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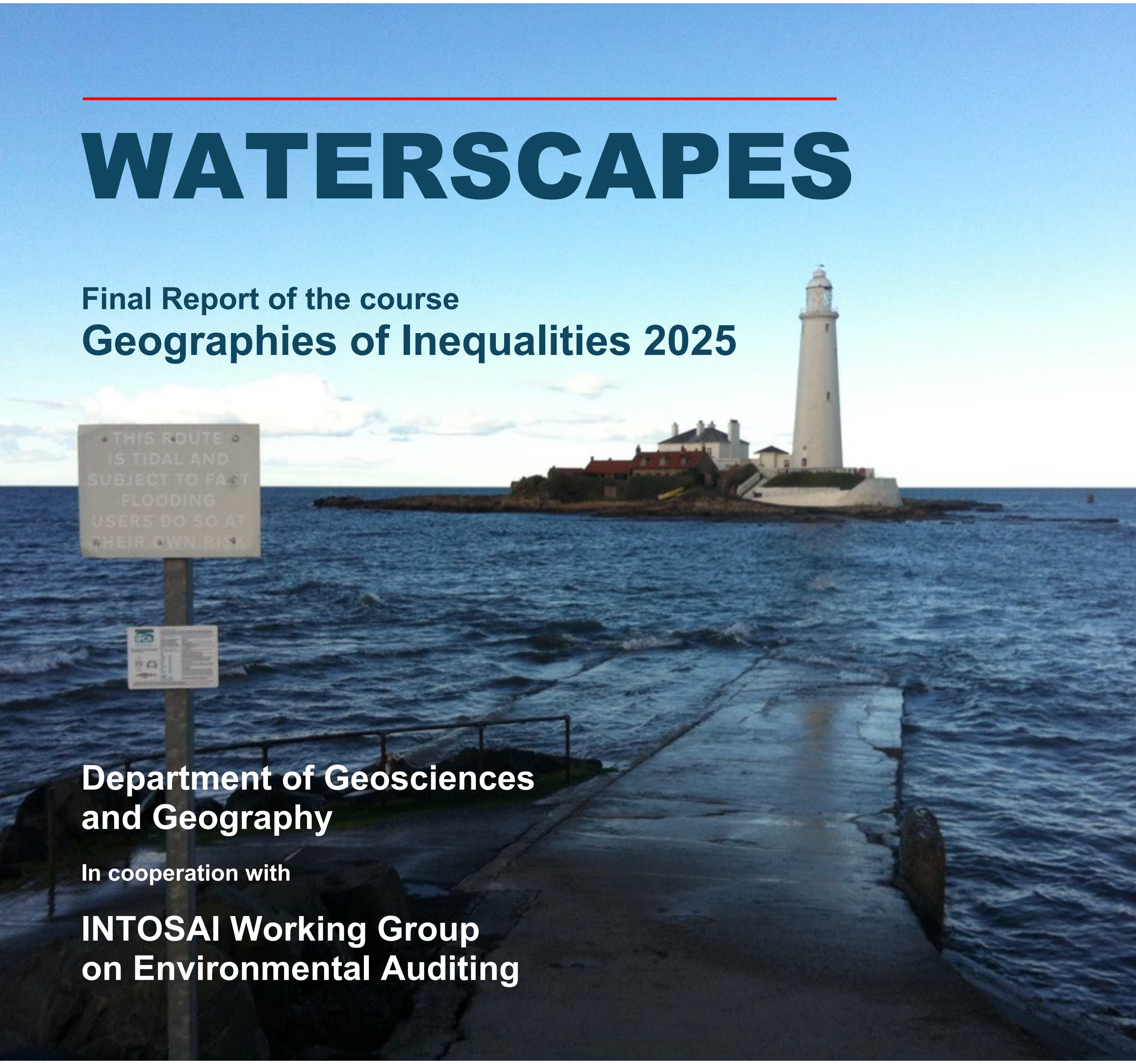

WATERSCAPES

Final Report of the course
Geographies of Inequalities 2025

Department of Geosciences
and Geography

In cooperation with

INTOSAI Working Group
on Environmental Auditing

Contents

Foreword

Water is a powerful example of a cross-cutting issue that demands a systemic and interdisciplinary approach. It is essential for both ecosystems and human well-being – providing drinking water, ensuring food security, regulating the climate, and supporting biodiversity. Yet, water-related challenges are intensifying. Droughts and water stress, exacerbated by climate change, lead to water shortages, crop failures, economic hardship, and conflicts. Poor water governance further compounds these issues. This makes water an ideal theme for exploring the interconnected nature of environmental, social, cultural, and economic systems, as well as sustainable development solutions.

This report is the outcome of the sixth year of collaboration between the University of Helsinki's Department of Geosciences and Geography and the INTOSAI Working Group on Environmental Auditing (WGEA) in delivering the interdisciplinary course Geographies of Inequalities. The WGEA Secretariat, hosted by the National Audit Office of Finland, is currently preparing new water-related projects. Therefore, we focused this year on water. The course and the students' contributions have provided valuable insights and helped the Secretariat navigate this complex and multifaceted topic.

As in previous years, students worked in groups to complete assignments, presented their findings in an international online seminar, and submitted their final reports in the form of infographics – highlighting the growing importance of visual communication, a core skill in expert positions. From a learning perspective, this cooperation offered unique opportunities for students to become familiar with environmental auditing in practice at the international level and to delve deeper into the role of the Sustainable Development Goals – and to understand the politics behind them. As we learned during the course, water is not only a physical element, but a social one as well.

The students came from both the Geography and Urban Studies and Planning master's programmes, thus creating a multidisciplinary learning environment. We are very proud of our students' commitment and work within a very limited timeframe, and we also wish to thank our course assistant, Liisa Ahokas. We are grateful for the contributions of national and international experts who provided the initial ideas for the topics and offered valuable comments during our final seminar.

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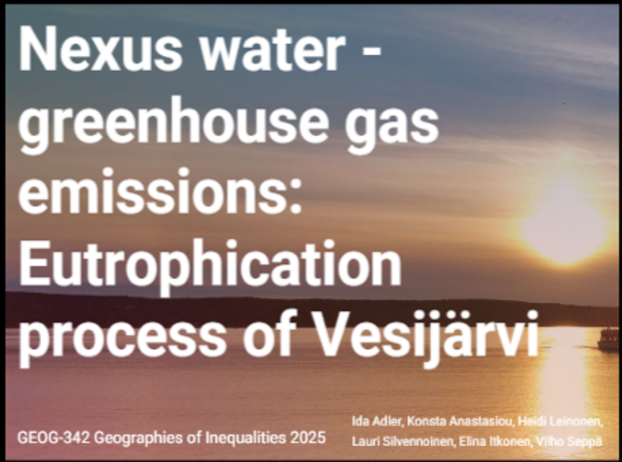
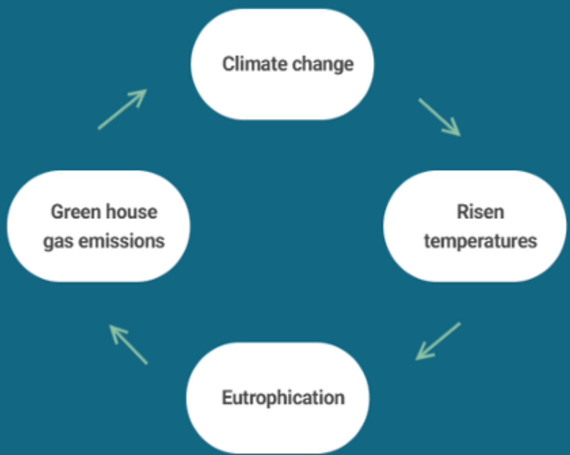
Nexus Water – Climate Change: Inequalities in the eutrophication and management of Lake Vesijärvi

Ida Adler, Konsta Anastasiou, Elina Itkonen, Heidi Leinonen, Lauri Silvennoinen, Vilho Seppä

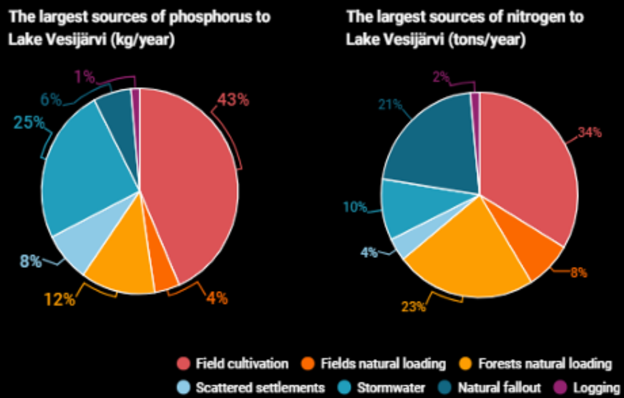


Eutrophication – climate change feedback loop



Current main reasons for eutrophication

1. Agriculture
2. Built areas and stormwater (Lahti)
3. Natural loading (fallout, forests, fields)



Effects of Euthrophication

Biodiversity
Aquatic ecosystems and living organisms
Livestock and wildlife

Drinking water
Human health
Recreational use
Landscape value
Economic

Management actions and financing

- Artificial oxygen supply
- Improving of water flow rates via dredging
- Mowing of water plants in summer and in winter
- Treatment of wastewater and stormwater
- Biomanipulation and management fishing
- Diffuse pollution control

