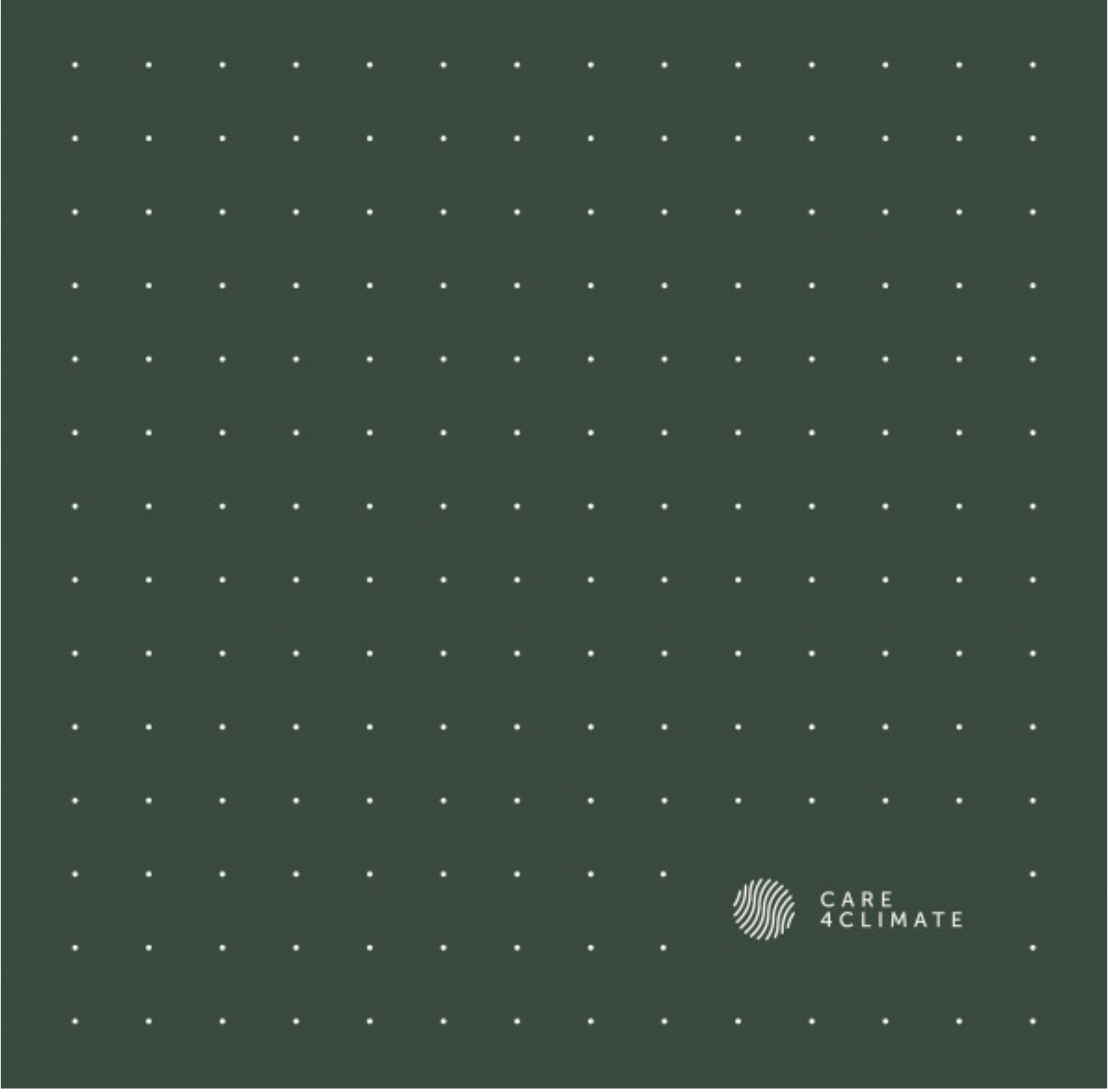

Zbornik: Mikrofon podnebju

LIFE IP CARE4CLIMATE (LIFE17 IPC/SI/000007)

CARE 4CLIMATE

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OKOLJE, PODNEBJE IN ENERGIJO

CIPRA ŽIVETI V ALPAH

Univerza v Ljubljani
Filozofska fakulteta
Oddelek za geografijo

Zbornik: Mikrofon podnebju
C2.4 Krepitev zmogljivosti za prehod v nizkoogljično družbo v visokošolskem izobraževanju
Mednarodni raziskovalni študentski forum

Urednik: CIPRA Slovenija, društvo za varstvo Alp
Lektoriranje: Sektor za prevajanje, Generalni sekretariat Vlade Republike Slovenije
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Zbornik: Mikrofon podnebju

V zadnjih letih se vse intenzivneje spoprijemamo s posledicami podnebne krize, ki niso več tako oddaljene, ampak jih vse močneje občutimo tudi pri nas. Prehod v podnebno nevtralno družbo je priložnost za ustvarjanje boljše prihodnosti za vse. Na Mednarodnem raziskovalnem študentskem forumu **Mikrofon podnebju**: znanje in kompetence za odzivanje na podnebne spremembe **»Koliko vode bo še preteklo?«**, ki je bil med 17. in 19. novembrom 2023, smo zato želeli udeležence podpreti s potrebnim znanjem za reševanje strokovnih, kariernih in družbenih izzivov, s katerimi se bodo srečevali zaradi posledic podnebne krize.

