Modes of Cooperation to Mitigate Water-related Conflicts Under Uncertain Climate Future

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Background

Over the past decade, water conflicts have surged while cooperation has dwindled. Research underscores the role of climate change as a threat multiplier, exacerbating tensions. Human activities like dam construction and extensive irrigation, alongside climate-induced hydro-climatic shifts, intensify the risk of heightened water conflicts. In navigating an uncertain climate future, the imperative lies in recognizing the interconnectedness of water-related challenges and fostering cooperation for sustainable water management. International collaboration is key to developing equitable frameworks, balancing diverse stakeholder needs and mitigating conflicts over scarce resources. Addressing the root causes involves a multifaceted approach, incorporating environmental conservation, responsible infrastructure development, and adaptive policies. By prioritizing cooperation, implementing conflict mitigation strategies, and embracing sustainable practices, we can proactively adapt to changing hydrological conditions and build resilience in managing water resources.

Method

To guide strategic interventions and counter the prevailing trend, our primary focus is on advancing our understanding of factors that facilitate successful cooperation and effectively mitigate water conflicts. Simultaneously, we aim to project the potential for conflict mitigation in the face of an uncertain climate future by the year 2050. This study spans the last 70 years, scrutinizing global cooperation and conflict events alongside key climatic and socioeconomic factors. These factors encompass wealth distribution, export-dependency, demographic patterns, and hydro-climate trends.

The intricate relationships between these factors and cooperation are meticulously analyzed through a dual methodology. Panel data analysis is employed to quantify the impact, estimating the potential reduction in future conflicts (within a 5-year horizon) for a given country upon the adoption of specific cooperation modes to address water-related issues. This analysis extends its purview to examine the effects of cooperation on conflict mitigation, particularly for nations characterized by power discrepancies and diverse levels of water stress.

A qualitative dimension is then introduced through textual content analysis, unveiling and categorizing the most prevalent types of cooperation and conflict events across various conflict scenarios. This qualitative exploration adds depth to our understanding, capturing the nuances of events that shape cooperative and conflicting dynamics. In anticipation of future outcomes, a forward-looking projection is conducted. This projection integrates machine learning and Shared Socioeconomic Pathways (SSP) analysis to predict the potential reduction in conflicts through future collaborations among nations. By leveraging these advanced techniques, we aim to provide insights into the potential impact of cooperative endeavors on conflict mitigation in the evolving landscape, extending our focus towards the year 2050.

Conclusion

Anticipated results from our study promise a deeper understanding of factors influencing successful conflict mitigation. We found that cooperation among nations facing water-related challenges significantly reduces expected conflicts over the next five years. Notably, a positive correlation exists between water-related cooperation and economic growth, particularly in export-dependent countries. Economic collaboration emerges as a powerful strategy for resilience in high-water stress areas, reducing future conflicts while fostering economic prosperity. Cooperative efforts contribute to growth, resilience, and decreased conflict risk, with projections indicating even more pronounced impacts on conflict mitigation, crucial amid anticipated heightened water stress due to climate change. Insights gleaned from successful conflict mitigation factors offer valuable guidance for global policymakers and water management leaders in navigating

current and projected water availability challenges.

Welcome to Schizotopia: understanding coproduction for sustainability in Swedish island communities

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Background

Coastal areas in many high-income countries face complex challenges of de-population, geographic conditions, and sensitive ecosystems. At the same time, they offer attractive leisure activities and nature for summer residents and visitors. In response to increasingly complex sustainability challenges, scholars have argued that co-production of knowledge is a useful method to navigate these complexities (Sesser et al, 2022; Bezerra et al, 2023; Miller and Wyborn, 2020). In this paper we contribute to an emerging discourse on co-production and sustainability on islands with observations and reflections from islands in the Baltic Sea. In two regional projects we have explored co-production as a form of action for sustainable coastal development.

Method

Two collaborative projects involving students, inhabitants, experts, civil society and local authorities were carried out on small islands in the Baltic Sea region between January 2019 and December 2021.The first project, Circular Water Challenge, was led by KTH Royal Institute of Technology, a Swedish university, and carried out during 2019 and 2020. The aim of the project was to develop new solutions for the use of freshwater on seven islands in the Baltic Sea. The islands are located in the archipelagos of Sweden, Finland, and Åland (self-governed part of Finland). In this project, university students and their senior supervisors collaborated with communities and local authorities to generate locally grounded knowledge on water resources and water use. This involved collecting facts describing (i) natural conditions like rainfall; (ii) human settlement patterns (for example residents, summer residents, and visitors) and (iii) the infrastructure (such as wells, piped systems or latrines). A follow-up project - called Pelago - was initiated by four actors on the Swedish side: the university; the coastal municipality of Värmdö; a consulting company (Ecoloop) and a large landowning foundation (Skärgårdsstiftelsen). Again, local water and sanitation challenges on islands were in focus. This time emphasis was placed on exploring the collaborative process itself, iteratively developing and testing a process model called “the Co-production Staircase” inspired by both Glasbergen's "Ladder of Partnership" as well as Moore's concept of "Business Ecosystems" (Glasbergen, 2010; Moore, 1993). The detailed findings in the two projects were documented through a series of student theses (BSc and Msc) and project reports. This paper summarizes the projects' observations and suggests important overarching implications for how to address local sustainability challenges on small islands.

Conclusion

All islands studied show very large seasonal variation in terms of population pressure and local water use. This has direct consequences for sustainability, as well as on the conditions for the local process of collaboration and co-production. Our findings indicate that while co-productive approaches are beneficial and can complement formal structures, we note several challenges to efficient collaboration. Most importantly, we identify an uneven temporal distribution of population that conflicts with the natural fluctuation of water availability as a key factor that affects, and potentially blocks, positive outcomes. We propose the concept of *schizotope* (split landscape) to describe this seasonal variation. We argue that *schizotopes* pose serious challenges to co-production and sustainable development of islands in general, which need much more attention in regional policy and in research.

Conflict and Cooperation – Reflections from Water-Conflict Research

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Background

Over two billion people remain without safe drinking water and more than four billion lack basic access to sanitation. Safely managing water is key for livelihoods, food security, energy production, and overall socio-economic development. This presentation will provide a brief overview of research on water within International Relations. In addition, this work analyzes how scarce water resources affect cooperation and conflict. In particular, the work investigates how insufficient groundwater access increases incidences of communal violence. I further consider the spatial spillover of conflict; specifically, the analysis shows that drought impacts violence not locally but through wider neighborhood effects. Shifting to the potential of collaboration, the research further provides evidence of how drought could be a harbinger for cooperation, both between individuals and groups.

Method

This research utilizes statistical modelling using geographic information (GIS). I focus on so called grid-cell units, which allow within-country comparison of water access and climate processes. The grids can be thought of as a global fishnet with each cell measuring about 55 by 55 kilometers. Geographically, I focus on different parts of Africa, Southern Europe, and the Middle East.

Covering larger areas with quantitative methods allows for a more general interpretation, yet an obvious disadvantage is that the analyses can lose case-specific depth. I have tried to overcome this challenge in two ways. First, case-specific research and critical literature inform the studies both empirically and theoretically. I corroborated desk-based information through conversations with other researchers who have conducted in-person visits in the regions that are covered by the studies. Assumptions on water access were further discussed with technical experts at international conferences.

Another integral part of the research is the use of hydrological data to capture water scarcity. The research accounts for rainfall, drought, groundwater, and major surface water bodies. The different water measures primarily build on data captured through remote sensing. A disadvantage with such data can relate to validity and reliability. It is also more difficult to obtain micro-level data on water resources. I also acknowledge that norms and inter-personal differences in water use cannot be obtained through remote data collection. I have tried to address this by considering ethnographic accounts of water usage as I rely on physical measures of water scarcity. Nonetheless, using remote sensing data even at lower spatial resolutions has several advantages. It allows one to compare large geographic areas and makes data collection possible without onsite visits. Using such data also avoids the use of surveys on water scarcity reporting which has several ethical upsides.

