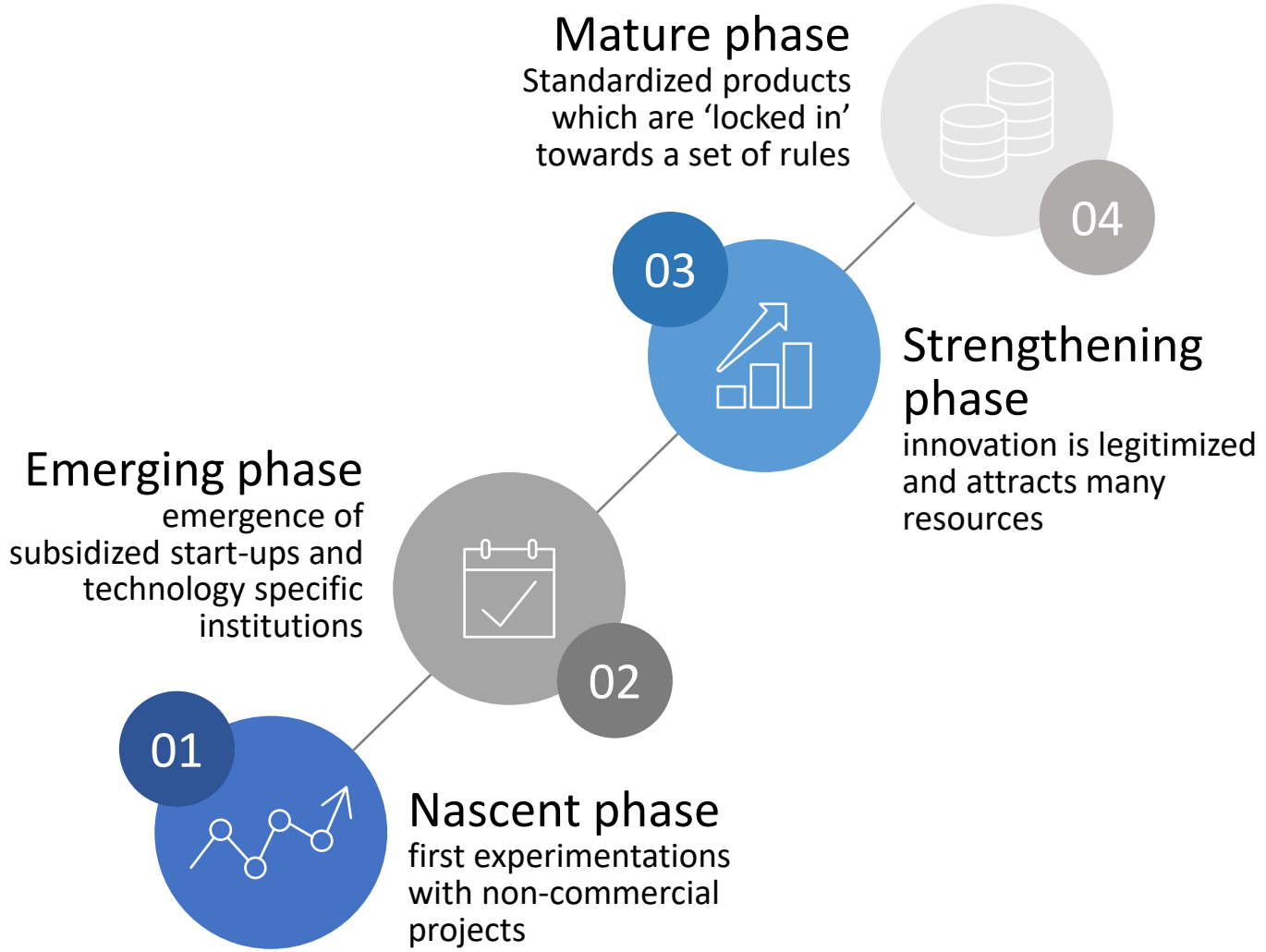
Key actors need to perform a set of activities or ‘functions’ to develop a well-functioning and inclusive Innovation System

System Functions	Description
Knowledge development	Learning is the most crucial part of any innovation process. New knowledge can be gathered by R&D or by learning by doing
Adaptive capacity	Level of technical training and higher education
Knowledge diffusion	This knowledge should then by exchanged through networks, i.e., learning by interacting or using
Guidance of the search	Setting clear goals and selecting the innovations to focus on. As resources are limited, they should be invested selectively
Entrepreneurial activity	Entrepreneurs with competences that turn capabilities into innovations by experimenting with new combinations of technology, markets and knowledge
Market formation	When technologies are emerging, they are often not ready-to-market, and should be protected during market-entry; either through the creation of niches or by favorable taxes and standards
Creation of legitimacy	New innovations lead to the creative destruction of incumbent innovations; those in power will show resistance. To take over the regime, advocacy coalitions should be formed to lobby for favorable subsidies and policies and to create social acceptance
Resource mobilization	Financial and human capital are the basic input to all other functions. Sufficient resources can be acquired through education, funds or investments

(Edsand, 2019; Bergek et al., 2008; Hekkert et al., 2007; van Alphen et al., 2008)

Assessment of the hydrogen Innovation System is done in relation to the development phase

- A nascent technology system needs to **undergo a period of experimentation** before entering the market.
- In developing countries**, creating adaptive capacity** for knowledge and technology transfer precedes this step.
- **Cooperation** between key actors, clear visions and expectation management, alignment of institutions and coordinated lobbying efforts are needed to move to the next phase.