V središče podnebne krize smo postavili vodo. V zborniku so zbrani povzetki predavanj s številnimi vidiki podnebnih sprememb – geografska razsežnost podnebnih sprememb z napovedmi za prihodnost, ekstremni vremenski dogodki in zmanjševanje poplavne ogroženosti, vodni konflikti v Alpskem prostoru, migracije, povezane z vodo, in prilagajanje obalnih mest na dvigovanje morske gladine, vpliv podnebnih sprememb na biološko raznovrstnost oceanov in celinskih voda ter taljenje ledenikov.

Proceedings: Microphone to the Climate

In recent years, we have increasingly been confronted with the consequences of the climate crisis. The transition to a climate-neutral society is both a challenge and an opportunity to create a better future for all. Therefore, at the International Research Student Forum Microphone to the Climate: knowledge and competences for responding to climate change **“how much more water will flow?”** which took place between 17 and 19 November 2023, we wanted to empower the participants to address the professional, career and societal challenges they will face as a consequence of the climate crisis.

We have put water at the centre of the climate crisis. During the three days of the camp, the students learned about various aspects of climate change – the geographical dimension of climate change with projections for the future, extreme weather events and flood risk reduction, water conflicts in the Alpine region, water-related migration and adaptation of coastal cities to sea level rise, the impact of climate change on ocean and continental biodiversity, and glacier melt.

Kazalo vsebine

Geografske razsežnosti podnebnih sprememb

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Ključne besede: podnebne spremembe, ekstremni vremenski pojavi, prilagajanje in blaženje podnebnih sprememb, alpski prostor.

Desetletjem razprav, ali se Zemlja ogreva, so v krogih klimatskih skeptikov sledila leta razprav, kaj je vzrok temu ogrevanju. V resnih znanstvenih krogih dvomov ne o prvem ne o drugem že vsaj 30 let ni več. Podnebje zadnjega desetletja tako na svetovni kot tudi na lokalni ravni (območje Alp) kaže, da so bile napovedi o učinkih antropogenih izpustov na svetovno podnebje kvečjemu podcenjene in ne precenjene. Simulacije podnebnih vzorcev za prihodnja desetletja kažejo visoko stopnjo ogrevanja, ki za Slovenijo pomeni vsaj 0,3 °C na deset let, a pospešeno ogrevanje zadnjega desetletja vzbuja skrb, da bo to še preseženo.

Slovenija je poleti 2023 doživela podnebno streznitev v obliki nenavadno nevihtnega poletja z uničujočimi nevihtami in tornadom, poletna neurja pa so dosegla vrhunec 3. avgusta, ko so nekatera alpska in predalpska območja dosegle katastrofalne poplave. Tudi jesen je prinesla poplavne dogodke. Skrajni suši in požarnemu letu 2022 je torej sledilo leto vodnih ujm, na tople in po nižinah večinoma zelene zime smo se pa že povsem navadili.

Geografi pokrajino razlagamo kot ravnovesje pokrajinotvornih in antropogenih sil, ki skozi stoletja oblikuje značilno ali tradicionalno strukturo prostora. Sile strukturirajo prostor na način, da funkcija in oblika pokrajinskih delov ustrezata delujočim silam, kar pomeni, da se pokrajinski vzorec v poteku časa bistveno ne spreminja. Človek se skozi čas temu prilagodi in tako dobimo tradicionalno kulturno pokrajino, kakršna je zagotovo alpska pokrajina. Intenzivne spremembe »podnebnih sil« v zadnjih desetletjih, zlasti pa v letih 2022–2023 (požari, poplave, usadi, plazovi, vetrolomi …) nam kažejo, da zaradi spremenjenih naravnih sil spremembi strukture sledi tudi pokrajina. To pomeni, da številna območja niso več primerna za rabo, kot smo je bili vajeni. Uničena naselja oziroma njihovi deli, tudi tisti z večstoletno zgodovino, so neizprosen dokaz tega.

Tako je danes poleg zmanjševanja vpliva človeka na podnebne spremembe (blaženje podnebnih sprememb) vsaj tako pomemben tudi proces prilagajanja nanje, ki obsega vsa področja človekovega delovanja, hkrati pa cilja na izobraževalni proces podnebnega opismenjevanja in krepitev formalnih in neformalnih skupin, ki vstopajo v vlogo odločevalcev in bodo krojili odločitve človeške družbe v prihodnjih desetletjih.