Discussion

- Will the management efforts lead to lasting positive effects if other stress factors increase (recreation, fishing, tourism)?
- Who is responsible: Polluter pays principle (EU)?
- Is stricter legislation needed for future accountability?
- Are management efforts motivated by financial incentives? What happens in absence of profits?
- Call to (re)examine our relationships to lake environments - intrinsic value of natural ecosystems

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Eutrophication and greenhouse gasses

Eutrophication is the consequence of an excess of nutrients in bodies of water (Törnroos-Remes, 2023). Although eutrophication can happen naturally, it is a largely anthropogenic issue (Salmi et al., 2014; Henderson, 2015). Nitrates and phosphorus are the biggest drivers of eutrophication, and they can end up in bodies of water through surface runoff and stormwater drainage (Törnroos-Remes, 2023).

One of the issues eutrophication causes are algal blooms, often consisting of toxic cyanobacteria (Salmi et al., 2014, Salonen et al., 2023). This can lead to reduction in the quality of fish, create health risks and damage the recreational value of lakes (Salonen et al., 2023). One of the things that makes eutrophication such a complex problem is the internal load and legacy nutrients (Salonen et al., 2023). Lakes can release previously accumulated nutrients from the sediment, meaning that the effects of external nutrients can be visible and current even decades later (Salonen et al., 2023).

Eutrophication is a source of greenhouse gasses (Beaulieu et al., 2019), with freshwater ecosystems creating the largest natural contribution of methane (Nijman et al., 2021). These methane emissions are increased when lake productivity increases, so eutrophication causes lakes to become a greater source of methane (Beaulieu et al., 2019, Nijman et al., 2021). At the same time, higher temperatures in lakes increase productivity, which causes further eutrophication and creates more methane emissions through the breakdown of organic material (Beaulieu et al., 2019, Nijman et al., 2021). This can cause a vicious circle where one problem feeds the other.

One of the examples of an eutrophicated lake is Lake Balaton in Hungary (Bernát et al., 2020, Hatvani et al., 2020) It became eutrophic due to anthropogenic causes, the main factors being increased fertilizer use in agriculture, growing population and increased amount of wastewater (Bernát et al., 2020, Hatvani et al., 2020). This had negative effects for the recreational and practical value of the lake and led to economic losses as a result (Bernát et al., 2020, Hatvani et al., 2020). Restoration was done in four main ways: Restoration of the connecting wetland system (1), diversion of sewage (2), wastewater treatment (3) and downsizing livestock farms located in the watershed (4) (Bernát et al., 2020, Hatvani et al., 2020). On top of these a large factor affecting the reduction of external load was the collapse of agriculture in the area, which significantly decreased the use of fertilizers in the watershed (Bernát et al., 2020).The funding for the lake restoration comes from different sources. These mainly consist of the Hungarian government, the EU (Hungary Today, 2023), the UN (UNDP, n. d.) and grants from the EEA (Norway Grants, 2009).

EU policy has the Polluter Pays Principle, which aims to ensure that the people responsible for the pollution also end up covering the price of managing issues caused by it (European Commission, n. d.). We can see this play out in the lake Balaton case, where the government with EU and international support covered the costs of restoration. Another policy directing the well being of water is the EUs Water Framework Directive, which strives to ensure good water health and management in EU countries (European Commission, n. d). Member countries can get funding through the EU to ensure the health and quality of water in their country (European Climate, Infrastructure and Environment Executive Agency, 2025).

Lake Vesijärvi

Lake Vesijärvi, located in southern Finland, is part of the Kymijoki watershed and drains into Lake Päijänne through the Vääksy River and canal. It has a surface area of 109 km², making it Finland's 42nd largest lake. The lake is shallow (average depth 6 m, max 42 m) and divided into several basins, the largest being Enonselkä, Kajaanselkä, Komonselkä, and Laitialanselkä. The surrounding land is mainly forested, with significant areas consisting of holiday housing, agriculture, and built environments.

Overall, Vesijärvi's water quality is stable and improving, though it varies by area. Kajaanselkä is in good ecological condition, while other areas such as Enonselkä and Komonselkä are in moderate condition. Vähäselkä remains the most nutrient-rich and ecologically weakest area. Phosphorus levels have continued to decline, although occasional high levels are still detected in low-oxygen bottom waters.

Eutrophication of Vesijärvi

Lake Vesijärvi is a good example of a culturally eutrophic lake – a lake that's eutrophication has been caused by human action (Salminen et al., 2021). The eutrophication process was triggered during the early 20th century by the establishment of the city of Lahti. Until 1976 all the raw sewage was poured into Vesijärvi. Additionally, the increase in urban infrastructure and mechanized agriculture caused soil erosion that affected nutrient loading (Salminen et al., 2021 p. 209). By the 1960s and 1970s, Lake Vesijärvi had become one of the most eutrophic large lakes in Finland (Salminen et al., 2021) and once eutrophicated, the ecosystem turned against itself, as some species populations grew while some species that reduce eutrophication shrank or were lost completely, further accelerating the eutrophication of the lake (Aito suvi ry 2022).

Currently, the stormwater loading from the built areas – mostly the city of Lahti – counts for 32% of all phosphorus and 14% of all nitrogen load that eutrophicate Vesijärvi. The surrounding agriculture accounts for 42% of all phosphorus and 33% of all nitrogen load, while natural load levels are 16% of all phosphorus load and 30% of all nitrogen load (Palomäki, 2024). Of both phosphorus and nitrogen load, 60% comes from the near-by areas of Vesijärvi. Additionally, the outlets of Harituenjoki and Hammonjoki stand out with relatively high loading levels (Id.). There are also surrounding industries, such as the Kymijärvi power plant that in 2014 directed over 76 million cubic tons of cooling waters through the river of Joutjoki into Vesijärvi (Järveläinen et al., 2015).

The Affected Groups of Eutrophication

Eutrophication, the excessive enrichment of water bodies with nutrients affects multiple groups, both human and nonhuman. The most direct victims are aquatic organisms. Overgrowth of algae, particularly cyanobacteria, depletes oxygen levels in water, resulting in hypoxic or anoxic "dead zones" where most aquatic life cannot survive (Chislock, Doster, Zitomer, & Wilson, 2013). This leads to fish kills and declining biodiversity, disrupting ecosystems (Parker et al., 2023; Davidson et al., 2018).

Human communities also suffer. Algal blooms reduce the recreational and landscape value of lakes and rivers, as waters become unsafe for swimming and fishing (Costa et al., 2018). In Lake Vesijärvi in Finland, blooms rendered the lake unusable for leisure or consumption, affecting local livelihoods and well-being (Kuoppamäki, 2023). International research also discusses cases in which toxic blooms further threaten public health through contaminated drinking water, and have been linked to wildlife, domestic animal and human poisonings globally (Chislock et al., 2013).

Economically, eutrophication burdens municipalities and households with increased water treatment costs to eliminate foul taste, odor, and toxins from drinking water. Also, tourism as a livelihood is at risk. The decline in tourism impacts especially local economies that depend on seasonal visitors. In more developing regions, this redirects scarce resources away from vital infrastructure projects (Addo, 2020). Vulnerable populations face compounded risks. Communities that are the most dependent on the fresh water are also more exposed to food and water insecurity as fisheries collapse and waterborne diseases spread due to poor sanitation (Parker et al., 2023). Ironically, even the industries contributing to eutrophication, such as agriculture, are at risk. Climate change-induced rainfall intensifies nutrient runoff, creating a feedback loop that both worsens eutrophication and threatens future agricultural productivity (Davidson et al., 2018).