(Bergek et al., 2008; Markard & Truffer, 2008; Bento & Wilson, 2016)

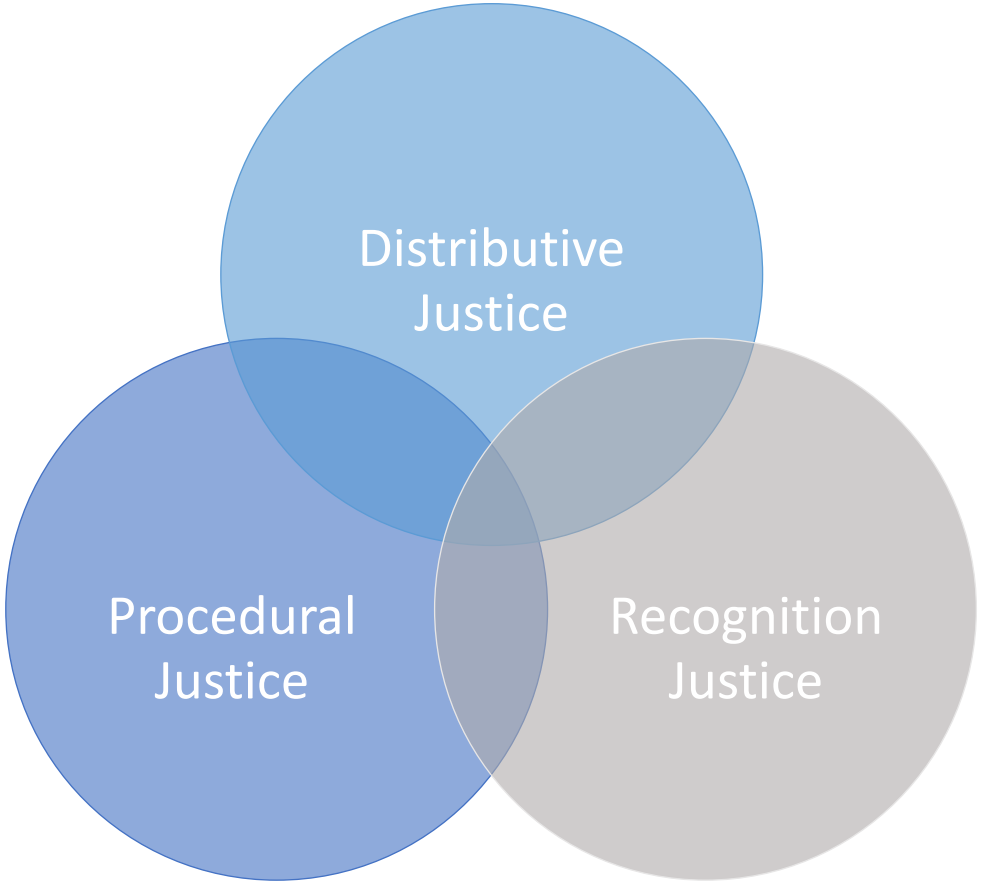
Energy Justice provides additional insight into the ethical concerns that come with large-scale hydrogen projects

Distribute

benefits and ills, and their associated responsibilities equally among stakeholders.

Include

all those affected in the decision processes through informed consent and institutional representation.



Three tennets of Energy Justice. Adapted from (Jenkins, 2016)

Recognize

and represent divergent perspectives from different cultures, genders, and income groups.

What is the current status of the upcoming hydrogen innovation in Namibia?

- Key actors and institutions
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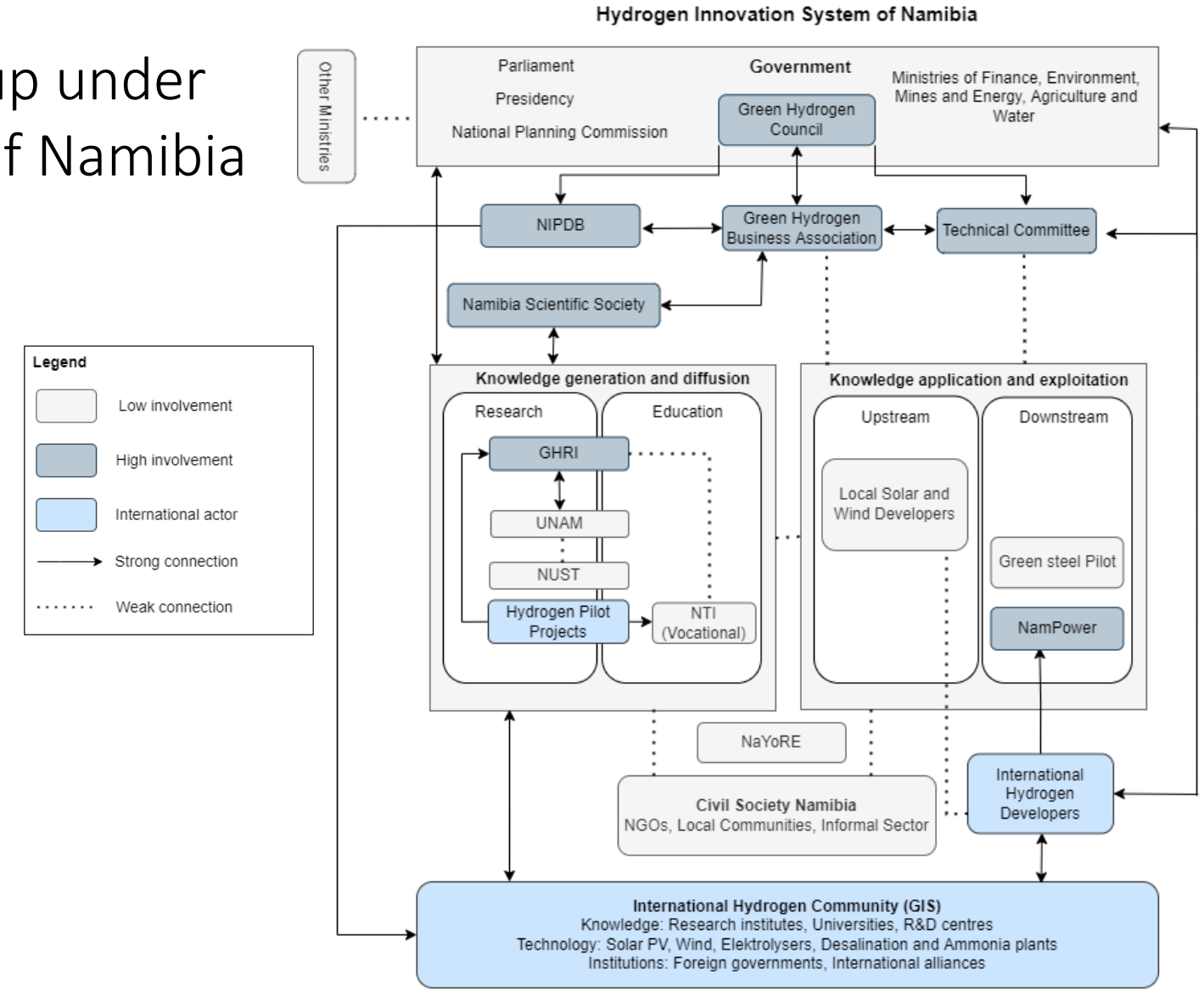
The Hydrogen IS is being set up under the lead of the Government of Namibia and Hyphen

- **Green Hydrogen Council** coordinates policy development and strategy.
- **Namibian Investment Promotion & Development Board (NIPDB)** assists foreign and local businesses.
- **Green Hydrogen Research Institute (GHRI)** is responsible for knowledge development, education, and training.
- **Green Hydrogen Business Association** recently launched to involve private sector.