Water conflicts in the Alps

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Key words: Water conflicts, Alps, climate crisis, hydropower, Alpine Convention

The reality

- Home to 14.9 million people in the perimeter of the Alpine Convention → 80 million in the EUSALP area
- A haven of biodiversity: No.1 or 2 in Europe (ahead or after the Wadden Sea)
- Massive deterioration due to the climate crisis: Glaciers are history. Extreme weathers create dry periods, droughts, floods, landslides, debris flows, avalanches → Resettlements, drinking water. lack of industrial and groundwater, loss of species...
- In the Alps, we are ahead of global average warming: if we reach +2.5°C globally → +5°C in the Alps → "This will be a new world" (Swiss Federal Office for the Environment).

Water: too many needs not enough protection

- Total exploitation for hydropower → overexploitation of water bodies and damage to the surrounding.
- Exploitation of groundwater flows for drinking water supply and irrigation → lowering of the groundwater table → dry soils.
- Exploitation for agricultural irrigation → damage to the ecology of watercourse areas.
- Exploitation for artificial snowmaking → damage to the ecology of watercourse areas.
- Exploitation for all kind of industrial production → lowering of the groundwater table → less drinking water.
- Conclusion: Too much water utilisation at the expense of aquatic ecology, biodiversity and landscape beauty as well as its conservation value.

Insight & commitment 2020

Declaration of the Alpine Convention on integrated and sustainable water management in the Alps (2020). In it, the contracting parties to the Alpine Convention commit themselves:

1. to protect the last naturally preserved river courses in the Alps;
2. to promote the revitalisation and restoration of the natural state of watercourses with the aim of functioning as close to nature as possible;
3. to consider the Alpine region as an increasingly drought-prone area where the management of water scarcity in each of the river basins should be addressed at a transboundary level;
4. in any further expansion of hydropower plants, take into account the protection of the landscape and ecosystems, the interests of local communities and downstream communities and the need to protect the last naturally preserved river courses and river sections in the Alps in such a way that they neither lead to a deterioration in water quality, water quantity, hydromorphology and the ecosystem nor jeopardise the achievement of the good status of the watercourses concerned;

9. to promote instrumentsof bottom-up governance to improve public participation and the acceptance of measures such as river treaties, river dialogues, river forums, also on cross-border level;
10. dialogue and transnational cooperation on water management issues to be continued in connection with transboundary water bodies;
11. to recognise that local and transnational cooperation helps to territorial cohesion through the development of trust, experience and to strengthen scientific exchange across borders and institutions.

Northern Italy calls for water aid from Switzerland – but no success

“For three months, it has hardly ever rained properly in the Po Valley and at the southern foot of the Alps, and the winter was also exceptionally dry.”

Meuccio Berselli, the Secretary General of the Po River Basin Authority, has therefore appealed to Switzerland for help.

According to Carlo Scapozza, Head of the Hydrology Department at the FOEN, precipitation in the form of rain and snow in recent months has been well below the long-term average.
According to the hydrologist, the Ticino reservoirs are currently only 30 percent full. That is the lowest level in the last fifty years. Drawing more water from the reservoirs to increase the level of Lake Maggiore would also have a negative impact on Ticino itself: in winter, less electricity would be produced from hydropower in the southern canton.

4000 km of watercourses to be revitalised in Switzerland alone

“In addition, global developments such as climate change, which cannot be responded to with water protection measures, are very likely to have a negative impact on aquatic ecosystems.

It is therefore all the more important that suitable measures are taken to strengthen the resilience of ecosystems in order to minimise the overall impact on ecological status.
Suitable, urgent measures include, above all, the reduction of pollutant inputs into water bodies and renaturalisation.

The aim is to revitalise 4000 km of watercourses over the next 80 years.
Priority action is required for the quarter of Switzerland’s 15,000 kilometres of watercourses that are in poor condition due to obstructions and intensive use.

Initial successes are already being seen in fishing surveys in revitalised watercourses. In terms of hydropower rehabilitation, around 1000 fish migration barriers, 100 hydropower plants that cause artificial flow fluctuations (hydropeaking) and around 500 hydropower plants and other facilities that cause bedload deficits must be rehabilitated throughout Switzerland by 2030.”

Conflicting interests

Upstream Countries Shift the water from summer to winter for hydropower production, snowmaking and touristic supplies.

Downstream Countries need the water in summer for drinkwater supply, groundwater fostering and irrigation.

Swiss tunnel vision in crisis mode

Federal Act on the Secure Supply of Electricity from Renewable Energies (September 2022 - September 2023 (shell decree)).

Positive:

- Expansion of production mainly through photovoltaics on new buildings & infrastructures with an area of 300 m2 or more (thus excluding approx. 70% of Swiss roof surfaces).
- Increased energy efficiency measures by electricity suppliers.
- Power plant construction in biotopes of natural importance, water and migratory bird reserves excluded.