Conclusion

Inter-state water negotiations often display a mismatch between “state-focused” water diplomacy and local water users. This means that the ground realities can be absent from water diplomacy. These diplomatic processes and water governance in general, can be improved by synthesizing and better coordinating work at the national or river-basin level with active engagement of sub-national stakeholders and local dynamics. Better data within a state can further help policy makers, local actors, and other stakeholders to take more targeted actions.

Clearly, accurate and reliable information can inform research and policymaking. Where applied, such synergies will be fruitful in enhancing evidence-based policy – a key ingredient for meaningful water diplomacy.

Redirecting carbon in wastewater treatment to enhance nutrient removal - a pilot study

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Background

Many municipal wastewater treatment plants (WWTPs) in urban areas are facing both increasing loads and stricter effluent demands, while the awareness of resource efficiency is growing. One solution to enhance the wastewater treatment and to improve the energy efficiency is to optimise the use of the resources available in the wastewater. Pre-filtration is a compact pre-treatment alternative to conventional settlers. The resulting filter primary sludge (FPS) from such pre-filtration can be fermented to produce volatile fatty acids (VFAs). These VFAs are an excellent substrate for downstream biological wastewater treatment, such as enhanced biological phosphorus removal (EBPR) and denitrification, and can replace the eventual need for external carbon source addition at the WWTP. The remaining FPS can be digested anaerobically to produce biogas and regain energy. This novel pre-treatment was tested at pilot scale for two years, and has recently been coupled with biological nutrient removal in a novel biofilm process.

Method

A pilot plant situated at Källby municipal WWTP in Lund (Sweden) consisted of flocculation and filtration using an SF1000 rotating belt filter (Salsnes) with 350 µm pore size cloth. The resulting FPS was fermented in two parallel reactors (1.5-2 m^3 each). The pilot plant was receiving wastewater flow proportionally to the main WWTP and was operated at ambient temperature. One of the reactors had a constant retention time (RT) of 5 d, while the other reactor had varying RT.

Performance of the pilot was monitored by 24-h composite sampling and grab samples, following the removal of solids over the filter as well as the production of VFAs in the fermentation. In addition, samples were saved for DNA sequencing and analysis of the microbial community. In order to evaluate the pre-treatment's impact on the biological nutrient removal and plant-wide energy performance based on design calculations, simulations of an activated sludge process were carried out in the modelling software WEST (DHI).

In 2023, the pilot plant was extended to include biological nutrient removal with a novel biofilm technology (CELLA^{TM} by AnoxKaldnes), in which the biology grows as biofilms on carrier material made from recycled, stabilised biomass. This process may provide a more compact and straightforward way to achieve nutrient removal with efficient carbon management compared to corresponding activated sludge (AS)-based processes. The CELLA^{TM} pilot consists of two alternating reactors (0.6 m^3 each) in which nitrogen removal and EBPR is achieved in continuous mode. The reactors are fed with filtered wastewater from the rotating belt filter pilot, and a mixture of VFAs to mimic the addition of fermented FPS. The performance of the process is followed by online monitoring, 24-h composite sampling and batch tests for EBPR activity. Effluent sludge is also collected to analyse biogas potential.

Conclusion

The pre-filtration removed a large share of the influent organic matter (64±10% of the influent TSS and 44±9% of the influent COD). Fermentation of the FPS showed considerable seasonal variations in the composition of the fermenting

microbiome as well as the production and composition of VFAs. The VFA production was however sufficient to nearly double the VFA concentration of the wastewater for subsequent biological treatment throughout the year. Calculations and simulations showed that an activated sludge process after the novel pre-treatment could be 18% smaller, and still render lower effluent values with lower electricity demand compared to an activated sludge process after a conventional pre-treatment with settler, without compromising the biogas production. Results from the start-up of the CELLA^{TM} process shows that both nitrogen and phosphorus removal can be achieved with the pre-treated wastewater, and preliminary studies indicate that the process produces a sludge with relatively high biogas potential.

The contribution of small-scale fisheries to food security and sustainable development - opportunities and challenges

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Background

Small-scale fisheries contribute at least 40% of the global capture fisheries productions and 90 percent of the people - men and women - employed along capture fisheries value chains operate in small-scale fisheries. It is estimated that 492 million people in the world depend at least partially on small-scale fisheries for their livelihoods. The benefits and contributions of small-scale fisheries – food, nutrition, income, and environmental stewardship – represent foundations for many of the Sustainable Development Goals (SDGs).

Method

The *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication* (SSF Guidelines) is a negotiated international instrument that provides agreed principles and guidance for how to address governance and development in small-scale fisheries. These guidelines, endorsed by the members of the Committee on Fisheries (COFI) of the Food and Agriculture Organization of the United Nations (FAO), are based on a human rights based approach and emphasise the need for holistic and participatory approaches. To gain better knowledge on how and why small-scale fisheries are important, a study was carried on *Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development* (IHH) and a report published in 2023.

Conclusion

The benefits of small-scale fisheries need to be better recognised and supported for the subsector to achieve its full potential as a contributor to food security and sustainable development. Fishing communities are often particularly vulnerable to the effects of climate change and of biodiversity loss, and also experience competition from other economic sectors, facing challenging to defend their tenure rights and access to resources. By a better understanding of small-scale fisheries and allowing them a voice in matters directly relevant to their livelihoods, much can be gained for an environmentally, economically and socially sustainable future.

Municipal wastewater sewage sludge as source for biomolecule production

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Background

Up till recently sewage sludge has been regarded as a waste with high risks and problematic re-use and due to its considerably lower quantities than solid waste, it has been neglected in circular economy targets. Nevertheless, constant increase in sludge quantities has been observed globally. Within the EU the amount of sewage sludge produced per year reach 7.5 million tonnes of dry matter (DM). Many countries have already set up their national wastewater management strategies to aid the industry, especially in resolving issues with sludge disposal. At the same time the importance of sewage sludge as potential resource has already been recognized in global community. Within this research we aimed to estimate the potential of sludge as the source for biomolecule production.

Method

To assess carbohydrate release potential, various commercial enzymes and extracts from white rot fungi were tested on sludge samples collected at various treatment stages (primary sludge, digested sludge, digestate, screenings and sewage grit). All substrates prior hydrolysis were characterized for their moisture content, volatile and fixed solids. Carbohydrate content was determined by DuBois method. Enzymatic hydrolysis tests were performed with batch scale tests at 2% w/v substrate loading for 48 to 120 hours at 30°C. After hydrolysis, all samples were treated with ultrafiltration to obtain concentrated carbohydrates. The method allowed sugars to selectively pass through the membrane.

Conclusion

Out of all substrates used in the enzymatic hydrolysis experiments, screenings were the most successful and provided the highest level of sugar release. Factors contributing to this result include the fact that screenings were dried before hydrolysis, protein content was exceptionally low and carbohydrate content – high. The highest sugar concentration in UF permeate was 0.32 mg/ml which was achieved when purifying the hydrolysate with the highest sugar concentration. Significant sugar concentration was also found in the UF concentrate samples, indicating that some sugars from the screenings hydrolysates did not pass through the ultrafiltration membrane.

Groundwater evaluation digitalization using remote sensing data and artificial intelligence algorithms

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Background

Inadequate management practices and excessive extraction of groundwater resources can cause a substantial decrease in the groundwater level, leading to potential land subsidence in the clay-rich aquifers. If the groundwater level falls beyond historical stress limits, the resulting soil compaction may become permanent. In severe scenarios, the aquifer may lose its ability to retain water, resulting in decreased productivity. Traditional monitoring methods lack efficiency in obtaining sufficiently detailed spatial and temporal data to understand the spatially diverse and time-varying dynamics of large-scale aquifer systems. Consequently, there is a growing demand for innovative technologies to facilitate long-term and reliable groundwater monitoring in productive aquifers, with the integration of satellite imagery and Artificial Intelligence (AI) emerging as promising solutions in the realm of subsurface water monitoring and management.