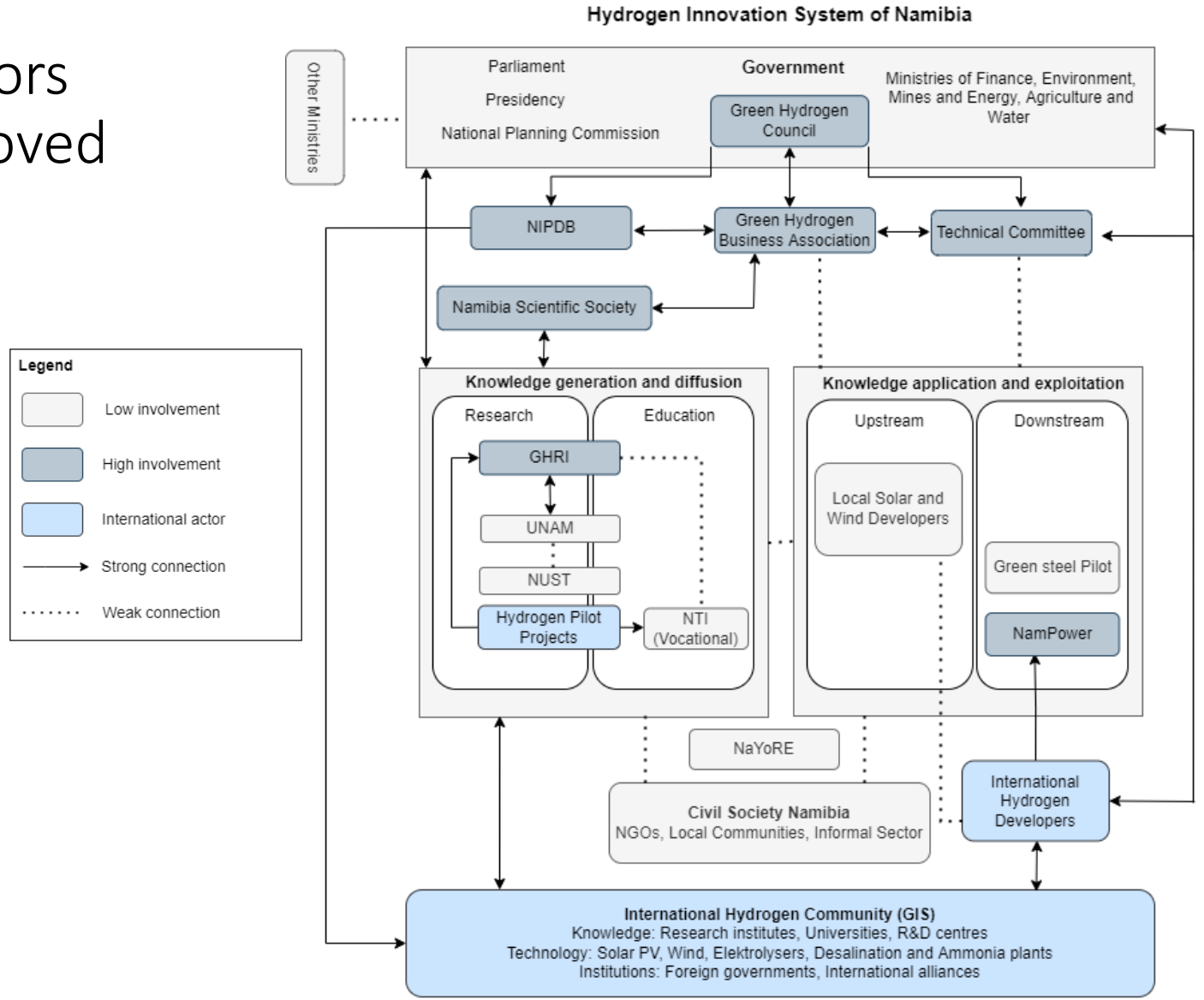


(Source: Interviews; Republic of Namibia, 2022)

(Image Source: Author)

Connections between key actors are strong, but could be improved with other stakeholders

- **Close cooperation** between key actors but **little involvement** of the local private sector and civil society - could lead to groupthink* and a lack of ownership.
- **Connections** between GHRI, NTI, and the local private sector could be improved to coordinate upskilling efforts.
- **Coordination** between hydrogen developers and pilot project could be improved to accelerate skills transfer.



*Groupthink is a phenomenon that occurs when the desire for group consensus overrides people's common sense desire to present alternatives, critique a position, or express an unpopular opinion.

(Source: Interviews; Republic of Namibia, 2022)

(Image Source: Author)

The exact skills gap is yet uncertain, but a lack of higher educated Namibians with practical experience can be anticipated.

- The **skills and knowledge** that are needed for hydrogen projects are manifold and range from relatively simple construction, maintenance, and monitoring jobs to highly complex engineering, management, and R&D functions.
- Namibia has some technical capabilities in the mining and electricity sectors, but **capacities are low.**
- There is a **general lack of relevant higher education and practical training** in Namibia, especially on the maintenance and service for windmills, electrolysers, and ammonia plants.
- Namibian **SMEs struggle to grow from MW to GW scale**, as they often lack the financial and human capabilities to invest in, use and learn about complex technologies.