Management Actions for Lake Vesijärvi

Management methods	Additional Information	Contributor	Timing
Artificial oxygen supply	First aeration started in 1979, second in 2009	No information found	1979-1985, 2009
Diffuse pollution control	Containment of agricultural runoff in major drains, Creation of wetlands and sedimentation ponds	No information found	Ongoing
Improving of water flow rates via dredging	Harbor dredging in lahti	No information found	1990-1991
Mowing of water plants in summer and in winter	"The mowing plan will be implemented in accordance with the opinion of the Häme ELY Centre."	Organized by Vesijärvi foundation since 2015, funding from Ely-keskus	Ongoing
Treatment of wastewater and stormwater	Start of sewage treatment: waste water diversion from the lake. Improved treatment of wastewater in sparsely populated areas	City of Lahti, Hollola, Asikkala (?)	1976, ongoing
Biomanipulation and management fishing	Mass removal of planktivorous and benthivorous fish, stocking of predatory fish, Management fishing of roach, pirch, European smelt	Was organized by Lahti environmental services. Currently is a purchasing service by Tmi Ile's Fisk ja Järvikalastus Turtiainen, and Lahti environmental services and volunteer work.	1989–1993, Ongoing

(Salminen, Tammelin, Jilbert, Fukumoto, Saarni 2021, Vesijärvi foundation n.d, Vesijärvisäätiö n.d)

Contributors to the management and financing

The management of Lake Vesijärvi is led by the Vesijärvi foundation. The foundation was founded in 2007 and its aim is the restoration and management of Lake Vesijärvi and its surrounding water bodies. The foundation is also a facilitator and organizer between the public, private and research sectors in the management of the lake (Päijät-Hämeen Vesijärvisäätiö, 2024) . The foundation is funded by private and public sectors, as well as foundations and private individuals. The share of the funding is 70 % public and 30 % private funding (Vesijärvi foundation, n.d). Largest public funders are the cities of Asikkala, Hollola and Lahti (Päijät-Hämeen Vesijärvisäätiö, n.d). Some management projects are funded by Hämeen ELY-keskus, for example mowings (Päijät-Hämeen Vesijärvisäätiö, 2024) . The economic contributions to the lakes restoration have been smaller than the economic gains that the restoration projects have yielded (Kairesalo & Kuoppamäki, 2004).

Conclusion and discussion

As a conclusion, we want to bring forth a few points for future consideration and discussion based on our work presented here. Firstly, it is important to recognize that eutrophication management efforts, even when successful, may not directly lead to a decrease in climate/environmental stress if other stress factors increase as a result. As we have discussed, eutrophication and climate change are clearly connected and operate in a cyclical manner. However, simply reducing eutrophication does not lead to lasting change if tourism, industry, fishing and recreational use don't remain under control. Thus, we want to highlight that decreasing eutrophication, and the resulting cleaner lake environment is not simply a target to reach, but a continuing process which should be understood in the context of the surrounding cultural and social practices as well as the historical context, owing to the problems of legacy nutrients.

Secondly, we wonder if the management efforts are often subjugated under financial interests. Economic prospects are a clear motivator for many actors involved with Vesijärvi. This is evident in Vesijärvisäätiö's messaging where the economic future is often emphasized. Increasing profitable fish species and reducing non-profitable ones, tourism and recreation are often brought up when discussing the positives of eutrophication management. But we must clearly recognize that lake environments such as Vesijärvi have value beyond just as a useful resource for humans. Dependence on private funding may be a threat to future management if certain methods/efforts prove to be expensive and/or non-profitable. This should also serve as a call to carefully examine our current societal/cultural/economical dimensions and how they produce, uphold and limit our understanding of water (Swyngedouw, 2009).

Thirdly, we bring up responsibility. Conservation efforts around Vesijärvi are mostly being facilitated through Vesijärvisäätiö, an organization which looks to bring together both public and private actors to participate in management. While the co-operation has been successful, a question remains about accountability and responsibility. Despite the EU clearly advocating for the Polluter Pays Principle, it seems that in the case of Vesijärvi it is not mentioned/utilized. While some of the historically biggest polluters (notably Lahti) are taking big responsibility in the management, we wonder if actors such as private landowners are not "doing their part" in the efforts. In the "Vesijärvi-ohjelma 2024-27" (Päijät-Hämeen Vesijärvisäätiö, 2024) it is noted that private landowners play a significant role in the management process, but that their involvement and level of organization varies, which may slow down progression around different areas of the region. Considering this, we ask whether stricter regulation enforcing accountability and responsibility would be beneficial for the future of Vesijärvi. While cooperation is extremely important, conservation can rarely be entirely convivial between actors.

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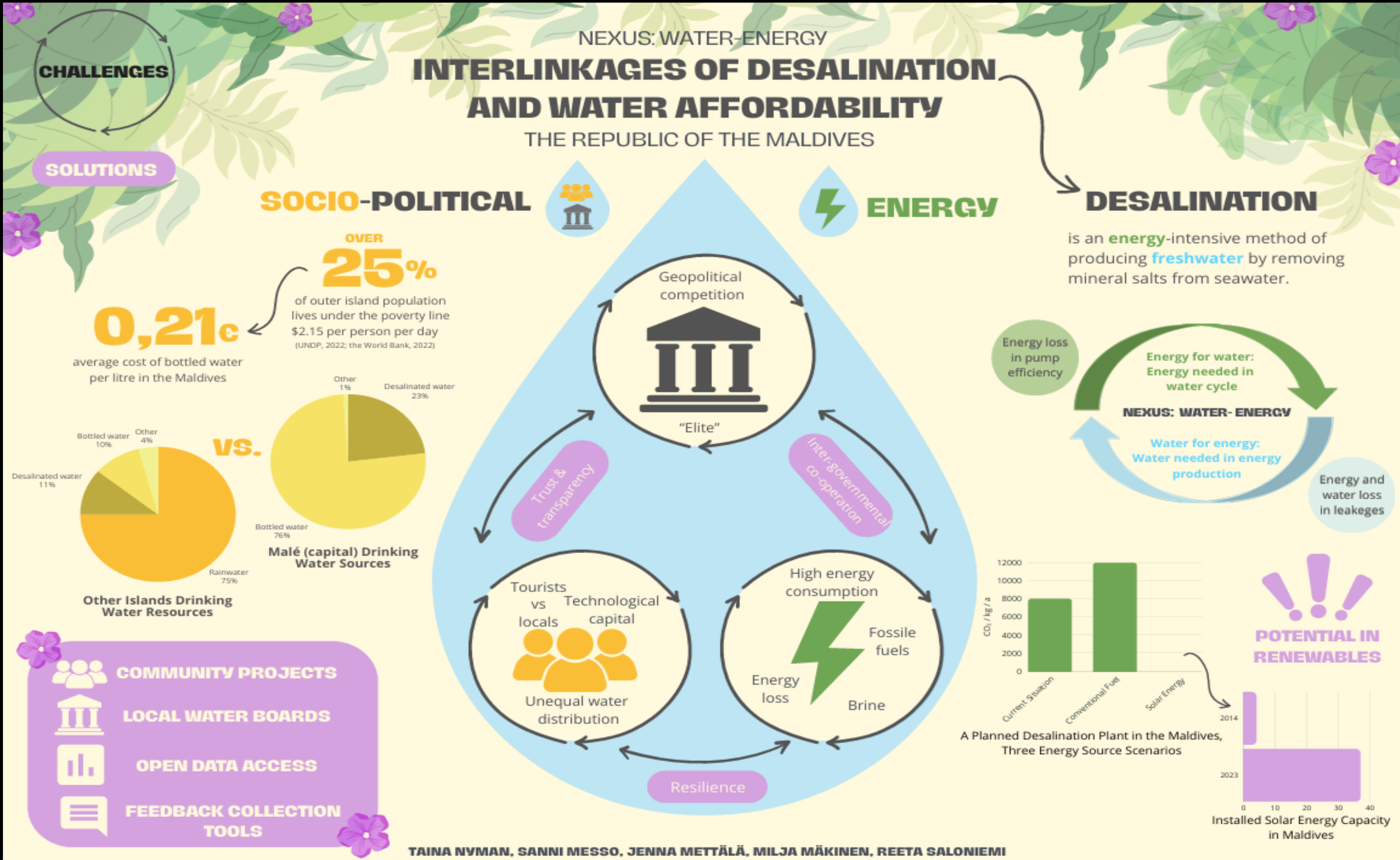
Interlinkages of Drinking Water Production (desalination) and Water Affordability in SIDS Countries – the Republic of Maldives

Taina Nyman, Sanni Messo, Jenna Mettälä, Milja Mäkinen, Reeta Saloniemi



Interlinkages of Drinking Water Production (desalination) and Water Affordability in SIDS Countries – the Republic of Maldives

Taina Nyman, Sanni Messo, Jenna Mettälä, Milja Mäkinen, Reeta Saloniemi

Introduction

Small island developing states (SIDS) are a group of small islands and states that share similar environmental, social, and economic challenges. Due to small land area and remote location, they often have limited opportunities for agriculture and industrial development, as well as scarce natural resources. As a result, they rely heavily on imports, making them vulnerable to external economic shocks, such as global market price fluctuations. Tourism is the most important sector in many SIDS countries, and it has led to significant economic growth. As reported by the Asian development bank, tourism comprises around 25% of the national GDP in SIDS (Acciarri et al. 2021). However, tourism also brings challenges, including environmental degradation and increased demand for limited resources such as water. Therefore, it is crucial to assess how the tourism sector could be developed more sustainably, without harming the local populations' livelihoods and the environment. The Republic of Maldives locates in the Indian Ocean, on the South West side of India. In this report, the Maldives are used as a case example of a SIDS country, to offer local examples for the nexus energy and water affordability context. The country has been described as an advanced SIDS country, meaning that the country has been taking big steps towards a more sustainable water use. However, some challenges still remain strong and this report brings up few of them.