Method

Recently, scholars have developed different techniques for monitoring groundwater level changes and calculating subsidence due to over-pumping using the Interferometric Synthetic Aperture Radar (InSAR) deformation time series. Reeves et al. (2014) and Chen et al. (2016) employed the inversion method to transform the observed seasonal deformation using InSAR to groundwater level changes with higher temporal resolution using existing well records. Smith et al. (2021) integrated the InSAR-observed seasonal deformation rate and the co-located groundwater level measurements to develop a technique to estimate the compaction of each aquifer layer due to pumping in a multilayer aquifer system. While effective, these newly developed methods are limited to the groundwater level data and InSAR measurement at the well locations. This study proposes AI-based techniques to address the spatial discontinuity of InSAR deformation observation, predict subsidence in the near future, and model groundwater level changes in the aquifer in time and space. We used multiple sets of hydro-environmental factors related to groundwater extraction, aquifer characteristics, topography, and hydrologic conditions of the studied areas. For modeling, deep learning algorithms such as Long Short-Term Memory (LSTM) and Machine Learning (ML) algorithms such as Random Forests (RF) and Extreme Gradient Boosting (XGBoost) were used to find the relationship between the groundwater head changes and surface deformation with the hydro-environmental factors at the well locations as well as anywhere in the aquifer. We tested our approaches on multiple aquifer systems in arid regions where groundwater resources are under stress. We designed an integrative approach using remotely sensed deformation data combined with AI to predict subsidence and groundwater level fluctuation in critical aquifers.

Conclusion

The integration of remote sensing technologies and artificial intelligence (AI) has brought about a revolutionary change in the way groundwater studies are conducted. It has provided efficient and accurate means of monitoring and managing groundwater resources in the vast aquifers. AI algorithms, particularly machine learning models, can analyze large datasets obtained from remotely sensed observations and in-situ measurements. The integrated InSAR-AI approach can extract valuable information about groundwater dynamics, predict subtle patterns and changes in land surface conditions, and help researchers identify areas prone to groundwater depletion and predict groundwater levels. This emerging technique contributes to the digitalization of the monitoring process and facilitates proactive decision-making in groundwater resource management, contributing to sustainable water use and conservation efforts.

Session: Digitalization in the water sector (Observation and monitoring)

Leveraging Hydrogeodesy to Address Water-related and Sustainability Challenges

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Background

Increasing climatic and human pressures are changing the world's water resources and hydrological processes at unprecedented rates. These changes require monitoring water resources from ground and space at different temporal and spatial scales. This monitoring can be achieved with Hydrogeodesy, the science that measures the Earth's solid and aquatic surfaces, gravity field, and their changes over time. Hydrogeodesy encompasses geodetic technologies such as Altimetry, Interferometric Synthetic Aperture Radar (InSAR), Mass gravimetry, and Global Navigation Satellite Systems (GNSS). During the last thirty years, these technologies have contributed to quantifying changes in surface and groundwater resources locally, regionally, and globally. Yet, to our knowledge, the evolution and combination of these technologies and their role within current hydrological, sustainability science, and management frameworks remain unaddressed.

Method

Here, we first perform a meta-analysis of over 3,000 articles to understand the range, trends, and applications of hydrogeodetic technologies. Second, we discuss the potential of Hydrogeodesy to significantly advance hydrology, water-related sustainability, and water management. For this, we focus on the 23 Unsolved Questions of the International Association of Hydrological Sciences and the Planetary Boundaries framework (meant as guidance towards a safe operating space for humanity). We find a growing body of literature relating to the advancements in methods, accuracy, precision, and measurements of these technologies and support of hydrological modeling. Hydrogeodesy is also largely published in multidisciplinary and remote sensing journals, which points to considerable potential for integration with water-related sciences, especially regarding terrestrial water features such as wetlands, permafrost, lakes, and rivers.

Conclusion

We call for a coordinated way forward for hydrogeodesists to increase interdisciplinary collaboration and broader and deeper application of Hydrogeodesy for understanding and managing water resources and to provide guidance for a safe operating space for humans.

Co-authors

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Assessment of Nitrosamine Formation Potential and Disinfection Strategies in Water Circularity

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Background

Water circularity aims to minimize waste by reusing water for various purposes like irrigation and potable supply. Disinfection is crucial in maintaining reused water quality, and preventing pathogen transmission. Different techniques like chlorination and ozonation are used but can lead to harmful disinfection byproducts (DBPs) like THM and nitrosamines. Nitrosodimethylamine (NDMA), a nitrosamine, is found in various water sources and its presence, formation, and mechanism are increasingly studied. Controlling DBPs, especially nitrosamines, is crucial for public health in water reuse systems.

Nitrosamines are nitrogen-containing organic compounds. Nitrosodimethylamine (NDMA), one of the nitrosamines, is present in different water media, drinking water in treatment facilities, rivers, and wastewater. The carcinogenic and toxic properties of NDMA are investigated in water. The studies including NDMA presence, formation, and mechanism are the research areas gaining importance day by day.

Method

In this study, the formation potential (FP) of NDMA was investigated either upon spiking selected precursors to distilled water or through measurement of NDMA precursors in different water matrices (swimming pool water and surface water). After the nitrosamine FP of precursors was determined, the amount of NDMA formed under chosen disinfection applications (chlorination, chloramination, ozonation) was determined and compared with the FP of the precursor to provide information on the effectiveness of the disinfection process in the formation of NDMA.

In this study, after optimization of NDMA measurement formation potential of different types of precursors was determined and different precursors in different water matrices were compared.

1. The first step includes both optimization of sample preparation based on Solid Phase Extraction (SPE) and method parameters optimization with LC-MS/MS (Thermo Scientific).

2. Determination of NDMA FP of precursors in different water media:

a) Pharmaceuticals: investigation of chosen precursor group of pharmaceuticals; ranitidine, sumatriptan, doxylamine, metformin. The formation potential test, chloramination in different Cl_2/N ratios and ozonation as disinfection processes were investigated.

b) Swimming pool: the potential of swimming pool water for NDMA formation and water quality parameters was monitored.

c) Surface water monitoring: NDMA formation potential and water quality parameters were examined in surface water taken from Geyve, Sakarya, Turkey.

Conclusion

It is important to identify NDMA precursors and the conditions under which its formation can be decreased. NDMA precursors are organic nitrogen compounds that could be of natural origin but research suggests that anthropogenic NDMA precursors are more important.

Seasonal changes in NDMA precursor concentrations in a river may arise either from changes in NDMA precursor

concentrations such as pharmaceuticals or personal care products; It is also possible that the variations in the river's volume affect the concentration of the NDMA precursors.

The content of the swimming pool provides the formation of nitrosamines in the operated conditions. The precursors of nitrosamines turn to NDMA in swimming pool water. The contact of humans with a swimming pool may not cause a problem but the inhalation of the semi-volatile NDMA is also a problem and must be investigated for inhalation.

Rising waters of inequality – an empirical analysis of income gaps and flood mortality

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Background

The income gap between rich and poor has been widening in many countries over the past decades, with implications linked to justice, welfare, human health and well-being. Inequality is, furthermore, considered as one of the key drivers of disaster risk during extreme weather events – through a combination of pathways relating to both lack of resources of individuals, segregation, and systematic underinvestment of public infrastructure. Simultaneously, climate change is intensifying extreme rainfall patterns, amplifying the flood hazard levels.

Despite these interconnected risk factors, empirical studies on the nexus between economic inequality and human losses from floods are scarce, much owing to data limitations. In this work, we address this research gap by leveraging the growing availability of subnational data on floods, their impacts, population patterns, and socioeconomic indicators. The main objective is to investigate the degree to which unequal countries also tend to suffer higher flood mortality.

Method

We examined the association between nationwide income distribution and flood mortality by integrating and statistically analysing geodata from multiple international databases. The analysis used mortality records from over 500 severe flood disasters in 67 middle- and high-income countries from 1990 to 2018, alongside global maps of population numbers, urban settlements, and socioeconomic indicators.