Problematic - unconstitutional, contrary to the Alpine Convention:

- Massive expansion of hydropower: implementation of 16 large scale hydropower projects (13 increases in the height of dams, 3 new dam constructions (2 of which in areas worthy of protection) including acceleration of procedures and fundamental priority for realization.

Serious exceptions in biotope protection:

- Nationally protected biotopes can be put on residual flow by power plants located outside of them.
- Power plants possible in emerging glacier forelands and unprotected alpine alluvial plains. In the canton of Graubünden alone, these 2 points affect 58 watercourse biotopes.
- Federal government sets watercourses to minimum residual flow in the event of “imminent (power) shortages.” → Further reduction in summer water runoff in the Inn, Rhone, Rhine, Adige, Po.
- Interventions in landscapes of natural importance (BLN areas) possible without protection, compensation, replacement or restoration measures.
- No solar power obligation on car parks.
- Generally favoured construction of wind and solar power plants (ground mounted systems) via spatial planning.

Bitter lessons learned

In parliament:

- Those responsible in crisis must (finally) act → Many breaches of law.
- Those who act too late make the most mistakes → Ignorance of the consequences.
- Nature gets the short end of the stick in populist prioritisation (“Every kilowatt hour counts”).
- For the environmental organisations:
- Expertise is key economic power is decisive.
- Only the weak adhere to consensus papers (2021 mutually agreed “Hydropower Round Table” of the Confederation, cantons, water management, fishing association & environmental organisations.
- Those who do not draw red lines are pushed against the wall and get crushed (USO stance on the referendum question: “We will only take stock at the end”).

Austrian Energy Politics

CONSUMPTION
Positive: economic growth is decoupled from consumption.
Negative: efficiency measures do not meet EU & national targets.

POWER PRODUCTION 2020
domestic 145 TWh
of which renewable 124 TWh (85.5%)

Renewable Energy production (124 TWh)

Biogen/Scheitholz	63 TWh	51%
Water	42 TWh	34%
Wind	7 TWh	6%
Toplotne črpalke	5 TWh	4%
Bigorivo	3 TWh	2%
PV	2 TWh	1.7%
Solarthermie	2 TWh	1.6%

Why so much hydropower?

No detailed, project specific overarching energy planning.
National conflict dialogue and compromises impossible.
Result , the federal states determine what is built where and when.

Example Tyrol / Total energy production:
Today : 95.5% Hydropower (6,6 TWh/2011), 1.5% Photovoltaic.
Goal 2036: +2,8 TWh Hydropower (whole Switzerland: +2,5 TWh).

- Not included: pump storage power plant Kaunertal.
- 90km additional residue water stretches.
- 2 additional river catchment areas drained Venter & Gurgler Ache).
- 1 additional high valley flooded.
- zusätzliches Hochtal überflutet (Platzertal).
- Increased hydropeaking in the Inn.

Production increase: 787 GWh/a
Pump energy consumption: 549 GWh/a (2040)

What kind of solutions? Solar power

Many countries generally favour energy production in which they already have a strong economic position. This needs to be scrutinised.

Example Switzerland

Total hydropower expansion:

According to the current Energy Strategy 2050+, electricity production from hydropower is to be increased from the average annual production of 36.7 TWh today to 38.6 TWh in 2050. → Net expansion of +1.9 TWh.
In September 2023, the targets were increased to at least 37.9 TWh in 2035 and at least 39.2 TWh in 2050.
→ Net increase of +2.5 TWh compared to today, with the aforementioned negative water impacts.

Hesitant solar expansion:

Switzerland produced 3.9 TWh of solar power in 2022, which corresponds to 6.76% of consumption. Target increase in September 2023 for solar energy and wind production:
2035: 17 TWh, 2050: 39 TWh.
However, Switzerland's solar expansion potential on suitable roofs and facades alone amounts to 67 TWh of annual production.
For comparison: Swiss electricity consumption as a multi-year average: 60 TWh.

Energy: Why we stumble across the Alps

- Overexploitation of water → Total exploitation of hydropower.
- Procrastination on energy efficiency → Building refurbishment rates too low.
- Regional disputes over wind power expansion → Loss of credibility of civil society and NGOs.
- Turning away from the roof offensive for solar expansion → Alpine ground mounted systems → more returns for energy supply companies → much more impact on nature.
- In response to the gas crisis:
  → gas fracking in the Alpine regions in examination,
  → hydrogen hype despite massive energy conversion losses.

Outcome: A stuttering energy transition at the expense of landscape, biodiversity and water protection.

Other forms of capacity management

The need for additional flexibility does not necessarily be covered by pumped storage.

Generation:

- flexible conventional power plants (H2-ready),
- system responsibility for renewable energies.

Grid:

- grid optimization,
- expansion of existing grids,
- new grid concepts (HVDC supergrids) and H2-grid.

Storage:

- short/long-term and centralised/decentralised storage facilities,
- cross-sector storage (power-to-gas).