Nexus: Energy

The water-energy nexus refers to the interdependent relationship between water and energy systems – specifically, the water used in energy production and the energy required in water management processes. As Ding and colleagues (2020) note, water and energy systems are inextricably linked: in the energy sector, water is essential for production, transportation, and use, while water systems require energy at every stage – extraction, treatment, and distribution (Sharif et al., 2019). Globally, water plays a significant role in energy production, including hydropower, cooling for thermal plants, fuel processing, and the mining of minerals needed for energy generation (Bredariol et al., 2024; Sharif et al., 2019). As drinking water systems become increasingly energy-intensive, they now account for 7–8% of global electricity consumption (Sharif et al., 2019). Energy and water losses, often caused by inefficient pumping and leakages, worsen the problem. In many developing countries, up to 30–50% of distributed water is lost due to system inefficiencies, resulting in wasted energy and water resources (ibid.). Optimizing energy use in water distribution is therefore vital for reducing emissions and advancing sustainability.

Challenges in water affordability

The Maldives is a geographically dispersed archipelagic state comprising numerous inhabited and uninhabited islands and atolls (Ibrahim et al, 2002). Historically, the Maldives have depended on imported bottled water, delivered by sea to various islands and sold in shops and tourist accommodations (ibid.). This reliance on imported water represents one of the country's major challenges. Due to its oceanic nature, the Maldives also possesses minimal natural freshwater reserves, which are increasingly threatened by saltwater intrusion caused by sea-level rise—a consequence of the country's low elevation. In response, local populations have traditionally relied on rainwater harvesting for their freshwater needs (Orellana Lazo, 2013). However, rainfall has become increasingly unreliable due to climate change, and prolonged dry spells are now common.

One of the key methods being developed to tackle this challenge is desalination—the process of removing salt from seawater to produce potable water. Desalination technologies have also been implemented on other SIDS, as many face similar water scarcity issues (Acciarri et al., 2021). However, desalination is not a straightforward solution; it is energy-intensive and currently relies on fossil fuels transported by ship to the islands, leading to both environmental impacts and continued dependence on mainland infrastructure (ibid.). Desalination remains an energy-intensive and costly technology, which can make water economically inaccessible for many residents. Over 25% of the population in outer islands lives below the poverty line of $2 per day, making bottled or desalinated water unaffordable (UNDP, 2022). While resorts operate their own desalination systems to provide high-quality water for tourists (Moosa, 2021), local households primarily consume lower-cost, locally produced alternatives. This disparity raises questions whether tourist resorts should be required to share their water production capacity with nearby communities.

The types of drinking water used in the Maldives vary significantly between regions, especially between the capital Malé and the outer atolls, as shown in Figures 2.1 and 2.2 (Ministry of Environment, Climate Change and Technology, 2021). This highlights how geography and infrastructure capacity play a major role in shaping water availability and reliability. Smaller and more isolated islands often face greater challenges, especially during the dry season, as they depend on rainwater harvesting or locally desalinated water, which are both vulnerable to climate variability and costly to maintain.

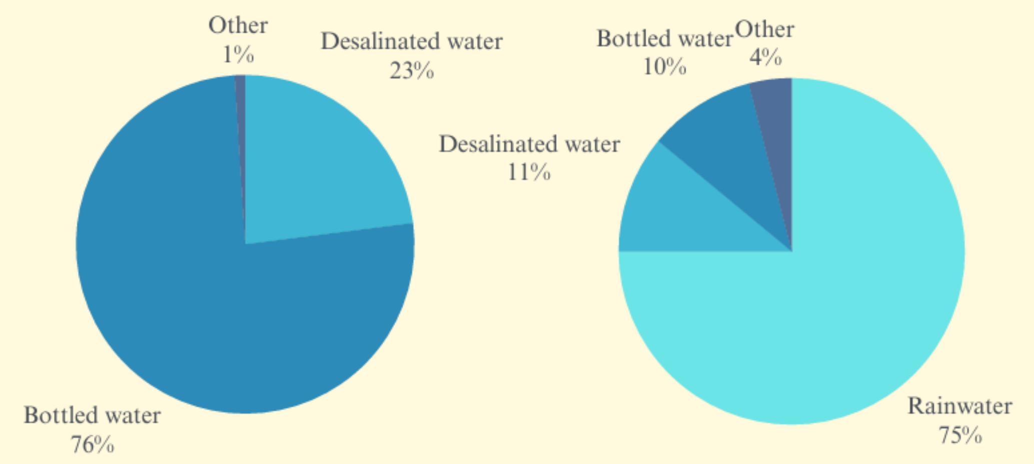


Figure 2.1 Malé Drinking Water Sources. Figure 2.2 Other Islands Water Sources.

Moreover, insufficient wastewater management poses challenges in the outer atolls. While improvements in the sector have been made in recent decades, insufficient sewage treatment continues to cause environmental issues, such as aquifer contamination and reef degradation (Ministry of environment, climate change and technology, 2021). Developments in the wastewater sector would not only protect the vulnerable marine environment but could also result in reduced desalination costs and improved water security, as aquifers could be used more effectively for human consumption.

Desalination

One widely adopted but energy-intensive solution to water scarcity is desalination, the process of removing mineral salts from seawater to produce fresh water (International Desalination Association (IDA), n.d.). Desalination has become critical due to growing water demand driven by population growth, economic development, and agricultural needs (Nassrullah et al. 2020). In Small Island Developing States (SIDS) like the Maldives, desalination is especially important, though it remains costly due to high energy requirements (Akiwumi, 2024). In addition to energy use, brine disposal – the management of extremely saline and chemically concentrated wastewater – is both expensive and energy-consuming. Environmental concerns also arise from brine salinity and the presence of harmful "forever chemicals" (Hopp, 2024).

Desalination can be implemented at both large-scale plants and small scale systems, such as those used in tourist resorts. The two most common desalination techniques are reverse osmosis and thermal desalination. In reverse osmosis, seawater is forced through a membrane under high pressure, separating fresh water from brine (Perez, n.d.; IDA, n.d.). In contrast, thermal desalination involves evaporating seawater to leave impurities behind, then condensing the vapor into fresh water (ibid.). In terms of energy demand, reverse osmosis typically requires 2.85–3.7 kWh per cubic meter of water (Acciarri et al., 2021; IDA, n.d.; Nassrullah et al., 2020), while thermal desalination is far more intensive, consuming between 18.3 and 28.5 kWh/m^3 (Nassrullah et al., 2020). As a result, reverse osmosis has become the preferred technique due to its lower energy costs.

The high energy demand of desalination also results in high CO_2 emissions, especially since most desalination energy worldwide comes from fossil fuels (Nassrullah et al., 2020; Sharif et al., 2019). The Maldives is particularly dependent on imported fossil fuels for energy generation (Ministry of Climate Change, Environment and Energy, 2025). To address this, integrated and climate-resilient approaches that incorporate renewable energy into desalination processes are essential for sustainable development (Akiwumi, 2024). Aligned with this goal, the Maldives' Energy Policy and Strategy 2024 2029 highlights the promotion of solar, wind, biomass, and ocean energy sources, along with sector-wide energy efficiency improvements. These efforts aim to reduce reliance on imported fossil fuels, enhance energy security, and decrease greenhouse gas emissions (Ministry of Climate Change, Environment and Energy, 2025). Innovative solutions such as mini and micro-hydropower systems, which harness existing pipeline flows for electricity generation, also offer promising alternatives (Sharif et al., 2019).

The Maldives also holds unique potential for renewable energy, particularly from its high solar radiation and vast seawater resources. Figure 3.1 (Acciarri et al., 2020) illustrates the dramatic growth in solar power capacity in the country, which increased approximately thirteenfold between 2014 and 2023 (ibid.). This trend demonstrates the Maldives' growing commitment to sustainable and self-sufficient energy solutions. The main barrier to this approach is the high initial cost of infrastructure—particularly the investment in solar panels (ibid.). However, over time, the use of renewable energy has been shown to be more cost-effective than fossil fuels. Transitioning to solar energy is not only economically beneficial in the long term but also essential for the future resilience of the islands, as sea-level rise poses a significant threat to their low-lying geography.