An initial data exploration allowed us to disclose patterns of flood mortality across regions, time, and economic conditions. This screening exposed that countries with large income disparities had, on average, seven times more flood fatalities per event compared to those with more equal income distributions. Regression analysis further confirmed this link after controlling for factors such as per capita GDP, population size, and urbanisation levels. This link was even stronger for the wealthiest countries in the sample, the OECD member countries.

We also note that, despite overall advances in average living standards since 1990, a majority of nations in the sample also became more unequal in terms of income distribution. Furthermore, while the initial data screening suggested a protective effect of the per capita GDP on mortality, this link did not persist after controlling for income inequality and population numbers.

It is essential to note that causality cannot be inferred from our data. Nevertheless, our findings contribute to a more nuanced understanding the relative importance of various independent variables, showcasing how the distribution of monetary resources may influence disaster outcomes in advanced economies.

Conclusion

In conclusion, our study shows that over the past three decades, middle- and high-income countries facing high levels of income inequality also bear the heaviest human toll from major flood disasters. At the same time, a majority of these nations have experienced widening income gaps. This underscores the critical importance of addressing root causes of vulnerability, including economic disparities within societies, in all efforts to understand and reduce disaster risk.

Ultimately, these findings stress the interrelated nature of distinct sustainable development goals, here represented as the nexus between the goals of reducing inequalities (SDG 10) and reducing disaster mortality through climate action (SDG 13).

The importance of post-event documentation and analysis of flash floods for increased resilience of mountain areas

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Background

The increasing frequency of intense rainstorms due to climate change will most likely result in an increase in the occurrence of flash floods that represent extremely destructive phenomena in various mountainous areas. The spatial and temporal scales at which flash floods occur, combined with those of conventional rainfall and discharge measurement networks, make these events particularly difficult to monitor, and urge opportunistic, event-based observation strategies. Increasing knowledge about flash floods is crucial for society to enhance preparedness, mitigate risks, and safeguard lives and infrastructure from the devastating impacts of these natural hazards.

Method

Effective documentation of flash floods requires integrated post-event investigation strategies that include indirect reconstruction of peak discharge from flood marks, observation of geomorphological processes, and transport and accumulation of large wood material. This contribution introduces a project named "APPARE - Analysis and Documentation of Flash Floods for Increased Resilience in Mountainous Areas" recently funded in the frame of the extended partnership RETURN (Italy's recovery and resilience plan - NextGenerationEU). The APPARE project aims to enhance the understanding of flash flood dynamics and the resilience of hilly and mountainous territories. Specific objectives of the proposal include: i) Refinement of analysis and survey procedures for reconstructing peak discharges based on flood marks and topographic surveys of cross sections affected by floods; ii) collection of new discharge data using the aforementioned procedure in small hilly and mountainous basins affected by flash floods, along with concurrent documentation of geomorphic effects for a thorough understanding of the event; iii) knowledge transfer and dissemination of project results to share insights and positively impact the affected communities.

Conclusion

Post-flood field data collection and analysis are a fundamental requirement to adequately characterize the response of mountain basins and streams to flash floods. An important project outcome will be the transfer of know-how on field survey procedures and the dissemination of results to professionals and personnel from organizations involved in watershed management in mountainous areas. Knowledge dissemination will raise awareness among affected communities and management agencies about best practices for documenting and analyzing flash floods. Consequently, this will enhance their ability to confront similar events in the future, thereby increasing the resilience of the affected areas.

Bridging the knowledge-action gap: an attempt to link climate sciences and decision-makers for future urban flood management in West Africa

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Background

In West Africa, rising frequency of intense rainfall due to global warming pose an increased risk of damaging floods, particularly in rapidly growing urban areas. While decision-makers acknowledge the challenges presented by climate change, their ability to formulate effective adaptation strategies is hindered by the lack of accessible scientific information. Simultaneously, scientists are generating sophisticated insights into climate change and hydrological impacts in West Africa, yet they struggle to translate these findings into practical decision support tools, creating what is commonly known as the “knowledge-action gap”.

Method

This study highlights an experience in co-constructing climate services, involving scientists from the AMMA2050 program and decision-makers, with the goal of better integrating climate information into flood management within the urban planning in Ouagadougou, the capital of Burkina Faso.

The main steps of this co-construction process will be described. The first phase was initiated by project leaders who approached two local and national water management actors. In collaboration with Burkinabe scientists from the consortium, the project's objectives were presented. This was clearly a top-down approach, but it was also accompanied by exchanges aimed at better identifying local needs as well as relevant agencies and decision-makers. The second phase took place through regular meetings and a technical workshop, bringing together nearly 50 stakeholders, facilitating an iterative dialogue to identify the needs of the stakeholders and enable scientists to address them with the latest scientific knowledge. We will present the decision support tools co-developed within a climate-hydrological impact modeling chain for Ouagadougou, along with associated key messages that were communicated to stakeholders.

Conclusion

Through a multi-year co-construction process of climate services conducted between scientists and decision-makers in Ouagadougou, Burkina Faso, our study sheds light on: (i)) functional modes of interaction with decision-makers; (ii) technical scientific advancements enabling the provision of useful and usable scientific information; (iii) successes and failures in the approaches taken; and (iv) lessons learned from these experiences. Bridging the "knowledge-action gap" necessitates innovative co-construction strategies, pushing both scientists and decision-makers out of their comfort zones. This experience provides general insights for facilitating future co-construction approaches and fostering effective collaboration between the scientific community and decision-makers.

Alginate based nanocomposite hydrogels films for dye remediation from water

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Background

Polysaccharides, as biopolymers, hold significant interest due to their wide availability, cost-effectiveness, and eco-friendliness. Among them, alginate has gathered attention for its unique properties. Derived from the cell walls of various algae species, alginate's natural resilience allows algae to withstand constant wave and tidal forces. Structurally, alginate is a copolymer of β-d-mannuronic acid and α-l-guluronic acid, influencing its mechanical characteristics. Its abundant carboxyl and hydroxyl groups and its capacity to form non-soluble 3D networks enable diverse applications through modifications and blending with other materials. In recent years, alginate-based materials have emerged as promising adsorbents for wastewater treatment, particularly for hydrophilic and cationic contaminants. With the focus on pollutant removal, especially organic dyes like methylene blue, this research explores the chemical functionalization of alginate with methacrylic groups, incorporating graphene oxide to optimize mechanical properties and adsorption efficiency, contributing to the development of efficient and reusable nanocomposite films for water treatment applications.

Method

Self-standing nanocomposite films for wastewater decontamination were fabricated by UV-induced radical copolymerization of methacrylated alginate (MALG) and acrylic acid (AA), reinforced with graphene oxide (GO). The integration of GO aimed to enhance both mechanical strength and dye adsorption capacity in water treatment applications. Dynamic mechanical–thermal analysis demonstrated a direct correlation between GO content and storage modulus (E′), shedding light on the compatibility between GO and the MALG/AA matrix. Swelling–drying studies, along with water contact angle measurements, highlighted rapid water uptake of the films and short drying times, emphasizing their potential practical application. The efficacy of the nanocomposite films in dye adsorption was evaluated using methylene blue (MB) as a model contaminant.

Conclusion

From this study it could be concluded that the introduction of GO into self-standing MALG/AA nanocomposite films enhances the mechanical properties of the material and improves efficiency in dye removal applications. The observed increase in storage modulus, rapid water uptake, and short drying times highlight the films' potential for practical implementation in water treatment technologies. The excellent adsorption yields and reusability, even under acidic conditions, further emphasize their suitability for sustainable applications. The prepared films offer a promising avenue for addressing water contamination challenges, providing a robust and reusable solution for effective water treatment. Overall, the study suggests that these nanocomposite films could serve as valuable materials for sustainable and efficient water purification technologies.