Consumers:

- load management industry,
- “new” flexible consumers (e.g. heat pump, electric cars).

What matters with hydropower

5 CIPRA requirements for hydropower exploitation:

1. foresighted planning and reduction of energy consumption prior to the expansion of hydropower,
2. renovate existing hydropower plants instead of building new ones,
3. preserve the freshwater pearls of the Alps, protect intact rivers and river sections as well as small rivers and streams,
4. use of small hydropower plants only for limited and isolated, local needs,
5. strengthening transnational exchange & cooperation on overall water management.

More and Less Water Leads to Population Migration

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Key words: Water, Population Migration, Climate Change, Flooding, Water Scarcity, Sea Level Rise

Population migration is predicted to be one of the most significant impacts of climate change on human populations (IPCC, 1992). Future migration rates forecasts vary between 25 million to 1 billion climate migrants by 2050. The most commonly cited estimate is around 200 million by 2050 (Swain, 2019). One of the most profound effects of climate change is its effect on the water cycle, by alternations in rainfall predictability and rising sea levels (Earle et al, 2015). Water's role in population migration is multifold. Too much water, too little water and rising seas can cause population migration. What they all have in common is that changes in local environmental conditions push people from their home locations. However, water is only one of many factors that can cause migration. Social, economic and political factors also play their role. These factors interact in a complex dynamic, which makes migration difficult to predict. Therefore, it is somewhat simplistic to argue that people migrate only because of water challenges. Nevertheless, the water situation can be an important factor that makes people migrate. People can be forced to migrate or do it voluntarily. Migration can be temporary or permanent, within or across national borders (IOM, 2019).

Flooding is a sudden environmental change that is easy to detect. In 2022, 8 million people were displaced by flooding in Pakistan (WMO, 2023). The majority of reported displacements by natural hazards in the Middle East and North Africa region between 2010 and 2019 are by flooding (IDMC, 2021). However, flooding sometimes only has a marginal effect on long-term migration where people often move back to their home community or relocate to an area close to their previous home after a flooding event. Future more frequent and intense flooding events risk pushing more people to migrate after reoccurring events that damage people's homes and livelihoods.

Water scarcity, when there is less water available than what is needed, is a five times higher driver of migration compared to floods. Between the years 1970 and 2000, declining water access contributed to a 10 % increase in global migration rates (Zaveri et al, 2021). Currently, more than half of the world's population suffers from severe water scarcity at least some parts of the year (IPCC, 2022). Water scarcity is a slow environmental change that through repeated experiences can lead to migration, mainly from rural areas dependent on agriculture. For agricultural workers, insufficient water availability can have a direct effect on their income because of reduced agricultural yields. If other adaptation strategies fail, such as changing crops or irrigation techniques, migration might be the best alternative to reduce negative impacts on people's livelihoods and well-being.

The slower and gradual impact on people's livelihood makes the connection between water scarcity and migration more difficult to monitor compared to sudden environmental changes.

The rising sea level is a growing threat to a large part of the world's population. Globally, 10 % of the population lives within areas at risk of sea level rise. The rising seas alone can displace 200 to 600 million people by 2100 (Kulp and Strauss, 2019). Low-lying small island states risk disappearing partly or completely, and many highly populated cities are at risk of being submerged. Although some people have already been forced to leave their home location because of sea level rise, no one has yet been granted protection in another country. Mainly, because climate migrants are currently not protected under international refugee law. Moreover, migration may cause greater water insecurity in the host location. This can bring further economic uncertainties and political instabilities, which again can force people to migrate to new areas in search of survival.

Climate migration is a global justice issue which creates greater insecurities. It is predominantly people from the Global South who are most at risk of being displaced by the increasing water challenges. At the same time, Global North are most responsible for the rapid climate change we're currently witnessing. To reduce the negative impacts on affected populations, the world has to urgently reduce greenhouse gas emissions, and invest in adaptation strategies that better prepare affected populations for future challenges.

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The ocean as our ally to fight climate change – the ocean's role, threats and glimpse of hope

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Ključne besede: climate change, ocean and seas, carbon sink, ocean acidification, loss of marine biodiversity

The ocean plays a crucial role in our fight against climate change. In being the largest carbon sink on earth the ocean is our key ally. To understand the connection between climate and ocean I first explained the ocean carbon pump, which is a very important factor in the overall climate system. In fact, without the ocean the earth would be around 35 degrees hotter. The ocean also generates half of the oxygen we need and has already absorbed about 93% of the heat generated by rising emissions. I exemplary showed the role of the ocean in fighting climate change with three marine superheroes, which are seagrass, whales and fish.

The increasing effects of climate change have devastating effects on the ocean and its climate regulating qualities, which can for example be seen in increasing marine heatwaves, dead zones in the ocean, ocean acidification, and the loss of marine biodiversity, like the loss of coral reefs. We can see that all these impacts become more frequent, have become longer-lasting and more intense and human influence can be identified as the main driver.