(Source: Interviews; World Bank 2021; Nambinga, 2017)

(Image Source: TaatiSolar)

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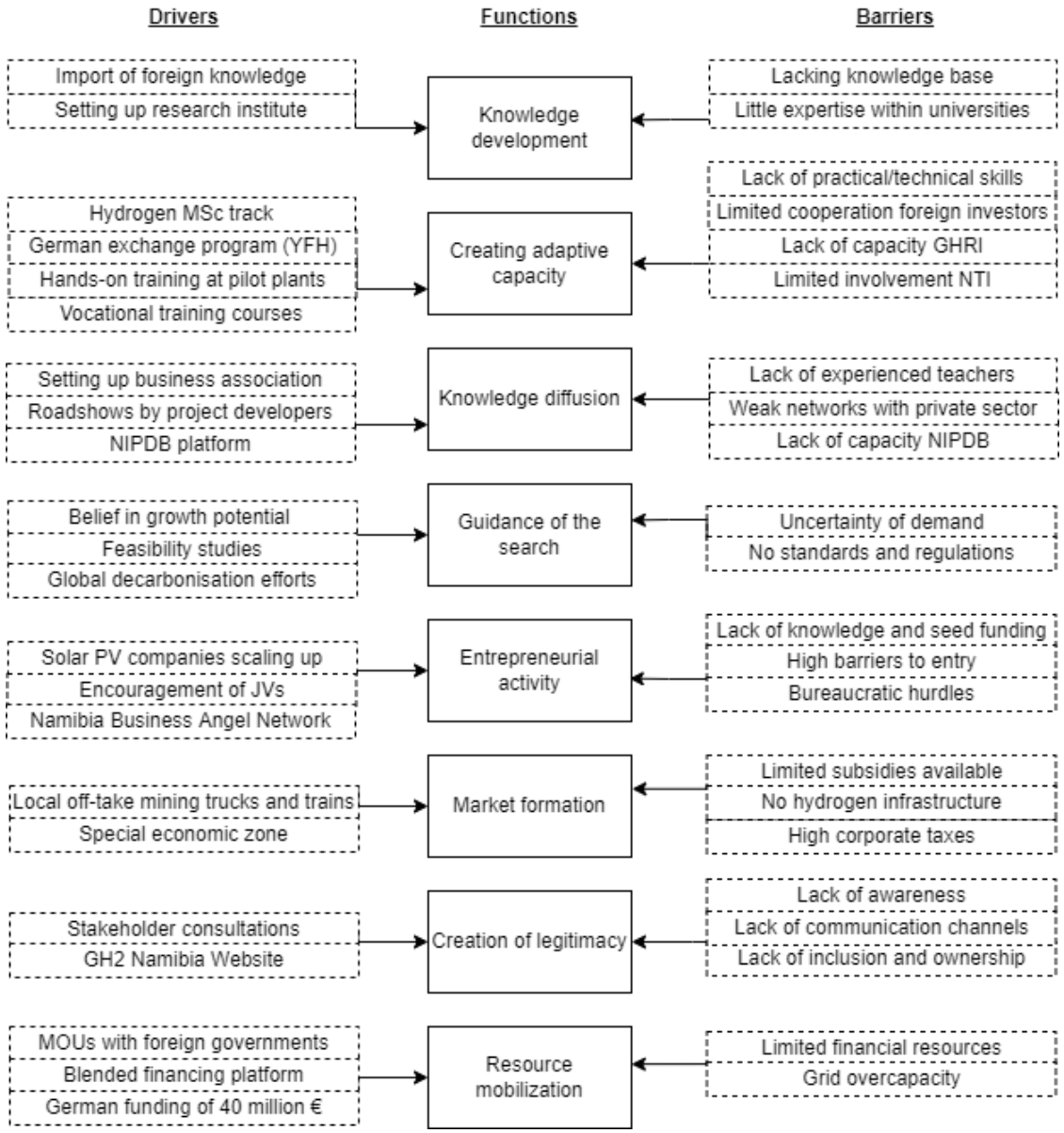
Creating adaptive capacity and knowledge diffusion are the key challenges for Namibia

- Lack of entrepreneurial activity, market formation, and structuration is **logical** for early development phase.
- But without adaptive capacity and knowledge diffusion **there can be no local development.**
- **Key drivers** are coordination and resource mobilization by Government, knowledge transfer, and development of (practical) course materials.
- **Key barriers** are a lack of experienced teachers, lack of awareness and inclusion, and limited capacity within GHRI.



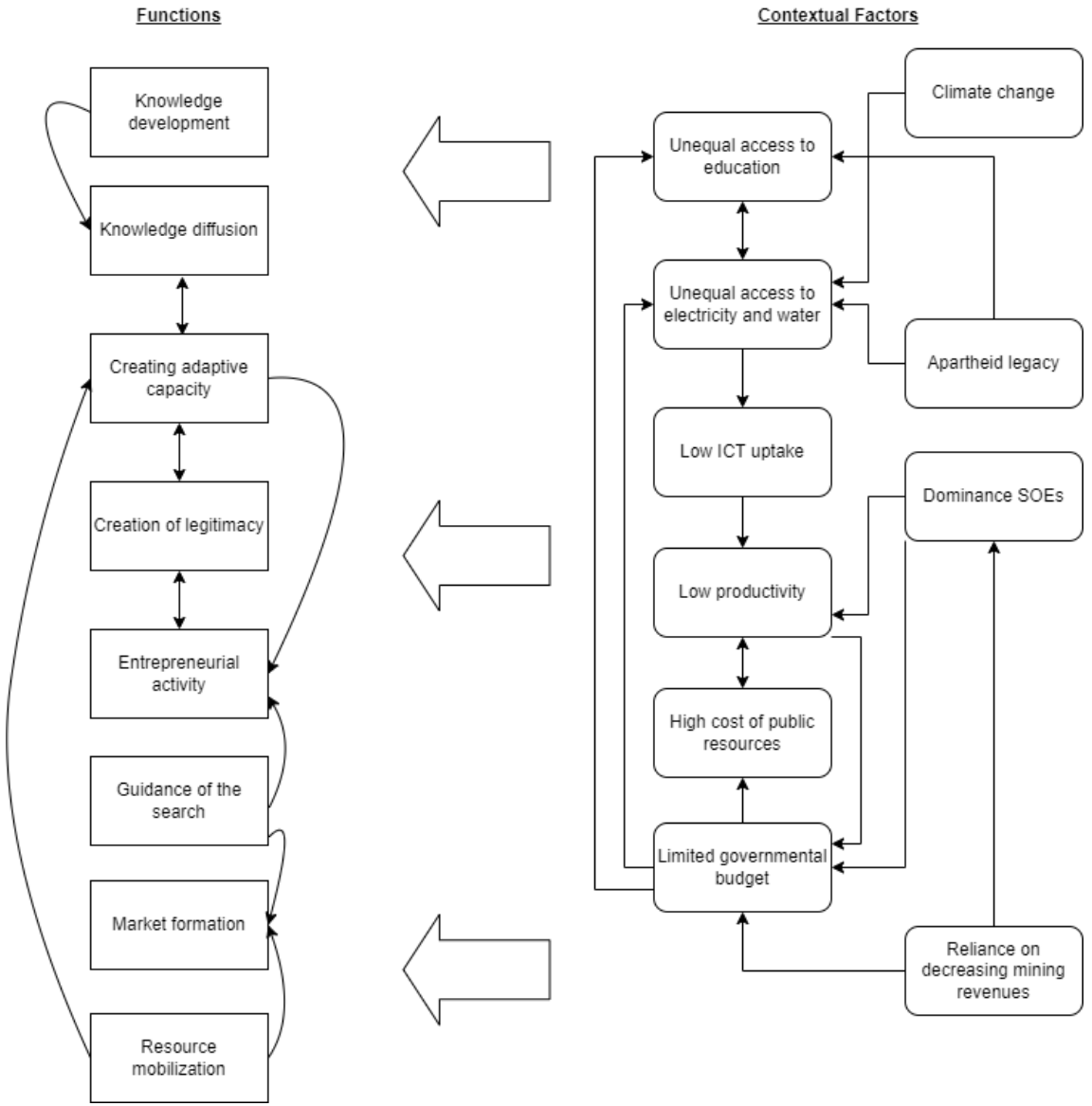
(Source: Interviews; World Bank 2021; Nambinga, 2017; Jauhiainen & Hooli, 2017)

