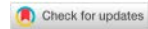


Meeting Abstracts

Open Access



Meeting Abstracts of World Conference on Climate Change & Sustainability

Alan Gadian, Bernard Amadei, Carla Woydt, Dai-Yeun Jeong, Gene R. H. Fry, Karl Aiginger, Robert Leland, Tomas Thierfelder, Anna Caughron, Anthony McGregor, Admire Nyamwanza, Anna Timonina-Farkas, Annette Toivonen, Augusta Costa, Basma M'lahfi, Cassia Lemos, Chigozie Nweke-Eze, CI Pardo Martínez, Clara Salina, Felix Boruchowitch, Francyne Elias-Piera, Gang Hyun Park, H. J. Sartorius von Bach, Ibrahim Abubakar Radda, Ikechukwu Eugene Onah, Isimar A. Santos, Jayanthi Murali, Joanna Adamczyk, Jonggu Kang, Ju-Ching Huang, Judite Vieira, Karen J. Cloete, Kathy Xu, Kirk Douglas, Klaudio Klaser, Leonid Fainzilberg, Niels Lundtorp Olsen, Nurul Huda Md Adnan, Patricia M. DeMarco, Ray Garnett, Robert Tippmann, So Yeon Choi, Theophilus Clavell Davies, Werner Neumann, Yee Lee, Yemin Jeong, You-Ren Wang, Amna AIRuheili, Lukas Kammerer, Marinella Passarella, Youngmin Seo

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1. Is the planet really going to be cooked?

Gadian¹, Stephen Salter²

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Climate Net zero is desirable but inadequate because it will leave all present CO₂ PLUS what we emit between now and the zero-emission date. Current releases suggest China is building 39 new power stations and India is reopening coal mines so it is likely emissions of CO₂ will increase. Some estimate emissions of CO₂ will consequently increase by 40%-100% over the next 20 years; thus, Net Zero will leave CO₂ levels much higher than current values.

Marine Cloud Brightening (MCB) is a cost effective and likely to have lesser negative impact emergency temporary tool to reduce the rising surface temperature forcing. This will be discussed in the paper and atmospheric model results will be presented.

The short life forcing and ability to “switch off” if required, of the Latham-Twomey MCB of sea salt injections and further the mobility of spray vessels gives regional and seasonal control. The amount of salt needed is orders of magnitude lower that what is put into the atmosphere by breaking waves. The difference is that salt mass is in a narrow spread of sizes where there is a gap between Aitken and accumulation modes and is injected into clouds where they can most effectively increase the albedo of the planet and reduce the short wave forcing. The Engineering design of spray vessels is nearly complete and economically feasible.

Overall, MCB can save polar ice and coral, moderate hurricanes reverse sea level rise and help mitigate the effects of temperature extremes which are affecting food production.

2. A systems approach to the peace-sustainability-climate nexus

Bernard Amadei

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There is enough evidence that humanity will continue to face significant challenges way into the rest of the 21st century. In that context, a question arises as to whether it is possible to envision a world where

all humans have fulfilling lives, meet their basic needs, and live with dignity and peacefully, without degrading the ecosystems and services upon which they depend. Meeting that overarching goal of human development will not be easy.

Promoting peace and sustainability in human development and security while accounting for the risks associated with climate change has become more imperative than ever. It is hard to envision (i) a sustainable world that is not peaceful and climate secured; (ii) a peaceful world that has not endorsed sustainable practices and does not support climate adaptation and mitigation practices; and (iii) a climate secured world that has not endorsed sustainable practices and is geopolitically unstable.

This paper makes a case for using an integrated and coherent approach to addressing human development and security issues and explores, more specifically, the underlying dynamic of the peace-sustainability-climate security (PSC) nexus at the community scale. Peace, sustainability, and climate security are considered as three interconnected states (or cultures) that emerge from the interactions of multiple shared systems in a community landscape (environment) subject to various constraints (political, social, cultural, economic, environmental) and adverse events.

These states influence and depend on each other.

The approach used in this paper acknowledges that there are no one-size-fits-all unified and optimized static states of peace, sustainability, and climate security as they are context and scale-specific. What works in one community landscape may not work somewhere else. As a result, it is easier to define all three states by what they are not rather than what they are. In doing so, multiple “good enough” states can be explored. Therefore, peace, sustainability, and climate security have “to be read as a plural”.

3. Navigating the voluntary carbon market: the challenges and opportunities the voluntary carbon market presents as a solution to climate change

Carla Woydt

CEEZER Software GmbH, Berlin 19 10405, Germany.