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Sustainable fisheries - an unending struggle - a critical crossroad for Thailand

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Background

Capture fisheries reached a global annual peak of about 90 million tons in the early 1990s and have not increased since. Aquaculture has continued to grow since the 1960s and now exceeds this level at over 100 million tons. Thailand is an interesting case where fisheries management regulations in the Gulf of Thailand and Andaman Sea were imposed only very recently in 2015. Up to then an "open access" approach was taken resulting in overfishing, seriously depleting the pelagic and demersal fisheries. The military government in 2015, responding to international pressure, imposed regulations to limit marine capture and provide safer conditions for migrant workers. Several reforms, e.g. fishing vessel monitoring and catch limits provided a basis for sustainability. Now that Thailand has returned to an elected government there are calls to relax or remove some of the restrictions, which has led to a heated debate on sustainability within the sector.

Method

Most fisheries around the world have been managed using negotiated quotas based on the principle of Maximum Sustainable Yield (MSY), an estimate of the allowable catch for a given target species or group of species designed to avoid unsustainable harvesting of the fish stocks. MSY is however difficult to estimate and is more of a model for exploitation instead of conservation, designed to test the limits of nature. This management approach has resulted in multiple cases of overfishing including significant levels of destructive bycatch around the world. This has resulted in prosperous fisheries collapsing after several decades of overexploitation, with some stocks never recovering to original levels. In the case of Thailand, MSY-based regulation got started in 2015 by the then military government that responded to pressure from the EU regarding illegal, unreported, and unregulated (IUU) overfishing and the USA regarding trafficking and unjust treatment of migrant workers within the fishing industry. SEI in collaboration with UNDP, ILO and IOM has recently studied the current situation in Thailand. A multi-stakeholder workshop was held in early 2024 presenting plausible future scenarios for the fisheries and seafood sector including potential impacts of climate change. The purpose was to canvass the opinions of various sector stakeholders as they grapple with regulations restricting allowable catch levels. Evidence from the data obtained indicates that there is potential for stock recovery, but the restrictions need to continue to really take effect. The study involved examination of published and grey literature plus direct contact with authorities and stakeholders. Scenarios were presented at the workshop unpacking what the impacts would be of rolling back the regulations to the previous open access approach, the present-day initial levels of sustainability and a more advanced level of sustainability.

Conclusion

It was generally acknowledged among Thai stakeholders that returning to unrestricted open access to fisheries exploitation is not desirable. There was also general understanding that MSY-based management of fish stocks must continue in order to avoid further depletion of target demersal and pelagic fish stocks. The question is what more advanced steps are possible, e.g. tradable species-specific quotas and forcing bycatch to be included in the Total Allowable Catch, which would act as a further deterrent. It was also generally recognized that climate change must be reckoned with for both preservation and management of coastal zones and fish stocks. Ocean warming, coral bleaching, fish habitat degradation, acidification, coastal zone erosion and sea level rise will create additional pressure on target fish and shellfish populations. Thus, a more sustainable approach to fisheries is necessary in order to optimize what is exploitable but also to allow for adaptation strategies.

Life cycle assessment for the whey biorefinery concept: Where we are and what lies ahead?

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Background

Cheese whey (CW) is an outstanding resource despite its widespread production globally, as it poses significant environmental challenges due to its high pollutant content. Among the industrial sectors producing wastewater potentially suitable for biorefineries, the characteristics of CW from the dairy industry may support the development of a biorefinery concept for the production of valuable bioproducts. Around 50–60% of whey undergoes conversion into various products, while the remaining 40% is utilized for animal feed, fertilizing cultivated areas, or disposed of directly into water bodies, potentially causing environmental harm. CW can create several significant environmental pollution problems if directly discharged into the environment without any treatment. On the other hand, CW represents a tremendous opportunity for producing green energy and platform chemicals. Despite the tremendous potential for CW valorization techniques outlined in the literature, the industrial-scale implementation of integrated processing schemes capable of fostering a sustainable dairy industry remains relatively limited.

Method

The LCA concept is at the heart of this study, which investigates producing chemicals (lactose, whey powder, succinic acid) and generating energy (electricity, and heat from biogas) from CW. In this study, the present and future production strategies of a CW processing factory were assessed by LCA methods. Four main scenarios were evaluated. Discharge of CW to the receiving medium was assessed as Scenario 1^{st}. Combined anaerobic and aerobic treatment technologies for CW were assessed as Scenario 2^{nd} . Lactose, whey powder, and succinic acid production processes are common for the 3^{rd} and 4^{th} Scenarios and are labeled as Process 1^{st} and Process 2^{nd}. All inventory data for Process 1^{st} and Process 2^{nd} were obtained from the real-scale plant data and laboratory scale studies, respectively. Recovered energy from produced biogas was evaluated in two different pathways as direct combustion and combined heat and power (CHP) unit in Scenario 2^{nd}, 3^{rd}, and 4^{th}. SimaPro 9.11 software was used for the computational implementation of the life cycle inventory data. The functional unit for LCA was selected as a one-tone CW. Eleven impact categories are assessed as abiotic depletion, abiotic depletion (fossil fuels), global warming (GWP100a), ozone layer depletion (ODP), human toxicity, freshwater aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification, and eutrophication. Also, evaluating specific environmental performances of the scenarios, Cumulative Energy Demand to assess direct/indirect energy consumptions, Carbon Footprint, and Water Footprint are evaluated.

Conclusion

This study revealed that LCA is a valuable tool for the evaluation of the environmental impacts of hybrid integrated processes. Abiotic depletion, global warming potential, ozone layer depletion, human toxicity, photochemical oxidation, and eutrophication potentials of Scenario 4^{th} created fewer impacts. On the other hand, freshwater ecotoxicity and marine aquatic ecotoxicity with terrestrial ecotoxicity are an acceptable level in Scenario 4^{th}. Scenario 1^{st} has the highest impact on CO_2 footprint in its life cycle, while in Scenario $3r^{d}$ and 4^{th} the implementation of a recovery scheme for multiple end products has led to reduced CO_2 footprint and cumulative energy demand values. On the other hand, because of the high water consumption in the fermentation of succinic acid Scenario 4^{th} resulted in a high water footprint.

A system dynamics-based approach to marginal cost assessment of water resources management options

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Background

Marginal cost curves (MCCs) are popular decision-support tools for assessing and ranking the cost-effectiveness of intervention measures in environmental policy and management. They come in different forms and are produced using various methods (e.g., expert-based and model-based) but typically comprise a graph specifying the potential of a measure on the horizontal axis and the associated marginal cost on the vertical axis. Although historically primarily used in climate and energy policy, MCCs are finding their way into the water resources management (WRM) domain. However, conventional MCC approaches have been criticized for lacking transparency, disregarding interaction effects between measures, not accounting for co-benefits and costs, and for ignoring intertemporal dynamics -all of which are important factors for integrated WRM. This paper addresses these limitations by presenting a system dynamics (SD)-based approach to produce dynamic MCCs for evaluating water scarcity mitigation options.

Method

An integrated SD model was developed and applied it to a hypothetical, but representative, groundwater-dependent Swedish city. Four water scarcity mitigation measures were considered: enhanced public groundwater extraction (GW), rainwater collection and treatment (RWC), greywater recycling (GwR) and vacuum toilets (VacWC). The model consists of seven interconnected modules covering each of the mitigation measures, the housing stock, public water pricing mechanisms, and marginal cost computations. CAPEX, OPEX, technological potential, adoption potential, quality of water supplied, and implementation delays for each measure were estimated from the scientific literature. The model simulates investment and implementation of one or a mix of mitigation measures over a 25-year period. For each simulated scenario, performance is dynamically tracked through six key outcome indicators: marginal cost of water, average water cost, groundwater use, service capacity, net water availability and consumer water price. 15 unique combinations of mitigation measures were explored through simulation experiments. The subsequent analysis was conducted by first comparing the results from the proposed dynamic MCC with those of the conventional static MCC. We then analyzed co-benefits and costs of different mitigation mixes by assessing their relative performance of across the selected key outcome indicators using a heatmap. Performance for each mitigation mix over time was qualitatively assessed using behavior over time graphs. Finally, the inner workings of the model were distilled into a causal-loop-diagram (CLD) representing the core feedback processes driving for the observed dynamic behavior in each simulation run.