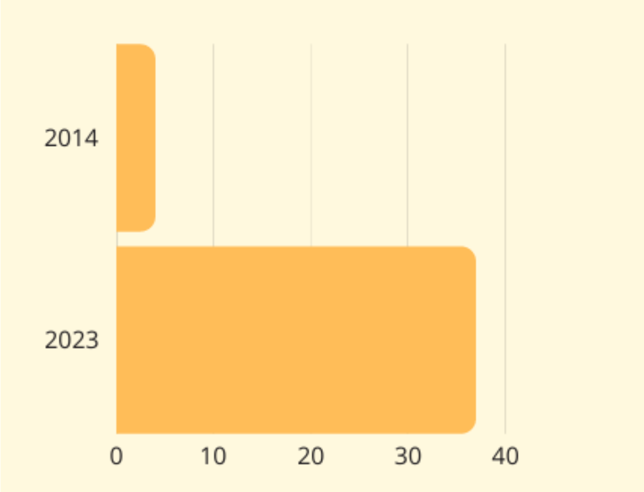


Figure 3.1 Installed Solar Energy Capacity in the Maldives.

Future challenges and opportunities

To address water scarcity and reduce regional disparities in access, the Maldives has adopted an Integrated Water Resources Management (IWRM) approach under the FP007 project, supported by the Green Climate Fund and UNDP (Green Climate Fund, 2022). This approach integrates rainwater harvesting, groundwater use, and solar-powered desalination to create a more stable and climate-resilient water supply. IWRM systems have been implemented on multiple islands, serving as decentralized hubs during dry seasons and reducing reliance on emergency water shipments from Malé. These measures aim to improve equitable access to safe drinking water, particularly for vulnerable communities in remote atolls, and mark a shift toward long-term, locally tailored water governance.

Yet challenges remain in terms of governance and inclusivity. As noted by Kothari and Arnall (2015), decision-making processes related to water access and climate adaptation in the Maldives have largely been dominated by elite and expert perspectives, with limited inclusion of local and non-elite voices. Although the need for more participatory and inclusive planning has been acknowledged, the practical integration of community-level perspectives into policy and implementation continues to be limited. In addition, data availability and reliability pose ongoing obstacles. During this project, it became clear that up-to-date and consistent information is often difficult to obtain and even statistics from the same year may vary between sources.

Conclusion

This project examined the interlinkages of desalination and water affordability in the Maldives. Our results show that while significant advances have been made to ensure equal access to fresh water, challenges remain due to issues in distribution, quality, affordability, and policymaking. Especially the fragmented geography of the country causes distribution issues and results in water insecurity in the outer atolls.

In recent years, more efficient desalination has been introduced as a key solution to ensure equal water access, but the technology remains costly and energy intensive. To address this, the Maldives have implemented solar-powered desalination plants; while these systems require substantial initial investments, they are projected to be more cost-effective in the long term compared to plants reliant on fossil fuels. To improve water availability for all, more renewable energy-powered micro plants are needed in the outer atolls.

However, challenges still remain in ensuring equitable access to water across all inhabited islands. In many cases, tourists have better access to water than local populations, as all the resorts operate their own desalination plants. Moreover, efforts are required to reduce the tourists' unsustainable water consumption as well as improving the transparency, consistency, and accessibility of data will be essential for informed future planning and decision making in the Maldives.

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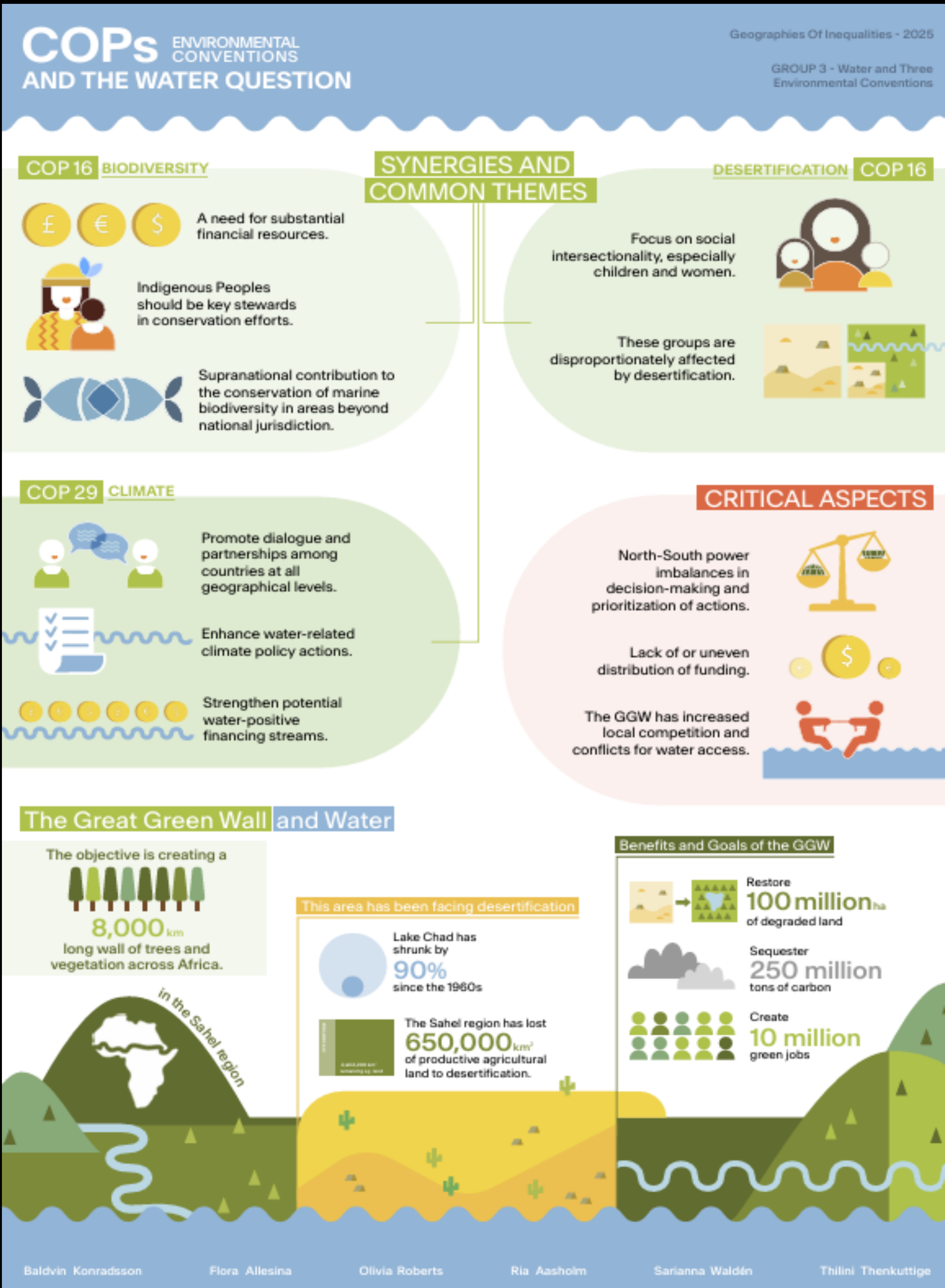
Water and Three Environmental Conventions: Research Findings

Baldvin Konradsson, Flora Allesina, Olivia Roberts, Ria Aasholm, Sarianna Waldén, Thilini Thenkuttige



Water and Three Environmental Conventions: Research Findings

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Introduction

This essay will provide a thematic synthesis of the results obtained from our research project, studying the prevalence of water related discussion in three different conventions: COP 16 on Biodiversity, COP 16 on Desertification and COP 29 on Climate. Through the analysis of our case study on the Great Green Wall - an active project in the Sahel Region of Sub-Saharan Africa – we have explored how each COP conveys water as a complex and interconnected issue. This summary will begin with an overview of the Great Green Wall, which aims to reverse desertification in the region by improving soil integrity and water retention, whilst improving the social conditions of the region. After this, we will summarise how each COP discusses water before identifying the synergies and critiques, concluding by discussing what these results mean for international water policies and governance.

The Great Green Wall

The Great Green Wall (GGW) is an initiative launched in 2007 by the African Union, with an aim to combat desertification and restore degraded landscapes across Africa's Sahel region. The Sahel is a semi-arid belt of land below the Sahara Desert, stretching across the entire African continent from Senegal in the west to Eritrea in the east (Dieng, 2021). Home to more than 150 million people from ten countries, the Sahel has faced increasing environmental degradation due to desertification, which has threatened food security, livelihoods, and regional stability (Dieng, 2021).

Desertification in the Sahel is driven by a combination of natural and human induced factors. The region experiences alternating periods of heavy rainfall and drought, making it particularly vulnerable to the effects of climate change (We Are Water Foundation, 2019). Temperatures in the Sahel are rising 1.5 times faster than the global average, worsening droughts and floods and severely impacting the agricultural and pastoral practices that are relied on across the region, with a high population of subsistence farmers (Dieng, 2021). Deforestation and overgrazing have further diminished the land's capacity to retain water, leading to soil erosion and degradation. According to the UNCCD, desertification is defined as "land degradation in arid, semi arid and dry sub-humid areas resulting from various factors including climatic variations and human activities" (We Are Water Foundation, 2019). The consequences are severe: loss of biodiversity, food insecurity, and displacement of communities (DGB Group, 2022).