The IPCC report from 2022 emphasizes that large carbon removal projects cannot be bypassed if we want to achieve global emission reduction targets. This stresses the urgency for an efficient and transparent voluntary carbon market. The current state of the voluntary carbon market is scattered across different project types, project categories, quality indicators, and verification standards. The market is opaque as transactions are most often facilitated through middlemen making it hard to trace back transactions and opening up for arbitrage. In this setup, it is difficult for companies to navigate the market which has led to an atmosphere of insecurity and distrust. We believe that transparency, in-depth data and rigid quality assessments are crucial to use voluntary carbon credits as a fundamental part of a company’s net zero strategy. We are addressing these structural challenges of the VCM by creating an infrastructure that allows buyers and project developers to transact directly with each other based on accurate

data and transparent information on projects and credits. On our digital marketplace for voluntary carbon credits, buyers are able to easily compare the quality and price of different carbon credits in order to make data-driven investment decisions and thereby support the most impactful projects. Sellers on the other hand get access to a fully digital infrastructure to facilitate their credit sales, provide information about their projects and interact with buyers. We use quality indicators, like permanence and additionality, that are based on scientific evidence, to compare different project types. On CEEZER, buyers can easily navigate more than 5000 climate protection projects to create an individual portfolio optimized for maximum

impact and minimal risk. By doing so, our mission is to make the voluntary carbon market more impactful.

4. A desirable approach to the establishment of climate change policies

Dai-Yeun Jeong

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Government, enterprises, citizens and civil organizations are the agents responding to climate change. Government responds to climate change by policy, enterprises by green management through improving eco-efficiency in the process of producing and distributing goods and services, citizens by eco-friendly behavior in everyday life, and civil organizations by environmental movement as a pressure group to government/enterprises and an educator to citizens.

This paper presents a desirable approach to the establishment of climate change policy by government, following the four stages below.

The first is to identify the vulnerability to climate change. A desirable conceptual model for identifying the vulnerability will be presented.

The second is how to select the vulnerable sectors as the prior targets of policy formulation, how to set up the goal of vulnerable sector to achieve, and what means to mobilize to achieve the goal.

The third is what type of governance system should be introduced in the process of establishing policy. This stage will present desirable phases of governance system being employed in the process of establishing optional policies on the basis of social consensus.

The fourth is how to analyze the effectiveness of policy to be launched. Two phases of policy effectiveness analysis will be presented. One is efficiency analysis of financial investment, and the other is effectiveness analysis of all policies as a whole set. The former is to analyze the efficiency of optional policies in advance before they are adopted as the final ones, comparing their effectiveness as the climate change response policies to financial investment. Based on the former, the final policies to be launched can be fixed in relation to the available finance. The latter is to analyze the effectiveness after all policies are launched.

5. Dominant role of albedo feedbacks in recent and future global heating

Gene R. H. Fry

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Vostok ice core data analysis, at 10,000-year resolution, connects today's CO₂ levels with 4.9 °C warmer global surface temperatures (GSTs, above the 1951-1980 mean), using a 60% polar to global Δ °C conversion. This result is consistent with CO₂ and Δ °C data from 4 and 14 million years ago. Adding Vostok CH₄ data yields 8.3 °C of GST warming at equilibrium.

The gap - between current GST and GST when last Earth had this much CO₂ in the air - indicates major lag effects to come, mostly from albedo changes. Albedo effects are estimated for changes in snow cover, sea ice and anthropogenic sulfates, and for slower changes in land ice cover. Amplifying feedbacks from induced water vapor and cloud cover changes account for most of the rest of warming. These 6 amplifying feedbacks accounted for 39% of observed warming over 1975-2016. More greenhouse gases accounted directly for 33%, their cloud and water vapor feedbacks for 9%. Natural emissions from permafrost and

other carbon reservoirs as they warm up also contribute to future lagged warming.

6 scenarios modeled embody these effects. Warming rates to 2100 are similar to those over the past 10 to 20 years. Across the 6 scenarios, GSTs at 2400 range from 2.5 to 10.0 °C above the 1750 baseline. Climate sensitivity depends strongly on the amount of Earth's surface covered by ice and snow; it declines as less is covered by ice and snow.

Merely ending human carbon emissions will be far too little to keep GSTs as low as they are now. The remaining carbon budget to hold GST to 2 °C is far less than zero. To hold warming to 2 °C, removing 3/4 of human CO₂ and CH₄ emissions to date and any future emissions is required. Solar radiation management will also be required, unless we can go carbon negative quickly and massively.