I explained some of the human threats to the ocean, like industrial large-scale fisheries and shipping and their role in hindering the ocean from capturing carbon especially by removing marine life from the ocean that acts as main driver for the ocean carbon pump. At the end of the presentation, I connected these issues to the consumption behavior of Europeans as well as justice issues that arise with the increasing fish consumption, mainly driven by the global North. I outlined that we need systemic change in the marine sector to overcome the named factors and to support the ocean in taking on its key role in the fight against climate change.

Podnebne spremembe, biodiverziteta in ekološko stanje celinskih voda

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Ključne besede: ekološko stanje, celinske vode, klimatske spremembe, onesnaževanje, invazivne vrste, hidromorfološke spremembe.

Večina vode v svetovnem merilu je v oceanih, manj kot 3 % pa je sladke vode. Od tega je velika večina v obliki ledenikov in podzemne vode, površinske sladke vode pa je razmeroma zelo malo. Kljub temu pa je ta izredno pomembna za biodiverziteto oziroma biološko raznovrstnost. Skoraj polovica vseh vrst vretenčarjev so namreč ribe, velik del pa tudi dvoživke. Celinska voda je ključna za življenje tudi mnogih drugih skupin vretenčarjev in nevretenčarjev, ki so prehransko, razvojno ali drugače vezani nanjo. Poleg tega se na stičišču vodnih in kopenskih habitatov pojavljajo organizmi iz obeh okolij, zato je biološka raznovrstnost tam povečana. Poleg pomena za biodiverziteto pa je celinska voda ključna tudi za človeka. Pomeni vir pitne vode za splošno uporabo v gospodinjstvu, kmetijstvu in industriji, izkorišča se za transport, proizvodnjo elektrike in številne prostočasne dejavnosti od ribolova do različnih vodnih športov.

Zaradi hitrih sprememb v zadnjem stoletju sta biodiverziteta in ekološko stanje številnih celinskih voda močno ogrožena. Zaradi rasti prebivalstva in sprememb življenjskega sloga se hitro spreminjajo tudi mnogi drugi dejavniki v svetu. Beležijo se povečanje CO_2 v atmosferi, porast temperatur, povečana uporaba gnojil, gradnje jezov, čezmerni ribolov v svetovnih oceanih in drugo ter navsezadnje tudi pospešeno izumiranje vrst. Vodni ekosistemi so prizadeti predvsem zaradi onesnaževanja, invazivnih vrst, hidromorfoloških sprememb, morska okolja pa tudi zaradi pretiranega izlova. Stanje močno slabšajo podnebne spremembe, ki imajo dopolnjujoči učinek s prej navedenimi stresnimi dejavniki.

Dober primer je kombinacija podnebnih sprememb z onesnaževanjem. Pri višjih temperaturah je v vodi raztopljenega manj kisika. Hkrati pa z višanjem temperatur narašča metabolizem organizmov in s tem njihova potreba po kisiku. To je še posebno kritično v kombinaciji z onesnaževanjem s hranili ter organskimi snovmi, saj se zaradi tega povečata mikrobna razgradnja in respiracija, kar lahko privede do upada ali popolne odsotnosti kisika (anoksije). Slednje vodi v pogin rib in drugih vodnih organizmov. Po količini hranil oziroma biološki produkciji delimo vodna telesa na oligotrofna (malo hranil), mezotrofna (srednje veliko hranil) in evtrofna (veliko hranil). V vodah je najpogosteje fosfor tisti limitirajoči dejavnik, ki narekuje, kakšna bo produkcija. Zato je trofična lestvica za jezera narejena kar na podlagi koncentracije fosforja ali klorofila a ali prosojnosti vode. Vsi trije dejavniki so namreč močno povezani; kjer je veliko fosforja, bo veliko alg (klorofila a) in zato bo prosojnost slaba. V rekah se povečanje količin fosforja odraža v povečani masi perifitona (obrasti površin z algami), dominanci le nekaterih vrst vodnih rastlin ali nižje v toku tudi v pojavljanju planktonskih alg. Redkeje pa prihaja do anoksije, ki je resen problem za stoječe vode. V teh se pojavlja temperaturna plastovitost, ki s tako imenovano termoklino (območje, kjer se temperatura zelo hitro spremeni) loči zgornjo od spodnje plasti. Ti dve plasti se slabo mešata, zato je v spodnjo plast omejen vnos kisika, ki prehaja čez gladino vode.

Na dnu globljih jezer je temperatura vode običajno 4°C (pri tej temperaturi je voda najgostejša, zato potone) in se lahko premeša šele, ko se zgornja plast ohladi ali segreje na 4°C, s čimer izgineta termoklina in plastovitost. Na območju osrednje Evrope se to običajno zgodi jeseni in spomladi. Višanje temperatur pa lahko vplivajo, da je ta režim spremenjen, termoklina ostaja čez večji del sezone in s tem je mešanje slabše.