(Image Source: Author)

Many barriers are caused by underlying and interrelated contextual factors

- Especially in early development phase, contextual factors have a **large influence**.
- Lack of adaptive capacity and entrepreneurial activity is largely caused **by low levels of practical training and education.**
- **Low ICT uptake** has a negative influence on knowledge diffusion and, through limited communication channels, creation of legitimacy.

➢ Improvements in the hydrogen IS should go **alongside structural reforms.**



(Source: Interviews; World Bank 2021; Jauhiainen & Hooli, 2017)

(Image Source: Author)

What is the current status of the upcoming hydrogen innovation in Namibia?

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Problem 1: potential undersupply of Namibian workers for the hydrogen projects.

Underlying problem:

- GHRI, project developers and German Government have made great efforts with research transfer, course development, and exchange programs for Namibians with higher education levels.
- However, there is a need for more **tertiary education and training focusing on practical hands-on engineering.**

Key barriers to progress:

- There are too little teachers with practical hydrogen experience, and it is unlikely that project developers can train sufficient Namibian workers themselves.
- There is a lack of knowledge and awareness among students and marginalized groups, which causes a lack of participation and ownership.

Problem 2: lack of local entrepreneurship and experimentation

Underlying problem:

- Namibia is only at the very beginning of a transition to green hydrogen future and there are still very many technical improvements and use cases awaiting to be made along the entire production and value chains relating to green hydrogen.
- However, local entrepreneurs currently lack the knowledge, financial capabilities, to experiment with such use cases and grow alongside the hydrogen projects.

Key barriers to progress:

- Local demand is too low for scaling up existing companies and large-scale hydrogen projects often cannot afford the time and risk to experiment with small SMEs and experimental start-ups.
- There is too little knowledge flowing from the key actors of the hydrogen IS to the private sector, which prevents local entrepreneurs from learning and experimenting.
- There is a lack of seed funding for start-ups and entrepreneurs face bureaucratic hurdles (e.g., permits, taxes).

How can stakeholders work together to further develop the hydrogen innovation system?

- Strategies
- Hypothetical local innovation examples
- Recommendations

Strategy 1 – accelerate capacitating of GHRI and vocational training centers to increase adaptive capacity

- Capacitating of the practical training department within the GHRI should be accelerated - **at least one person** should be responsible for coordinating the development of practical training materials and increasing capacity within vocational training centers.
- MOUs could be leveraged to set up **exchange programs** and (online) **knowledge transfer** structures between vocational training centers in the EU and Namibia.
- Foreign universities and research institutes could assist in setting up the institutional basis for the GHRI, by **temporarily sending senior professors and industry professionals** with practical experience in the field of hydrogen.
- This would accelerate the process of creating adaptive capacity, because the GHRI does not have to **train and recruit their own staff first.**

Strategy 2 - improve communication by setting up a collaboration platform and empowering bottom-up movements

- To improve awareness and inclusion, an **online collaboration platform** could be developed, which could be a one-stop-shop for all hydrogen related questions and information, including exchange programs, scholarships, course programs, and jobs.
- **Offline communication** could be outsourced to bottom-up movements such as NaYoRE, as such an approach is **likely to lead to more engagement** than National Government initiatives and reaches more people in informal settlements and rural areas.
- The Government of Namibia and project developers could **cooperate with bottom-up organizations** like NaYoRE by organizing joint conferences, and by providing education, information and funding.
- These actions would improve legitimacy of hydrogen projects and create more incentives and possibilities for local students and start-ups.

Strategy 3 - create more opportunities for local hydrogen-related experiments and entrepreneurship

- Local entrepreneurs should have the **opportunity to organically grow their business** – either by working with pilot projects or in a test ground connected to the main project.
- Local knowledge development and **experimentation** should focus on **adapting technologies to local circumstances** (*see examples following slides*) instead of working on solutions for which comparative advantage is hard to achieve in Namibia (e.g., fuel cells and elektrolyzers).
- **Local incubators** could be upskilled, upscaled, and connected to European incubators, to (jointly) incubate hydrogen-related start-ups.
- **EIF funds** could be directed to local experiments with hydrogen-related technologies and micro-loaning companies can be repurposed to provide secure and legitimate financing options for local entrepreneurs.