The GGW initiative aims to address these interlinked issues by growing an 8,000 kilometre stretch of greenery across the Sahel. Its goals include restoring 100 million hectares of degraded land, sequestering 250 million tons of carbon, and creating 10 million green jobs by 2030 (United Nations Convention to Combat Desertification, n.d.; African Union, n.d.). In practice, the GGW focuses not only on tree planting but also on 1 water harvesting, protecting natural vegetation, and enhancing both indigenous and local land-use techniques to create a mosaic of productive landscapes (Morrison, 2022). This approach supports local communities by involving familiar practices and native species, reinforcing soil stability, boosting food and water security, and empowering vulnerable groups, particularly women.

Despite its promise, the GGW faces numerous challenges, including inadequate funding, political instability, poor governance, and coordination issues. Furthermore, climate variability continues to pose risks to progress, and the initiative has fallen behind on its 2030 targets. However, with renewed commitment and collaboration, the GGW remains a symbol of hope and resilience for the Sahel region.

COP 16 on Biodiversity

The first COP we analysed for the presence of water related discussion was the COP16 on Biodiversity, which underscored the critical need for substantial financial resources to support water-related biodiversity initiatives (IISD, 2024a). Recognizing the integral role of water in sustaining diverse ecosystems, the conference highlighted the importance of investing in conservation efforts to ensure the health and resilience of aquatic habitats. In this context, the establishment of the Cali Fund was a significant milestone. This fund aims to ensure the equitable sharing of benefits derived from the use of water and other resources, thereby promoting fairness and sustainability in resource management (UNU, 2024). To ensure that water management practices align with biodiversity goals, COP16 introduced mechanisms to track progress in water related biodiversity conservation efforts (Euronews Green, 2024). These mechanisms are designed to monitor and evaluate the effectiveness of conservation strategies, providing a clear framework for assessing achievements and identifying areas for improvement. This systematic approach is essential for ensuring that conservation efforts are both effective and adaptive to changing environmental conditions.

Several key goals were identified during COP16 to guide future conservation efforts. One of the primary goals is to recognize people of African descent and Indigenous Peoples as key stewards in conservation efforts, as highlighted by Vanegas in 2024. These communities possess invaluable traditional knowledge and practices that are crucial for the sustainable management of natural resources. Their involvement is essential for the success of biodiversity conservation initiatives, as they bring unique perspectives and expertise to the table. Another important goal is to enforce the implementation of the UN system strategy for water and sanitation (IISD, 2024a). This strategy aims to ensure universal access to safe and affordable drinking water and adequate sanitation, which are fundamental to human health and well being. By addressing these basic needs, the strategy also supports broader environmental and social goals, contributing to the overall sustainability of communities. Strengthening efforts to prevent overfishing and illegal, unreported, and unregulated fishing is also a key priority identified at COP16. These practices pose significant threats to marine biodiversity and the livelihoods of communities that depend on fisheries. By addressing these issues, COP16 aims to protect marine ecosystems and ensure the long-term sustainability of fish stocks.

Furthermore, COP16 emphasized the need for supranational contributions to the conservation of marine biodiversity in areas beyond national jurisdiction (IISD, 2024a). These areas, which include the high seas and the deep ocean, are home to a vast array of marine species and ecosystems that are vital to the health of the planet. International cooperation is essential to protect these areas from the impacts of human activities and to ensure their sustainable use.

Water's role as a critical resource intersects with health, environmental sustainability, economic development, and social equity. This multifaceted importance makes it a central theme in international environmental conventions, where sustainable management practices are advocated to address the challenges associated with water scarcity, quality, and access.

COP 16 on Desertification

Desertification and its related phenomena, such as soil depletion, are amongst some of the most pressing environmental issues we face in the 21st century. Desertification is a global phenomenon, which is not limited to hot, arid regions, and is influenced by an interplay of biodiversity, plant coverage, the make-up of soil, land use, and precipitation (UNCCD, 2021; Georgsdóttir, 2012).

The COP 16 on desertification, held in Riyadh in December 2024, is the latest of the COPs on desertification, where the main points addressed were land restoration, drought resilience, and impact mitigation on food production (UNCCD, 2024). Most pressing of these were how current practices in food production often accelerate the process of desertification, as they require clearing large swathes of land of foliage, often to be replaced by shallow rooted monocultures, vulnerable to erosion. In tandem with food production are changes in precipitation. Changes in either direction can have major consequences, especially where land is managed poorly (UNCCD, 2021). While heavy precipitation can have disastrous effects, the more influential type of precipitation on desertification is none at all. Droughts affect soil cohesion negatively, often leading to sandstorms, and repeated ones lead to severely depleted soils (Georgsdóttir, 2012; UNCCD, 2021). As dry regions are becoming even drier, increasing the risk of desertification of these regions, COP 16 concerned itself heavily with addressing these changes in precipitation, though the conference has been criticised for not putting enough emphasis on the role climate change has on these factors, as the host country, Saudi Arabia, isn't known for being an advocate for curbing emissions (Arasu, 2024; UNCCD, 2024).

Water plays a huge role in desertification. Deserts are defined by their lack of it, and soil cohesion depends on water, as it is usually the root systems of plants that keep the topsoil intact. When the binders of soil disappear, be it because of human agents clearing them away, or because the rain hasn't come, the path to desertification is clear.

COP 29 on Climate

As the most recent conference, COP 29 played an important role in creating continuity and consistency within water-related climate activities, whilst addressing SDG 6 (clean water and sanitation), SDG 13 (climate efforts), and SDG 17 (partnerships for the goals). According to the International Institute for Sustainable Development (IISD), while COP 29 was criticized for its inadequacies and lack of transparency in agreement on climate finance and technology, it made significant advancements by prioritising water management within climate policy frameworks (IISD,2024b). As their 3 official website says, COP 29 has paid much attention to water and hydrological processes as climate change is altering important parameters of the global water cycles, exacerbating challenges at the global scale. Such challenges include floods, droughts, mass glacier loss, landslides, degraded water quality, water scarcity, and changing water availability (cop29.az, 2025).

One of the key achievements was the launch of the COP29 Declaration on Water for Climate Action and the establishment of the Baku Dialogue on Water to serve as a COP-to-COP collaboration platform. These facilitate continuous and coordinated engagement across the COPs on water-related processes under the UN Framework Convention on Climate Change, the Paris Agreement, the UN Convention on Biological Diversity, and the UN Convention to Combat Desertification, while also addressing previous gaps in cross-COP collaboration (COP29.az, 2025). These initiatives not only work at the international scale, but also help facilitate partnerships across regional and local scales, whilst strengthening scientific evidence bases in terms of the impacts of climate change on water resources and ecosystems (IISD, 2024b). The Water for Climate Pavilion at COP29 also plays a key role by representing over 70 organisations as an international collaborator to support the global goal of adaptation and implementing water-positive financing streams (Water for Climate Pavilion, 2025). In particular, the water-positive funding streams aim to finance projects that increase water availability, make investments in water-efficient technologies and support climate initiatives that also benefit water systems.

Overall, fostering dialogue and partnerships at the international, regional, and local scales enhances the generation of scientific evidence regarding the causes and effects of climate change, whilst improving water-related climate policy initiatives and constituting the principal contributions of COP 29 to mitigate water-related climate challenges.

Synergies

There are many themes on water that intercept across the different COPs we studied in our research project. All three COPs recognize water as a nexus to addressing climate change, biodiversity conservation, and desertification. There are similar approaches to water management as a cross-sectoral and integrated action, such as linking water with food systems, ecosystems, health, and resilience. Water access and rights are also increasingly framed as cross-sectoral issues within broader narratives of environmental and social justice, across all three COPs. There is also increasing recognition of the role of local people and communities and indigenous knowledge, especially considering Africa. Local and indigenous knowledge are vital to sustainable water management and conservation efforts. There can also be seen a shared emphasis on Africa and dryland ecosystems. Lastly, there is growing institutional cooperation across the different COPs on water (for example, the Baku Dialogue fosters cross-COP continuity).

Critique & Challenges

While COPs in general are meant to foster international cooperation on global challenges, they have been widely criticised for failing to address the socio-political roots of ecological crises. Wealthier nations tend to dominate the agenda and commit insufficient financial support for adaptation in the Global South. Many COP decisions 4 reflect a top-down governance style, where local realities and grassroots voices are easily overlooked. This top-down governance can lead to poorly contextualized solutions, weak implementation on the ground, for example failed distribution of fundings, and local resistance or disengagement.