Conclusion

Key insights from the paper include: 1) The marginal cost of studied measures was consistently higher for the dynamic MCC compared to the conventional MCC; 2) Interaction effects between measures and systemic feedbacks can have a significant impact on their performance; 3) Intertemporal dynamics can effectively be captured by using SD-based simulation models to derive the MCC and provide valuable insights about when in time the costs and benefits of different measures occur; 4) Use of CLDs, or other system conceptualization tools, can make the logic of the model and structural assumptions of the MCC more transparent.

We conclude that the presented SD-based approach to MCC assessment effectively addresses documented limitations of conventional MCC methods and encourage its further research and application in the WRM domain.

Improving the assessment of urban water shortages by modelling the human-water interplays

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Background

Over the last two decades, more than 900 million people living in about 200 large cities have experienced water shortages. Future climatic and socio-economic projections reveal alarming scenarios, with escalating urban water shortages (difference between water use and supply) for more than 2 billion people. A number of methods have been developed to quantify drought risks and reduce the negative consequences of droughts on urban water shortages. Unfortunately, these methods do not account for the bidirectional feedback between the natural and human systems, possibly leading to a severe underestimation of drought impacts and risk

Method

Here, I will present the results of our previous studies focused on modelling the complex interplays between the components of the human-water systems leading to drought in urban areas. In these studies, we used a system dynamic modelling framework to simulate the influence of different adaptation strategies and the unequal interplay between water availability (from public and private water sources) and water consumption of different income groups on urban water shortages

Conclusion

The findings of these studies show that the presence of social groups with diverse risk attitudes and socio-economic characteristics leads to higher drought losses due to the unsustainable water use of groups with lower income and risk-neglecting characteristics. These studies emphasizes the importance of including the interplays between society and drought to better assess urban water shortages and provide more informed sustainable climate-resilient drought adaptation actions

Resource Recovery Toolbox: developing an online platform for making decision support tools for planning and implementing resource recovery more discoverable and accessible

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Background

Urban areas are increasingly seeking to recover valuable resources like water, energy, and nutrients from organic waste streams. However, the lack of accessible decision support tools hinders the planning and implementation of such resource recovery initiatives. These tools, ranging from software and design tools to datasets and case studies, are often dispersed across various platforms, limiting their practical use. The Resource Recovery Toolbox project aims to address this gap by creating a centralized platform to collate and curate these diverse tools, enhancing their discoverability and accessibility for professionals in sanitation, waste management, recycling, and related fields. This conference presentation will provide an overview of the Toolbox's purpose and target audience, describe the ongoing development process, and enable us to gather critical feedback and input for the further development of the platform.

Method

The development of the Resource Recovery Toolbox employs information knowledge management techniques, including the use of knowledge graphs and taxonomies, to systematically organize and relate the wide array of tools. This methodological approach ensures that the Toolbox is not only a repository of tools but also an intuitive platform where users can easily navigate and find the resources most relevant to their needs. Collaboration with stakeholders in the water and waste management sectors, as well as related sectors from e.g. agriculture and energy, is integral to this process, enabling the Toolbox to encompass a broad spectrum of knowledge and tools that reflect the latest innovations in resource recovery. By working closely with professionals, academics, and organizations, the project gathers essential tools and resources that support the circular management of water, nutrients, energy, and other resources embedded in wastewater and other organic waste streams.

Conclusion

The Resource Recovery Toolbox project, while still in development, presents a significant opportunity to bridge the gap between the abundance of scientific research on resource recovery and its practical application in urban settings. The Toolbox aims to empower professionals with the necessary tools to effectively plan and implement resource recovery initiatives, thereby contributing to the advancement of circular economy principles in urban waste management. The presentation at the Blue Planet Conference in April 2024 will highlight the project's progress, methodologies, and potential impact, inviting further collaboration and feedback to enhance the Toolbox's utility for its intended audience.

Candidatus Scalindua, a biological solution to treat saline recirculating aquaculture system wastewater

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Background

As the aquaculture sector development intensified, concerns regarding the impact caused by the high discharge of nutrients to the environment (eutrophication) are rising, especially for open-water systems. Closed systems such as recirculating aquaculture systems (RAS) allow water reuse up to 95-99% and ensure optimal control of the farming conditions. In RAS, ammonium is oxidized into nitrate via nitrite by nitrifying bacteria. All these compounds accumulate over time in RAS and if not appropriately managed, can affect the fish welfare. Nitrate can be managed through denitrification (unstable and difficult process), or by regular water exchanges (not sustainable). As an alternative, the anammox (anaerobic ammonia oxidation) process is a cost-effective and environment-friendly way to remove nitrogen wastes from wastewater, where ammonium and nitrite are directly transformed to nitrogen gas. In this study, we evaluated the potential of the marine anammox species *Candidatus* Scalindua to clean RAS wastewater.

Method

For this purpose, we have carried out a series of experiments in laboratory conditions to test the potential of *Ca.* Scalindua to clean RAS wastewater. In our first experiment, we exposed *Ca.* Scalindua to either a synthetic wastewater, enriched in ammonium (28 $mg.L^{-1}$), nitrite (34 $mg.L^{-1}$) and a mix of trace elements (phases 1, 5, control) or RAS wastewater enriched in ammonium and nitrite, in the absence (phases 2, 4) or presence (phase 3) of trace elements. This sudden change in environment led to a reduction in activity of the bacteria. Therefore, in our second experiment, we slowly adapted *Ca.* Scalindua to RAS wastewater in a 3 phases experiment. In the first phase (control), *Ca.* Scalindua was fed the same enriched synthetic wastewater feed as in the pilot experiment. In the second phase, we slowly exposed *Ca.* Scalindua to nitrogen-enriched RAS wastewater by gradual increases over 80 days. Once *Ca.* Scalindua was acclimated to RAS wastewater, we removed the trace element to investigate if this marine anammox species really needed supplementation (phase 3). Since nitrate accumulation is common in RAS, in our third experiment we investigated the impact of chronic exposure to high nitrate concentrations (400 $mg.L^{-1}$) on *Ca.* Scalindua over 9 months. In all these experiments, we kept the environment optimal for *Ca.* Scalindua (high ammonium and nitrite supplementation). However, since these compounds are quite toxic to fish, in our fourth experiment, we investigated the performance of *Ca.* Scalindua without nitrogen supplementation, using levels relevant for a real RAS (1 $mg.L^{-1}$), first with trace elements supplementation (phase 1), and then without (phase 2). In this experiment, we use a higher flow rate in order to keep the nitrogen load similar to the previous experiments.

Conclusion

Our results show that the sudden exposure to RAS wastewater reduced the activity of *Ca.* Scalindua, without impairing the bacterial community structure. A gradual exposure to RAS wastewater on the other hand resulted in a successful acclimation of the bacteria, which maintained high ammonium and nitrite removal rates. Despite a slight decrease in relative abundance (from 21.4% to 16.7%), *Ca.* Scalindua remained the dominant species in the granules throughout the experiment. Exposure to high nitrate concentrations did not affect the removal rate of *Ca.* Scalindua but did reduce its relative abundance (from 22.7% to 10.2%). Preliminary results suggest that *Ca.* Scalindua can maintain removal rates above 70% when exposed to nitrogen concentrations encountered in RAS. We concluded that *Ca.* Scalindua can be successfully used to treat marine RAS wastewater under laboratory conditions. Future studies need to evaluate the nitrogen removal performance of *Ca.* Scalindua at the pilot scale.