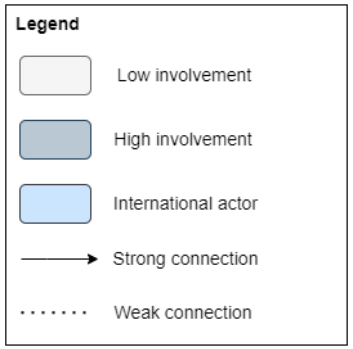
Summarized: weak connections could be improved by upscaling institutions, associations, and platforms

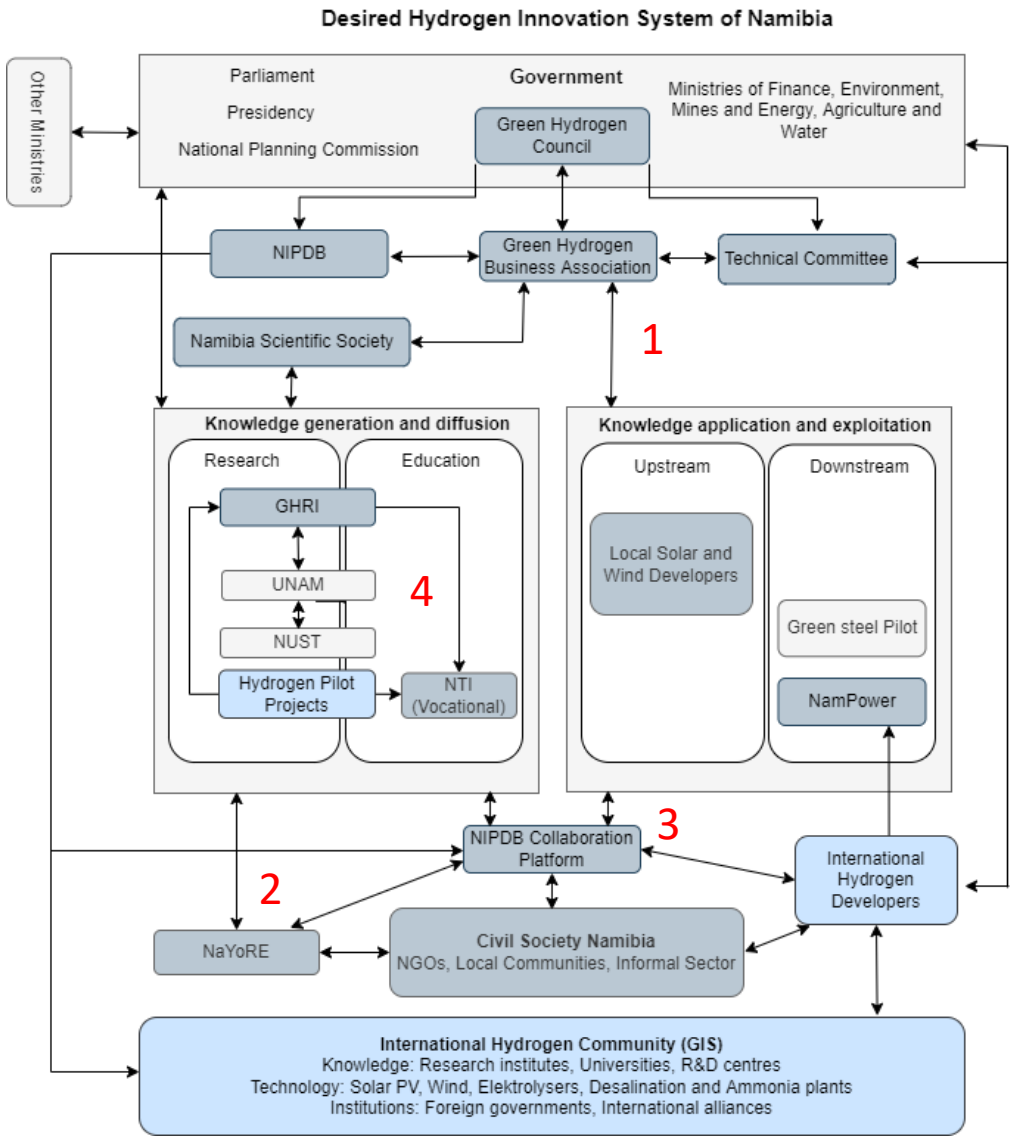
1. Green Hydrogen Business Association could provide **missing links** between the Governmental bodies and the local private sector.