Our case study topic, the Great Green Wall in the Sahel region of Africa, has also been criticised for its implementation. As Dieng (2021) recalls, water is a scarce resource in the Sahel region, while more than 70 percent of the people are employed in agriculture and farming. The lack of water in the area due to desertification, deforestation and overgrazing leads to conflicts between local farmers and pastoralists, as well as other groups. Weak governance makes it difficult to fight against climate change, which leads to these social, political and economic issues. For example, in the 2010s, over 15,000 people died in the confrontations between local farmers and pastoralists over water-related issues. Armed groups have benefited from the conflicts by recruiting people in vulnerable positions.

According to Alsobrook (2015), the Great Green Wall as a top-down-governed project has entered Senegal holding much more power than the local, traditional institutions. The Great Green Wall has shifted the power over water away from the local people – the GGW nurseries are often prioritised for water over the locals' needs, and the protection of GGW saplings can restrict grazing land for pastoralists. This has increased the locals' demand for scarce water and led to competition between local people and the Great Green Wall institutions. Even though being an ambitious project for reforestation and social development, the Great Green Wall has its disadvantages and issues. In the UN Human Development Report (UNDP, 2006) it is highlighted that during periods of water scarcity, those most affected are typically the individuals who lack representation or influence in decisions about how water resources are distributed. In the case of Senegal, the village leaders did not participate in the decision-making process of planning and putting the Great Green Wall into action and the locals have been water stressed because of the project (Alsobrook, 2015). Diop and others (2018) reinforce this view of local water shortages and point out that despite many actions for water conservation, the GGW should address these issues of water availability and develop more ambitious and inclusive water management strategies.

Conclusion

To conclude, water prevails as a central concept across COP 16 on Biodiversity, COP 16 on Desertification and COP 29 on Climate, due to the cross-cutting nature of water in relation to these issues of climate change, maintaining biodiversity and desertification. The prevalence of water throughout the specific issues discussed at each COP in conjunction with human development and social factors are seen as examples throughout the Great Green wall as a case study, which illustrates the overlaps between biodiversity, desertification and climate change in relation to water practices. An example of this includes the environmental restoration of land in the Sahel as part of the Great Green Wall initiative, increasing biodiversity via afforestation and reforestation, which consequently improves the soil integrity and reverses the impacts of desertification. In turn, the landscape has a greater ability to withhold water and becomes increasingly resilient to climate change.

Although the Great Green Wall can be seen as a success story of a top-down governance strategy complimentary to the COPs we discussed, this entire approach can be criticized for a lack of consideration for local realities and power imbalances. However, with this said, in addition to the success of the scheme itself, the Great Green Wall and COPs have accustomed positive developments including the Baku Dialogue and water positive financing.

Our research project has displayed how equitable cooperation and collaboration across a range of scales can create the most successful and resilient strategies for ensuring water security in the current time of crisis.

We created and collated a list of questions to inspire future thought:

What are the most effective ways to protect water-related biodiversity while meeting human water needs?

How can the integration of water management strategies be improved across the three conventions?

How can local communities be more actively involved in biodiversity conservation efforts that impact water resources?

How can the lessons learned from the Great Green Wall initiative be applied to other regions facing similar issues?

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Nexus Water Availability – Climate Change: Focus on Mountain Regions

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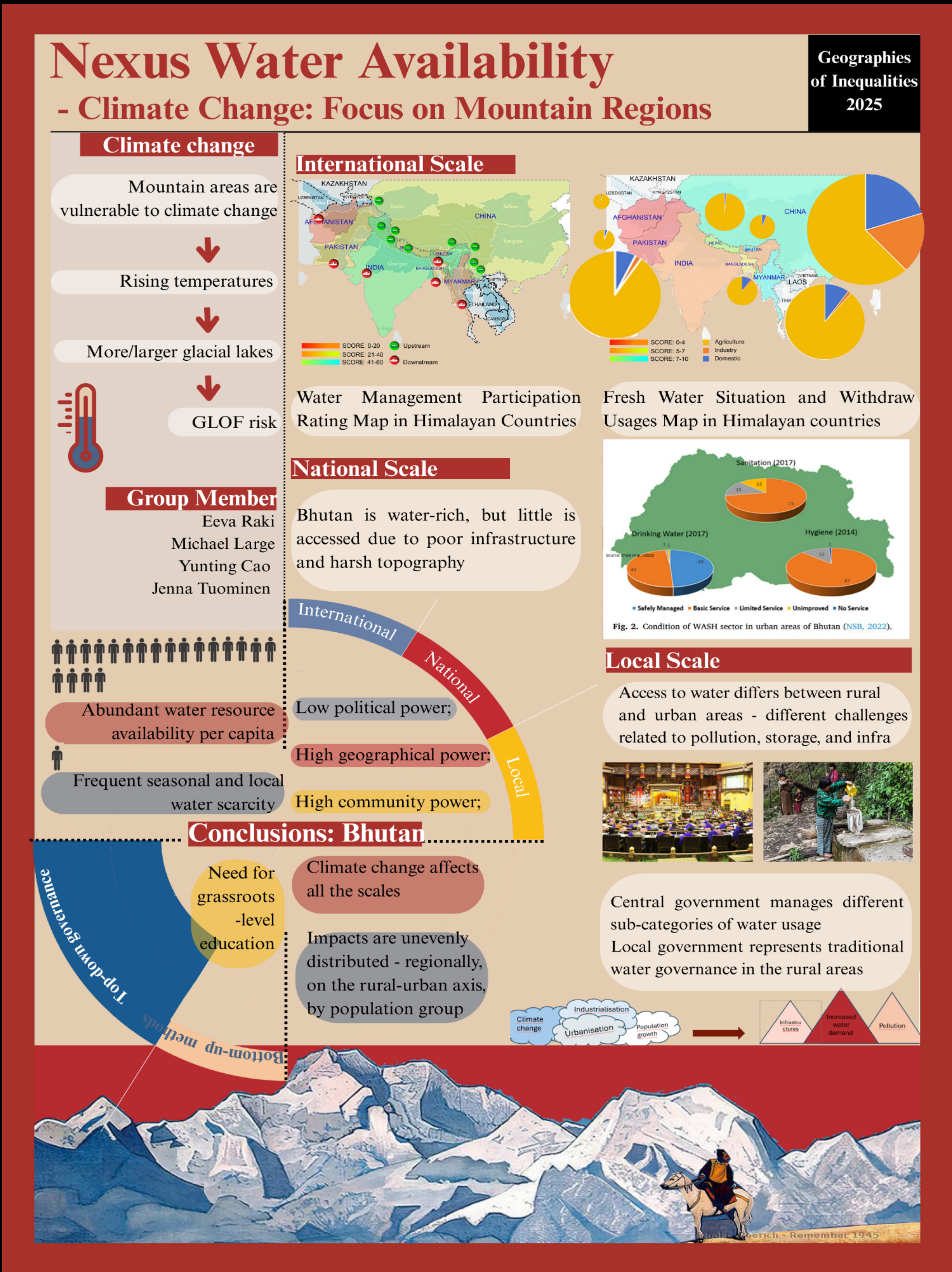

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Introduction

Our focus on this course was nexus water availability – climate change: focus on mountain regions. Mountain areas are unique ecological zones that play a disproportionate role in the global water cycle. Although mountain ecosystems cover only a small fraction of the Earth's surface, they produce and store a significant proportion of the world's freshwater resources. Mountain regions not only contribute a disproportionately high share of global runoff but also regulate seasonal water availability by redistributing winter precipitation to spring and summer flows (Viviroli et al., 2011).

The Himalayan region is highly vulnerable to climate change. The Himalayan region, particularly the Hindu Kush Himalayan (HKH) region, stands as a critical global water system with unprecedented vulnerability to climate change. Spanning over 2,000 kilometres across eight countries, this mountainous system is home to the world's highest peaks and serves as a lifeline for over a billion people through major river systems like the Indus, Ganges, and Brahmaputra (National Research Council, 2012).

According to Bajrachaya et al., (2017) the Himalayas have the largest concentration of glaciers outside the polar region. Himalayan glaciers are melting at an unprecedented rate, increasing both the number and size of glacial lakes and the risk of glacial lake outburst floods (Bajrachaya et al., 2017). Consequences of climate change include the drying up of irrigation sources and crop losses due to weather events (Chhogyel et al., 2020). This is a serious threat as Bhutan's agricultural production is mainly small-scale subsistence farming, with about 69% of the population working in agriculture (Parker et al., 2017). Changes in weather and climate are also affecting regional ecosystems, for example through significant reductions in the size and distribution of Himalayan glaciers, as well as in water availability (Parker et al., 2017).