Using Satellite Images And Self-supervised Deep Learning To Detect Water Hidden Under Vegetation

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Background

In recent years the wide availability of high-resolution satellite images has made the remote monitoring of water resources all over the world possible. While the detection of open water from satellite images is relatively easy, a significant percentage of the water extent of wetlands is covered by vegetation, which traditional water detection methods based on optical images cannot detect. Recently convolutional neural networks have shown great success in the task of detecting water hidden under vegetation in radar satellite images. However, training these models requires large amounts of manually annotated satellite images, which are slow and expensive to produce.

Method

In this project we use self-supervised training methods to train a convolutional neural network-based model to detect water from radar satellite images without the use of annotated data through the task of semantic segmentation. The training algorithm we use is adapted from the paper "Unsupervised Single-Scene Semantic Segmentation for Earth Observation". The algorithm presented in that paper is specifically designed for the task of semantic segmentation of remote sensing images and takes advantage of the spatial properties of those images to facilitate the self-supervised training. The algorithm combines two different self-supervision methods, deep clustering and negative sampling. Deep clustering methods use a clustering method to cluster representations of the input data that are produced by the model and afterwards use those cluster assignments as pseudo-labels to train the machine learning model. Negative sampling methods train a model by encouraging it to produce similar representations for so-called positive pairs of inputs (such as a data point and an augmented version of it) and produce dissimilar representations for negative pairs (such as two random data points). After observing high variance in the performance of the algorithm across different experiments, we implement a class-weighted version of the deep clustering loss function of the algorithm and implement a simple ensemble version of the model that combines the outputs of 5 individually trained models through majority voting. We also replace the model used in the original paper with a significantly smaller one specifically designed for semantic segmentation tasks, greatly increasing training speed.

Conclusion

Our experimental results on two datasets of radar images of Swedish wetlands show that self-supervised learning methods can be successfully used to train a machine learning model to detect water from radar satellite images. Moreover, the changes we made to the original algorithm and model architecture improve the performance in our datasets, with the final ensemble model outperforming even a fully supervised model trained on the same data.

The municipality's role in adapting society to present and future risks from extreme weather events – focus on flood mitigation with the current legal regime

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Background

Contrary to public knowledge and, most likely, opinion, Swedish municipalities have few legal obligations and, strictly speaking, a rather small economic incentive, to adapt the public domain with the aim to reduce risks posed by extreme weather events, such as cloud burst flooding.

The responsibility to secure public as well as private property and societal functionality from extreme weather events falls on the owner of the property and/or the party responsible for suppling a certain service within the property, depending on arrangements between parties.

In contrast to the low level of responsibility for municipalities to reduce climate related risks, the municipalities (for obvious reasons) have a great interest in the overall reduction of risk of severe damage to property, vital societal functions and critical infrastructure within their geographical domain and for their citizens.

Method

Securing critical societal functions and property values thus become a hard task to perform, as the party responsible for doing so (e.g. a power grid company) cannot do so per default, as they may not have access to land on which to establish protective measures. Furthermore, it must be considered rather inefficient for every party to secure their own operation, instead of a consortium of interest owners working together to reduce the most severe risks to the most valuable assets, from a societal perspective.

The city of Stockholm focuses a lot of effort on the task of advancing the possibilities to establish such consortiums of interest owners. Several strategic initiatives have been commenced in order to facilitate such cooperation.

The city of Stockholm has created a strategic urban flood function at the transport department, with a City-wide responsibility and perspective, in order to strategically advance the City's efforts in mitigation extreme flood risks. The function works with all of the City's departments and companies, as well as being main contact for external parties for flood risk mitigation inquiries.

The presentation during the conference would be focused heavily on which role Swedish municipalities *can* shoulder, and perhaps *should* shoulder, with regards to the current legal regime. The presentation will describe the findings of the City of Stockholm's strategic urban flood function, in regards to how the municipality can actually lead and provide opportunities for flood mitigation, using the municipality's resources, knowledge, data and mandate as both local authority, but also land owner.

Conclusion

The presentation takes aim at what is possible, and how Swedish municipalities can take charge in prioritizing and enabling flood mitigation initiatives, even when not being responsible for providing investment funding. The municipalities' focus should be, arguably, on finding the most efficient way to reduce flood risks overall, not solely securing their own operations. Shifting the focus in this direction presents a vastly different platform, and it is this platform that the presentation will aim at defining.

Environmental Life Cycle Assessment of a Multi-use Offshore Farm: Integration of offshore mussel farming into offshore wind farms in the Belgian Continental Shelf

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Background

The world population's demand for food and energy is constantly increasing due to increase in global population, urbanisation, economic growth and changing eating habits, creating the water-food-energy nexus. Aquaculture is a valuable source of protein for human nutrition and there are efforts to expand it to offshore marine areas to meet growing demand for seafood. On the other hand, existing marine space and resources are being used more intensively for a wide range of activities. The Belgian Continental Shelf (BCS) is an example of this as being heavily used by various maritime activities especially by the offshore wind energy sector. This also creates the need for multi-use of marine space and therefore, in the BCS, it is possible to combine existing concession zones of offshore wind energy with aquaculture activities. This study evaluates the environmental sustainability of a designed multi-use offshore farm (MUOF), combining mussel cultivation and wind energy production in the BCS.

Method

A life cycle assessment (LCA) study is conducted according to ISO14040-14044 standards on the MUOF covering all life cycle stages from raw material extraction to its end-of life phase. The functional unit contains a basket of products; yearly average production of mussels and electricity. In this context, after defining the goal and scope of the study, an comprehensive data collection study is carried out to establish the Life Cycle Inventory (LCI) using various resources (including pilot scale projects and expert interviews). ReCiPe 2016 V1.05 (H) method is used as the impact assessment methodology to produce endpoint level results in three Areas of Protection (AoPs). A hotspot analysis of the results is executed. Also, possible synergies along the value chain of the two activities are evaluated through a scenario analysis.

Conclusion

The hotspot analysis shows that the manufacturing phase of the MUOF is the largest contributor to the environmental footprint, followed by activities during the operation and maintenance phase. These findings are due to the supply of materials for the production of components of the mussel farm and offshore wind farm (OWF). Comparing the two activities, the mussel farm has a higher net impact compared to the OWF because the latter has more benefits due to large amount of avoided products. Scenario analysis revealed that possible synergies in terms of shared transportation do not contribute significantly to an overall reduction of the net environmental impacts; however, they provide a considerable reduction at certain phases of the value chain.

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The Blue Food Centre, Sweden

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Background

The future is “Blue” we need to unlock the potential of the oceans for mariculture and aquaculture and better use of wild catches, in-order to achieve a prosperity for humanity.

Method

This presentation presents the new Swedish “Blue Food Centre - the Centre for future seafood”, where cultivation and the utilization of marine and freshwater biomass for food and feed are an essential part of the 13 million € investment with eight academic partners and 75 industrial companies, organizations and NGOs from the seafood sector. The human population will increase from 7.3 billion people in 2015 to 9.8 billion by 2050 and reach 11.2 billion by 2100. The oceans can help to satisfy the global demand of food and feed by both direct food production or indirectly by the harvesting of biomass for feed. The current and growing population is both a nutritional challenge connected with hunger, undernutrition and micronutrient deficiencies. But also, a growing global demand for food, feed and biomass. The total food demand is projected to increase by 60 % by 2050. Our oceans are home to a large number of resources that are marginally or not exploited and may improve food security and wellbeing for humans. A sustainable use of this resources could release some of the pressure that has been put on both land-based agriculture and industrial fishing and may also have a positive environmental impact on the global, regional and local environment. Today’s exploitation of ocean resources is not sustainable from both social, economic and environmental aspects.

Conclusion

The potential is connected with mariculture and aquaculture that may increase 50-100 times if focused on low trophic levels e.g., seaweeds, sea squirts and mussels.