2. NaYoRE and EIA consultations could **improve** communication with, and inclusion of, civil society.

3. NIPDB platform could be leveraged for **stakeholder collaboration.**

4. GHRI could be upscaled to improve educational **coordination.**



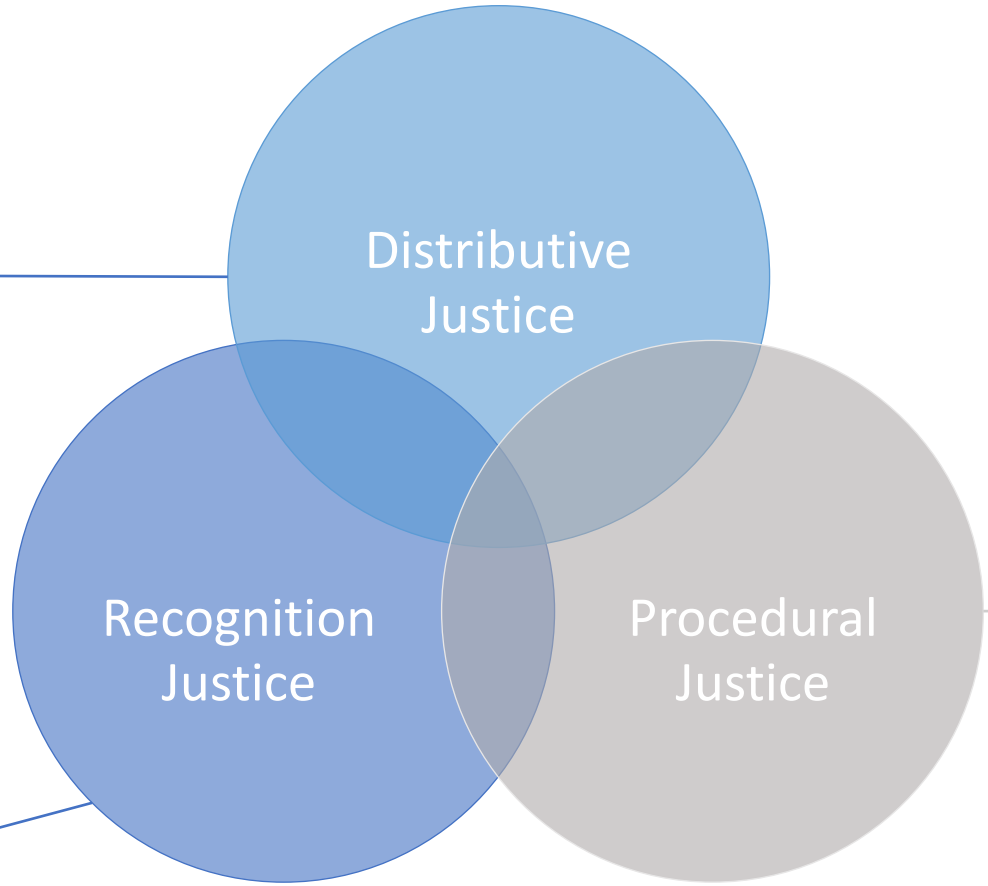


(Image Source: Author)

Besides innovation strategies, there are various energy justice issues that should be considered with large-scale hydrogen projects

- **Inclusion** is dependent on targeted training efforts for the poor.
- Sovereign Wealth Fund and equity stakes are effective tools to redistribute earnings and overcome a potential resource curse, *if* **radical transparency** is applied.

- Consider the **cultural impact** of hydrogen projects on various ethnic, social and cultural groups.



- **EIA** stakeholder consultations should inform about the benefits **and risks** of these projects in a way that is **understandable to all stakeholders.**

- **SEA** could give insight into cumulative environmental effects.

- A **citizen forum or collaboration platform** could be a useful tool to include a representative group of stakeholders.

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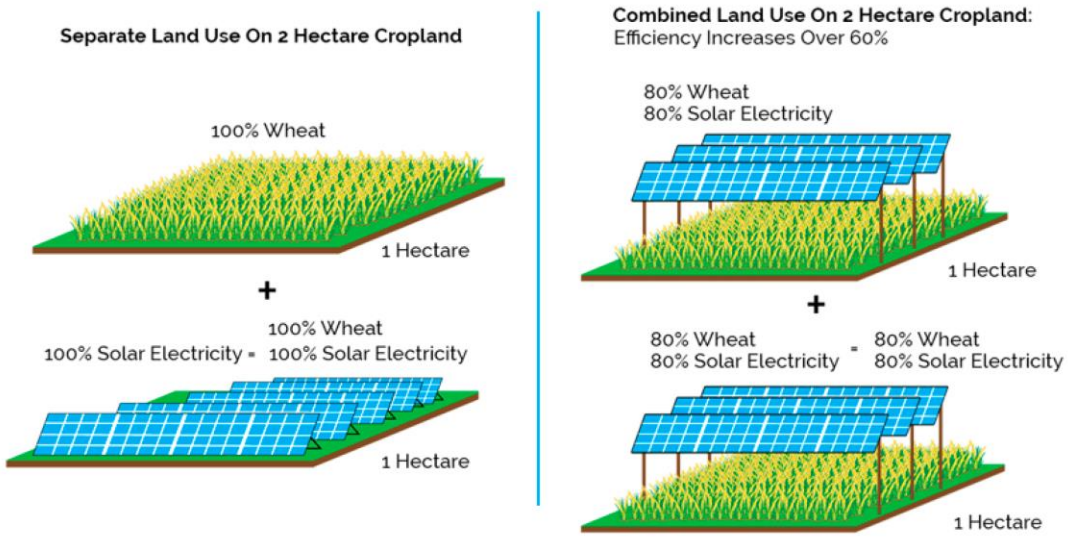
Example 1: agrivoltaics and desalinated water could improve business case and address local developmental challenges

- Combining solar panels with crops and small livestock could create a **symbiotic relationship**, where the shade of the panels increases the yield of crops and reduces water use, while the plants make the panels colder, which **could increase their efficiency by 10%.**

- The agrivoltaics system could be combined with DOT windmills to produce **cost-effective desalinated water,** which could be used for simultaneously cleaning solar panels and watering the crops.

- **Total revenue and the social impact** of a solar PV field could be increased if hydrogen developers work together with local farmers.

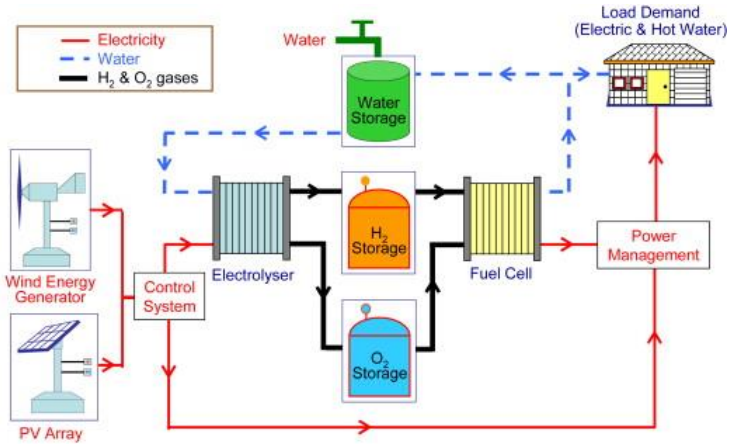


Comparison of efficiency traditional farming versus AVS (Source: Abidin, 2021)

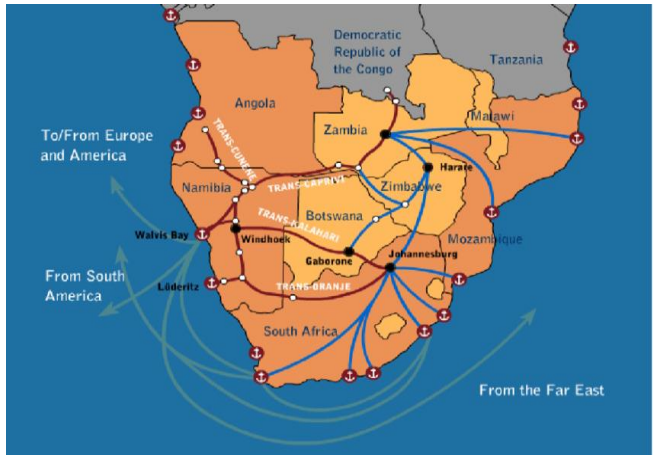
(Source: Fraunhofer ISE, 2022; Abidin, 2021)