Viviroli et al (2011) mention that the combination of seasonal variations and changes in total runoff are likely to have implications for future water availability, increasing the challenges of managing mountain water resources. Current management systems based on historical climate and hydrological variability are likely to be inadequate, as the combination of seasonal variability and changes in total runoff is likely to affect future water availability (Viviroli et al, 2011). According to Viviroli et al (2011), this makes managing mountain water resources more difficult. Current water management systems, which are based on past climate and hydrological patterns, may not be suitable anymore.

In this project we will examine the specific impacts of climate change on mountain water systems. We take Bhutan as an example to research how Himalayan countries may react to climate change in water management across different scales, and what is the state of water usage and equal access to good-quality water. Bhutan is a country located in the eastern Himalayas. It is an example of the wider challenges facing mountain ecosystems, and its unique characteristics make it particularly vulnerable to environmental change.

Freshwater Access Differences in the Himalaya Region

The huge difference in freshwater scarcity in these areas results in geographic, climate, economic, technical and political differences in water resources and management. Combining water stress level, per capita renewable internal freshwater resources and per capita domestic water consumption, the research grades eight Himalaya countries and turns out that upstream Himalayan countries have a better situation that those downstream. The difference is mainly because of diverse geographical and climate characters. As the rivers are fed by rainfall, meltwater from snow and ice, and groundwater. The amount of water from each source varies by river. It also varies depending on the location within each basin (ICIMOD et al., 2015). Moreover, except for challenges of uneven water resources, climate change and population growth, water management abilities also influence water scarcities. For example, In the absence of coordinated water planning on the part of the state, a complex mix of government, community, and private systems of water supply have emerged in the Himalayan towns across both Nepal and India (Hemant Ojha et al., 2020). Therefore, the improvement of the freshwater scarcity of Himalaya region needs both environmental techniques and political management.

International Water Management in the Himalaya Region – Focus on Bhutan

There are international water managements in different levels in Himalaya region, but the cooperation characters are lacking formal multilateral treaties, institutions and legalization. In government level, complicated political and territorial issues make cooperation challenging. India now plays the key role in this cooperation. Most current treaties are bilateral instead of multilateral and effective transboundary governance has remained limited (Tiwari et al., 2025). Moreover, China as the major upstream country tends to unilateralism and due to a long-term mistrust and territory dispute, China and India are unlikely to reach full implementation of Integrated Water Resources Management (IWRM) of the SDGs in the Brahmaputra River Basin (MDPI, 2019). However, transboundary water management benefits regional economic development. For example, Bhutan has its per capita GDP increased due to its transboundary rivers collaboratively with India by selling hydropower (Biswas, 2011).

In international institution level, non-political institutions provide communicating platform to improve cooperation, but their limited amount and abilities reduce effectiveness. ICIMOD is the only institution combining all the eight Himalaya countries, promoting data-sharing and communication programs outside formal treaties. But the programs are knowledge and technique based with project cycle and limited power, which lack sustainable ability to deal with conflicts. In private company level, private sectors often joined transboundary hydropower development, but these companies tend to be dominated by the more influential country, leading to unequal benefits. For example, as in India's and Bhutan's cooperation, according to the Bhutan Chamber of Commerce & Industry (BCCI), the Bhutanese private sector has not reaped the benefits of hydropower development in the country (Amit, 2018). As Shawahiq (2017) introduced, belong the Pandai, both a previous sharing formula from traditional communities and break down of the formula from political changes were ignored as 6,000 are shared between Nepal and India.

In conclusion, on an international scale, water resources in the Himalaya region are sensitive to climate, ecological and political aspects. The complicated historical, political, terrestrial conflicts make formal transboundary water management challenging at the national level. International institutions and private sectors mainly function in knowledge and technique aspect, with ability to build trust out of political conflicts, less power to promote formal cooperation and potential risk of new liberalism.

National and Local Scale Perspectives on Bhutan's Water Governance

Bhutan is a nation of under a million people in the Himalayas, where water security is a daily concern for residents, which is in turn influenced strongly by geographies of inequalities and power. In Bhutan specifically, the availability of freshwater is far above the global average at 94,500m^3/capita/year, but only a tiny proportion of what is theoretically available is utilised of which, as in most countries, a majority goes to agriculture (Tariq *et al*., 2021). While agriculture forms only a relatively small proportion of GDP in the country, water resources directly or indirectly support most other economic activity, including most obviously hydropower (accounting for around a quarter of GDP) as well as tourism, a sector of increasing importance. As such, management of these resources is deeply significant for the functioning of the nation.

In terms of natural challenges, Bhutan's incredibly rugged terrain makes construction of infrastructure challenging, with most of the country divided into narrow, steep river valleys (Sinclair *et al*., 2015). This is the root cause behind water scarcity especially in the rural areas (p. 4). Glacial Lake Outburst Floods, where a lake bursts its banks in a glacial region causing a downstream flood, are a significant issue in the county, and have caused deaths and destroyed vital infrastructure in the past. GLOFs, runoff and flash floods cause trouble in both rural and urban areas (Chathuranika *et al*. 2023). As climate change takes hold, wildfires and droughts are also predicted to increasingly become issues.

Bhutan has long been recognised for its innovative Gross National Happiness (GNH) model of development, which privileges human wellbeing and harmony with the environment above simply GDP growth, but modernisation efforts and encroachment by foreign business interests have begun to partially erode this in recent decades (Uddin *et al*., 2007). It is also important to note that Bhutan is ruled by a king with strong ties to the majority Buddhist religion; although democratic, the country has had a somewhat mixed relationship with both bottom-up development and inter-ethnic tensions in the past (Sinclair *et al*, 2015). Water was not often addressed directly by law until 2003, but before and since there have been numerous acts and policies relating to habitats and natural resources that relate indirectly to water, such as the 1995 Forest and Nature Conservation Act and the new Constitution of 2008 (Tariq *et al*., 2021). Buddhist religion reflects into water governance in the form of a Buddhist "conservationist ethos" (Ura and Kinga, 2004, p. 30) and this reflects in GNH being the metric of development.

Water, sanitation, and hygiene (WASH) services are improving in urban areas (Chathuranika *et al*. 2023), but there are gaps in WASH facilities due to inequalities, however according to National Environmental Commission (2025) 78% of population would have access to clean drinking water (p. 19). However, the reliability, consistency, quality of tap water, withdrawal, storage, and sewage infrastructure varies significantly between urban and rural areas, Dzongkhags (districts), and socio-economic status (Chathuranika *et al*. 2023; NEC, 2025). The central government of Bhutan governs different sub-categories of water usage under different ministries for urban and rural drinking water, irrigation and land use, hydropower development, and GLOFs (Royal Government of Bhutan, 2023). A more bottom-up, decentralized form of water governance comes from the local government comprising of Dzongkhag Tshogdu, Gewog Tshogde and the Thromde Tshogde, who report upward to central authorities and represent the needs of local rural communities (Ministry of Home Affairs, 2021). On an even more grassroots level in remote rural communities, traditional forms of water governance are guided by Buddhist beliefs in spirits and deities present in nature (Ura and Kinga, 2004, p. 30). As impacts of climate change combined with urbanisation and population growth continue to starken, growing demand for water increases pressure on the already weak water infrastructure. For Bhutan to respond to these challenges, there is a need for not only international collaboration in water management but also incorporating the national adaptation plan (NAP) and REDD+ strategy (Dorji and Waiba, 2024, p. 14) together with traditional customs in water management. Concrete measures are needed to mitigate impacts of climate change, but also existing "effective coping mechanisms" that are "being practiced by communities in dealing with climate-related issues and impacts" should be harnessed (Dorji and Waiba, 2024, p.15).

Conclusions

Our research shows that climate change affects people and places on all scales in the Himalayan Mountain region countries, but in very different ways. Its impacts, and access to water are unevenly distributed — across regions, among different population groups, and between urban and rural areas. Bhutan is in a relatively good position compared to other countries in terms of natural water availability, because upstream Himalayan countries have a better situation than those downstream. Its position upstream of major river systems gives it significant influence on an international scale. This creates both opportunities and challenges in regional water cooperation and resource sharing. On a local scale, there are notable differences in water access and challenges between rural and urban areas, as well as across districts and communities. Factors like income, education, and gender also play a role in determining access to water.

Overall, we discover from this research, how these challenges must be responded to across all scales: international, national and local. In addition to fostering international relations in the Hindu Kush Himalaya, Bhutan ought to continue taking national policy measures to protect its land and people, "from the adverse impacts of climate change by building adaptive capacity and resilience" and do this "to reduce vulnerability by integrating adaptation actions into the developmental planning process at all levels" (NEC, 2020). Combining the call for action from NAP (2023), with strengthening local communities' adaptive capacity, spreading awareness, and harnessing already existing local knowledge, ought to create a thorough foundation for adaptation into climate change adversities (Waiba and Dorji, 2024, p. 13-15).

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