Delineating Drinking Water Protection Areas Using Analytic Element Models (AEMs) With Focus on Enabling Uncertainty Analysis Using Monte Carlo Simulations

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Background

The delineation of a wellhead protection area (WHPA) is a crucial task aimed at safeguarding underground water resources. There are various methods available to achieve this, ranging from simple approaches with inherent limitations like fixed radius estimation to more sophisticated numerical models, which are considered to be the most detailed and reliable but time-consuming and data-intensive option. An analytical element model (AEM) provides a middle ground between these two extremes, offering users the flexibility to implement different boundary scenarios without being constrained by grid limitations. Moreover, AEM can perform better in cases where data is scarce. However, it is important to recognize that the output of groundwater modeling can never be claimed to fully reflect reality due to inherent uncertainties arising from conceptual understanding, model simplifications, and lack of data. To empower policymakers to make well-informed decisions concerning underground water resource protection, a comprehensive description of these uncertainties is essential.

Method

To address uncertainties in inputted hydrogeological parameters, TimML, a multi-layer, analytic element model, is employed and further developed to enable Monte Carlo Simulations. The research method used for this study is a combination of groundwater flow modeling and backward particle tracking, utilizing the groundwater time-of-travel as the delineation criterion. To account for the stochastic modeling of WHPAs, hydraulic conductivity, thickness of aquifer, and effective porosity are considered as key input parameters. After identifying the probability distribution functions for uncertain parameters, Monte Carlo Simulation is employed to generate a set of values for each parameter. These values are then randomly assigned as input values in multiple iterations of the groundwater flow modeling process. Through repeated calculations and sampling from the probability distributions, a range of model outputs is obtained.

To evaluate the effectiveness of the approach and consider the uncertainties in conceptualization, a test site in Färgelanda municipality, Sweden, was selected as case study. In this area, eight different scenarios were considered, and the calculated ranges of protection zones corresponding to a predefined percentile are illustrated for the study area. These results are benchmarked against the outcomes of the wellhead analytical element model (WhAEM), an existing software for the delineation of WHPAs developed by the US Environmental Protection Agency.

Conclusion

The results from the integrated TimML and Monte Carlo Simulations illustrate the added value of considering parameter uncertainties and how they affect the WHPA. Furthermore, the comparison reveals that the largest differences are between the different scenarios rather than the two applied models. This emphasizes the significant role of uncertainties arising from different assumptions in the case study, highlighting that stochastic modeling alone is not sufficient to capture all relevant uncertainties.

Mineralization as a mechanistic approach for bringing the nexus between water and nutrient inputs in decoupled aquaponics and flocponics.

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Background

Globally, two systems are recognized as efficacious methodologies in the aquaculture sector: the Recirculating Aquaculture System (RAS) and the Biofloc Technology (BFT). Broadly, these techniques enhance water utilization, culture quality, spatial efficiency, and infrastructure optimization, establishing them as sustainable approaches to food production. Nevertheless, it is noteworthy that despite their merits, both RAS and BFT are commonly applied in monoculture systems and typically do not fully represent the entirety of nutrients generated within the respective systems. Circular food production embodies a concept emphasizing environmentally friendly practices across all production facets, particularly optimizing waste reutilization throughout the production cycle. Aligning strategies with this conceptual framework is imperative. To address this challenge, adopting integrated systems capable of multifaceted production utilizing shared infrastructure, space, and raw material gains prominence. The evolution of integrated systems can be described as polyculture, aquaponics, and flocponics. Even though these advantages, nutrient and water management are actual concerns.

Method

This research aims to analyze the mineralization process as a methodology that can improve the recovery of nutrients and management of residual water to improve fish and plant production in decoupled aquaponics and flocponics systems. Two experiments were developed in the CIBNOR to analyze tilapia (*Oreochromis niloticus*) production. The first experiment consisted of 12 RAS units of $1m^3$, with a density of 100 organisms; the experiment was developed over 34 weeks. The second experiment consisted of producing in BFT; the same conditions and time were utilized. During the experiment, the liquid and solid fractions were collected and collocated in mineralization tanks using aerobic and anaerobic mineralization. The mineralization process worked for 34 weeks; the samples were taken to analyze the composition of nutrients using ICP and characterize the elements contained. The effluents from the different mineralization processes were used to formulate five nutrient solutions as treatment (t1-t5) and one control with inorganic fertilizer. These treatments were tested in the production of lettuce, pakchoi, basil, and spinach using NFT hydroponic systems. The plant experiment was for six weeks. The production, quality, and total yield from fish and plants in all the treatments in aquaponics and flocponics systems were registered and analyzed.

Conclusion

The principal conclusions: Mineralization is a bioprocess that helps improve nutrient recovery and integration of monoculture production to diversification. This process allows the recovery of phosphorus, nitrogen, potassium, and micronutrients such as iron. In general, producing plants using mineralization effluents allows the reuse of water and nutrients from aquaculture production. The bioprocess to manage the mineralization effluents should be considered the nature of the aquaculture effluents.

Flowing toward tomorrow: hydrological and sediment connectivity for improving landscape planning and water resources management

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Background

In recent decades, the concept of hydrological and sediment connectivity has increasingly gained traction in scientific discourse, owing to its ability to characterize potential spatial and temporal patterns of hydrological and sediment dynamics across various scales. Among the various approaches proposed, the sediment connectivity index introduced by Cavalli et al. (2013) has emerged as one of the most widely used methods, primarily due to its minimal data requirements, its capability of leveraging high-resolution topographic information but also thanks to the availability of free and open-source software implementing the proposed method. This approach has demonstrated its utility across various applications, including landscape planning, flood hydrology, and the assessment of gravitational process hazards and susceptibility, particularly when integrated with field data and complementary modeling results.

Method

Enhancing natural resource management, improving landscape planning, and optimizing water use can be regarded as fundamental tasks that require ongoing attention from the scientific community. In this framework, the present contribution tries to address how the hydrological and sediment connectivity paradigm can significantly contribute to the aforementioned objectives. Through a review of theory and applications in fact, we will spell out the ways in which characterizing sediment connectivity can enhance various aspects of river management and small-scale catchment sediment dynamics. Additionally, we will explore its implications for nutrient transport, flood risk assessment, and the resilience of infrastructure to gravitational or flood processes. Ultimately, we will explore how this metric can be tuned and adjusted to meet the analysis requirements, aiming to achieve optimal results by considering the quality of available data and appropriately integrating target selection and weighting factors derivation.

Conclusion

The hydrological and sediment connectivity paradigm has demonstrated its value as a cost-effective tool for landscape planning, offering insights into various aspects related to sediment, nutrients, and water pathways. By integrating this versatile analysis into a broader landscape planning framework and incorporating field data, a valuable characterization of spatio-temporal sediment connectivity patterns can be achieved. Such insights can prove beneficial across diverse settings, such as high or low relief areas, enhancing our comprehension of natural system dynamics and facilitating the implementation of effective nature-based solutions aimed at ensuring a more secure water and sediment cycle.

Multi-Use of Ocean Areal Recourses for Wind Energy and Kelp-Aquaculture

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Background

Offshore wind power will contribute to large-scale renewable electricity production. There is a rapid technological development in offshore wind power throughout the world, which will be one of the pillars of the green energy production of the future. Large areas in the sea will be used upon establishment, therefore it is of great importance to identify sustainable multi-use between several different activities.

Method

A sustainable and fast-growing bio-based resource is kelp e.g. *Saccharina latissima* and other green and red algae. The biomass from algae can be used for a variety of products such as food, feed, fertilizer, textiles, bioplastics and energy. Cultivation of algae also has positive effects for the marine environment as they absorb nutrient salts such as nitrogen and phosphorus as well as carbon dioxide. In Sweden, there are excellent conditions for combining offshore wind power and kelp cultivation in the salty and healthy North Sea.

Conclusion

The purpose of this presentation is to give an overview of the potential of this type of multi-use of the interaction between offshore wind power and algae cultivation and to demonstrate the possibilities of creating a profitable and sustainable co-utilization of these two activities. A key aspect of achieving profitability is also exploring the potential for automated surveillance during operations, where autonomous underwater robots and AI technologies can play a critical role.