Example 2: decentralized filling stations along Walvis Bay corridor for hydrogen trucks and passenger cars

- Local communities could **co-invest and run hydrogen filling stations alongside the Walvis Bay Corridor.**
- Microgrids with solar PV (potentially agrivoltaics), a water purification/desalination, and an elektrolyzer.
- Local communities could **improve their living circumstances** (connectivity, light, clean cooking, refrigeration, crop yields, clean water and sanitation), while producing hydrogen at peak hours.
- Potential customers could be hydrogen trucks and passenger cars.



Sustainable energy and hydrogen storage solution

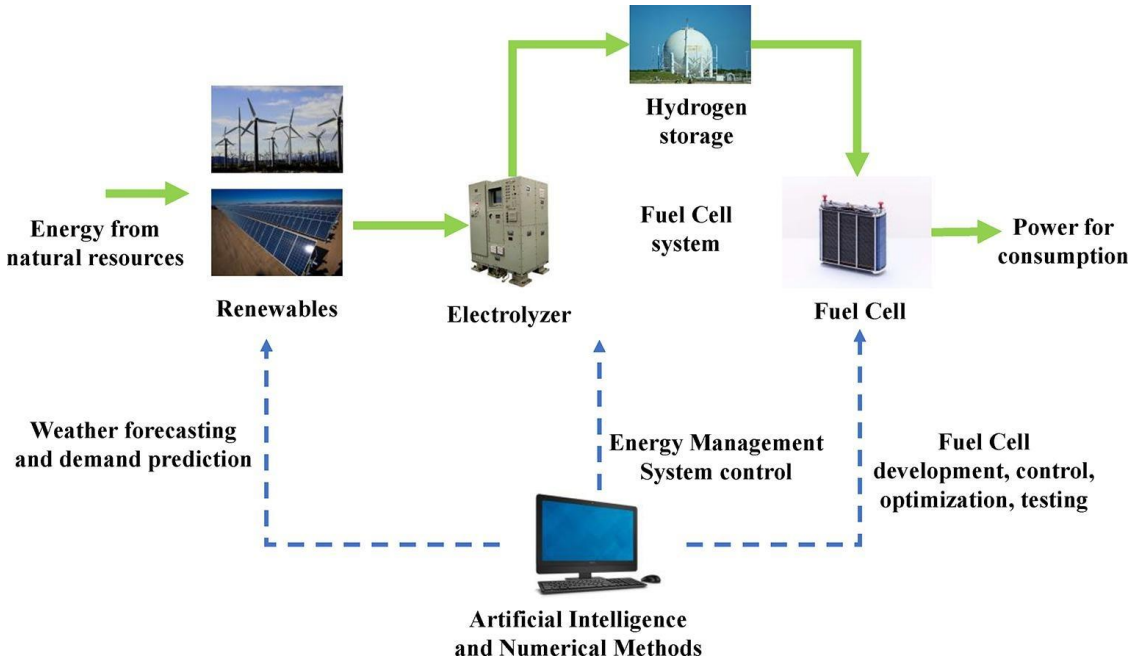


Walvis Bay Corridor

(Source: Brundige et al., 2011; Clarke & Badwal, 2010)

Example 3: digital and environmental solutions for the hydrogen value chain

- **Big data and AI** could be used to monitor the weather conditions and the energy supply, or to detect technology failures.
- Environmental solutions are needed to deal with the **large amounts of brine** (from desalination) and long-term recyclability of materials.
- Digital and environmental solutions are **easily scalable and require little to no supportive industries.**
- Could go along with increased roll-out of ICT infrastructure and 4IR strategy.



Application of AI in hydrogen value chain (Source: Al-Othman et al., 2022)

(Source: Al-Othman et al., 2022; IPPR, 2022)

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Recommendations to Namibia

1. Accelerate capacitating of practical training department GHRI with at least one FTE by 2023.
2. Leverage MOUs to set up collaborations (exchange programs and course materials) between vocational training centers, private training facilities, and universities in the EU and Namibia.
3. Jointly develop a collaboration platform with key stakeholders and foreign universities, with the aim of improving access to information and educational material.
4. Leverage grass-roots communication actors (e.g., NaYoRE) to reach and inform marginalized groups that have limited media access and no awareness of hydrogen and RE.
5. Upscale and upskill local incubators like Start-up Namibia, so they can help set up hydrogen-related start-ups.
6. Prioritize knowledge development, education, and experimentations for solutions that can be adapted to local circumstances (e.g., agrivoltaics, digital solutions) over solutions for which comparative advantage is hard to achieve in Namibia, e.g., fuel cells and elektrolysers.
7. Leverage the Blended financing platform to finance local experiments and start-ups with hydrogen-related solutions.

Recommendations to the Netherlands

1. Establish cooperation (in the form of exchange programs and course materials) between MBO/HBO schools and Namibian Training Institute. The Orange Knowledge Program by the Ministry of Foreign Affairs and Nuffic can be leveraged for this purpose.
2. Revive the MOU between TU Delft and UNAM to share hydrogen-related courses (MOOCs) and guest lectures with Namibian universities.
3. Send one or two senior professors or industry professionals with practical hydrogen experience to Namibia to establish the institutional basis for GHRI practical academy.
4. Establish an international incubator program with Yes! Delft where TU students will be matched with Namibian students and can set up businesses together.

Recommendations to the Port of Rotterdam

1. Establish cooperation (in the form of exchange programs and course materials) between STC Rotterdam and Namibia Training Institute.
2. Perform a feasibility study with PortXL to establish the innovation potential for the port ecosystem of Namibia, with regards to green hydrogen.
3. Extend the matching ecosystem of PortXL to Namibia, so project developers, pilots, and SOEs can place challenges and Namibian and Dutch start-ups can provide (joint) solutions.