Podnebne spremembe tudi slabšajo razmere z invazivnimi vrstami. Poleg dodatnega okoljskega stresorja za že prizadete domorodne vrste pa višanje temperatur pospešuje širjenje določenih tujerodnih vrst. V Sloveniji je veliko vrst vodnih organizmov, ki so v zelo kratkem času zavzeli veliko površino, posledice pa so bile uničujoče za lokalne vrste in ekosisteme. Hidromorfološke spremembe naravnih vodotokov lahko prav tako negativno vplivajo na lokalno biodiverziteto in odpornost ekosistema na stresorje. Pri kanaliziranju rek in potokov je grožena poplavna varnost dolvodnih regij, zaradi homogenih habitatov pa prihaja do zmanjšanja ekosistemskih storitev, kot sta zadrževanje vode in samočistilna sposobnost. Hidromorfološka degradiranost vodnih teles v Sloveniji je tudi glavni razlog za slabo ekološko stanje. V splošnem je za poslabšanje ekološkega stanja pogosto krivih več dejavnikov. To se vidi tudi na primeru visokogorskih jezer, ki jih zaradi klimatskih sprememb ter vse daljše rastne sezone vse bolj preraščajo alge. Veliko bolj so prizadeta jezera, ki so v bližini planinskih koč in so v njih umetno naselili ribe.

Spremembe so edina stalnica – tudi v zgodovini so bile velike spremembe CO_2 in temperatur. Kadar je teh sprememb preveč in so prehitre, imajo živa bitja (še posebno večji organizmi) premalo časa za prilagajanje in prihaja do izumiranja. Zato je pomembno ohranjati ekosisteme v naravnih stanjih, saj so ti bistveno bolj odporni na spremembe.

Water resilience strategy of the city of Antwerp

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Key words: Climate adaptation, urban hydrology, flooding, drought, water scarcity

The city of Antwerp, the second largest city of Belgium, is, as many other cities in the world, confronted with the consequences of climate change. Temperatures are rising globally and, additionally, temperatures in a city during a summer night can be 4°C to even 9°C higher than in rural areas, because of the urban heat island effect. This causes health issues and even mortality. More intensive rainfall leads to more (pluvial) flooding, while longer dry periods lead to droughts and water scarcity.

To prevent pluvial flooding, the city has prepared a Water Plan that is based on an analysis of 3 water cities: the historic water city, the natural water city and the artificial water city. The actual city is primarily artificial and consists of large (underground) sewer systems and pumping stations. The historic water city, with many spots for open water even in the city center, has almost completely disappeared. The natural water city, with some open water and swamps, has been reduced to a minimum. The vision of the Water Plan is to find a new equilibrium between these three water cities, where the artificial one is still important, but where the historic and natural water cities are revaluated. Water will become more visible, present and tangible. An area with a lot of open public space is completely different from a very densely built city center. So the way to do this will also be different for each city quarter or urban typology.

Implemented water measures are: water permeable parking spaces, infiltration zones, garden streets, green roofs, depavement of school playgrounds, … These are all protection measures. Protection is, along with Prevention and Preparedness, one of the three so-called P's. In principle protection is not needed if problems are prevented by good spatial planning and building high enough. However, mostly because of historical reasons, this is not always the case. And in low lying areas even well protected buildings can still flood, during extreme events. So emergency services, like the fire brigade, will have to be prepared to intervene (sand bags, …). Recently awareness is growing that also civilians have a role to play in this. Therefor the city started a pilot where civilians are experimenting in how they can be more self sustainable during floods.

To tackle drought and water scarcity the city is using more and more circular water in stead of drinking water. Circular water can be rain or grey water.

Rain falls everywhere, but not continuously. Therefor reservoirs have to be built to store the water for the dryer periods. In Antwerp individual rainwater reservoirs are mandatory for new constructions and are promoted for existing constructions via subsidies. Also collective reservoirs are constructed, with an example being the 'South Park'. A reservoir of 1 500 000 liters collects the rain water of all surrounding roofs so it can be used for cleaning streets, irrigating urban green and as circular water (toilet flushing) for a new building of 300 residents.

In contrast to rain water, grey water (groundwater drainage, treated waste water) has the advantage of being permanent but the disadvantage of not being everywhere available. Rain water and grey water are therefor complementary.

For reusing grey water no reservoirs are needed, but pipe lines have to be constructed between water source and the user. The city has built a first one of these pipe lines and is planning to build two more in the near future.

A lot of work still needs to be done, but with this clear strategy on adaption and the first implementations on the ground, the city of Antwerp hopes to be ready to remain a nice, livable and attractive city in the future.

Triglavski ledenik in ledenik pod Skuto kot kazalnika vpliva podnebnih sprememb na vodni krog

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Ključne besede: Triglavski ledenik, ledenik pod Skuto, podnebne spremembe, talilna doba, dvig temperatur, značilnosti ledenika in ledu.

Posledice podnebnih sprememb so najbolj izrazite in opazne v gorskih pokrajinah, k njihovemu prepoznavanju in zavedanju pripomore tudi čedalje večji obisk gora. Raziskovalci Geografskega inštituta Antona Melika ZRC SAZU že vse od leta 1946 opazujemo oba ledeniška ostanka pod Skuto v KamniškoSavinjskih in Triglavom v Julijskih Alpah. Zadnji obisk obeh ledenikov ob koncu talilne dobe 2023 je pokazal, da se še naprej krčita in tanjšata; posebej izrazito je bilo nazadovanje površine in prostornine Triglavskega ledenika. Namesto ene sta na južnem delu Triglavskih podov dve zelo majhni večinoma z gruščem prekriti zaplati ledu, katerih skupna velikost ne presega 0,2 ha. Na mestu, kjer so konec poletja 2022 raziskovalci vzorčili led in je bila debelina ledenika 4,5 metra, jih je pričakala gola skalna podlaga! Prav na temelju vzorcev iz leta 2022 so ocenili, da je bil tamkajšnji led star okrog 300 let. V zadnjem letu dni je izginila okrog tri stoletja stara zgodovina našega vremena in njegove dolgoročne različice – podnebja.

Stanje ledenika nas je toliko bolj presenetilo ob dejstvu, da je bila s 445 centimetri izmerjena največja sezonska skupna višina snežne odeje v snežni sezoni 2022/23 šele v drugi polovici maja (18. 5.). Pozno zapadli sneg je hitro skopnel, saj ga je pobralo v nekaj več kot mesecu dni. Že drugo leto zapored je bila temperaturno rekordna polletna talilna doba (maj–oktober). Prvič po letu 1955, odkar imamo na voljo meteorološke podatke za Kredarico (2513 m), smo bili v letih 2022 in 2023 priča dvema zaporednima talilnima dobama z najvišjo izmerjeno temperaturo (6,1 °C) tega polletnega obdobja (povprečje 1990–2020 je 4,3 °C, za celoten 69-letni niz 1955–2023 pa 3,8 °C). V zadnjih šestih letih smo kar štirikrat izmerili najvišjo temperaturo talilne dobe, in sicer v letih 2018, 2019, 2022 in 2023! V zadnjih treh desetletjih se je poletna temperatura zraka dvignila kar za 0,4 °C na desetletje. V letu 2023 (poplave!) velja omeniti še obilje poletnih padavin, ki jih je prinašalo iznad pregretega Sredozemlja oziroma tamkajšnjih morij. Povprečne temperature morske vode so bile ob tem času kar za tri do štiri stopinje Celzija nad dolgoletnim povprečjem.

Rezultati meritev na ledeniku pod Skuto so bili v okviru pričakovanj – tudi ta se je precej stanjšal in nekoliko skrčil – namerili so namreč 1,2 ha. Z lanskoletnim prevzemom primata glede površine se je še enkrat več potrdilo, da je za vztrajanje ledenih zaplat pod našimi najvišjimi vršaci, poleg obilice snega in snežnih plazov, precej bolj kot nadmorska višina – ledenik pod Skuto leži kar 400 metrov niže od svojega zahodnega soseda – pomembna senčna lega v osojni visokogorski krnici.

Več kot tri četrtine stoletja dolgo opazovalno obdobje je pri obeh ledenikih v znamenju izrazite in stalne rasti temperatur, daljšanja talilne in krajšanja redilne dobe, dlje časa trajajočega sončnega obsevanja, zmanjševanja števila dni s snežno odejo, poznejšega prvega in zgodnejšega zadnjega sneženja, nižanja najvišje sezonske in povprečne skupne višine snežne odeje kot tudi pogostejšega in zgodnejšega izginotja starega snega na površini ledenikov.

Krčenje obeh ledeniških zaplat je postalo izrazito v 80. letih 20. stoletja, se pred poldrugim desetletjem prehodno upočasnilo in v zadnjih petih letih vnovič obnovilo. Kar trinajst najtoplejših talilnih dob po letu 1955 ima letnice 21. stoletja. V sušnih poletjih ima bližnji Triglavski dom na Kredarici že težave z vodooskrbo, še vedno pa ni urejeno čiščenje komunalnih odpadnih voda. Podnebne spremembe vplivajo tudi na geomorfološke procese in pojave. Posledica teh sta opustitev in sprememba poteka okoliških planinskih poti ter preusmeritev v varnejše plezalne smeri zunaj območij sklanih podorov. Ob dejstvu, da smo na Kredarici že drugo leto zapored izmerili najvišjo temperaturo polletne talilne dobe, predvidevamo, da bo izginil tamkajšnji ledenik prej kot njegov »dvojnik« pod Skuto. Oglejmo si ju torej, dokler je še čas, saj smo zadnja generacija, ki ju še lahko spremlja v živo.