6. A deeper union: from a failed project to the European Quality lead

Karl Aiginger

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The European Unification Project- as revealed by the European Union- has often been called a failed project, be it by US economists or by populists longing back to old structures and to small nation states. It has often been criticized as sole to be an economic project, without political arm. This paper objects that the European Union is a soft peace force, as rewarded by the Nobel and that Europe's leading in many welfare measures beyond GDP and labor productivity. It gives evidence on European life expectancy, the content of democracy, freedom, ecological sustainability. From the perspective of the European Green Deal and the increasing emphasis of the younger generation, Europe can take the lead in combating climate change. It must combine this goal with reducing inequality and increasing cooperation with its neighbors in the East the West. Synergies between goals will be a driving force. The US and China neither able nor cooperative enough to take the lead. The war in the Ukraine is a crucial conflict, which will show whether Europe can enforce a cooperative and sustainable international strategy without military force. A quality lead in sustainability should be easier, if really attempted, than going back to old technologies and habits.

7. Projected climate security risks in the arctic motivate advances in situational awareness

Robert Leland, Diana L. Bull, Richard Garrett, Elizabeth James Kistin Keller, Daniel Krofcheck, Howard D. Passell, Natalie Prittinen

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Climate change is resulting in well-documented environmental impacts that, in turn, drive societal impacts with implications for global security. Addressing these security issues, and the underlying drivers of climate change, requires a broad scope of activities and advances. This presentation will explore the foundational role situational awareness will play in supporting these activities, and specifically in successfully applying the Intergovernmental Panel on Climate Change (IPCC)'s conceptual climate risk framework to adaptation planning. Situational awareness comprises three classes of action: monitoring, projecting, and assessing. Using projections of a changed Arctic region in 2100 as an exemplar, we explore future climate-driven security risks and how they motivate needed advances in each class of action that contributes to situational awareness. These advances will also be characterized in a global context.

8. Climate-change effects on the geographic distribution of infectious diseases in the Arctic

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Introduction: Climate change is considered to have a significant impact on the epidemiology of Northern infectious diseases, that threatens Northern societies by terms of socio-economy, culture, health, welfare, security, animal husbandry, and food supply (*etc.*). With far-north societies being generally dependent on husbandry animals, the erosion of animal welfare introduced with emerging zoonotic diseases adds to the effects of human exposure, where the resulting dynamic scenario requires a holistic OneHealth study-approach.

Methods: The authorities that administer national programs of infectious diseases control have been engaged in the acquirement of diseases data covering Denmark/Greenland, Iceland, Norway, Sweden, Finland and Russia/Siberia through the past 30-year climate reference period, regarding incidences of anthrax, borreliosis, brucellosis, cryptosporidiosis, leptospirosis, hantavirus infection, Q-fever, tick born encephalitis, and tularaemia. These data were supplemented with satellite-sensed climate and landscape data covering the same reference period of time with approximately 35 standard variables ranging from different temperature cumulations, via snow-cover duration, to chlorophyll density. The combined data were used to statistically infer the observed spatiotemporal variation of diseases incidences.

Results: Preliminary studies indicate strong climate sensitivity regarding some diseases, and no sensitivity regarding others. With climate sensitivity indicating a potential of diseases migrating with landscape effects of climate change, and where this potential is much regulated by the ecological characteristics of the vector and reservoir organisms that carry diseases pathogens through the landscape, climate sensitive infections (CSI's) may hence be identified and further assessed with respect to societal effects and adequate counter-measures.

Discussion: By geographically correlating the spread of climate and landscape characteristics with CSI incidences, future CSI scenarios may be predicted as a function of the IPCC climate projections. Such CSI projections constitute invaluable decision support in the process of strengthening the climate resilience of Arctic societies and cultures.

9. A changing climate in the maple syrup industry: variation in Canadian and USA producers' climate risk perceptions and willingness to adapt across scales of production

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Maple syrup production (“maple sugaring”) is an important cultural and economic activity in eastern Canada and the northeastern United States (U.S.A.). Climate change is a concern for maple producers because maple sugaring is dependent upon climate for both sap sugar content as well as for the specific patterns of freezing and thawing in springtime needed for sap flow. Meanwhile, the maple industry itself is in transition: historically, maple sugaring has been a small-scale seasonal activity, but today large producers tap thousands of trees, contributing to a widening gap in production volumes and production practices between small- and large-scale producers. Drawing on original survey data from 354 maple producers in Canada and the United States we ask how attitudes towards climate change risks and adaptation strategies differ between smaller-scale and larger-scale producers. Findings suggest that small-scale, medium-scale

and large-scale maple producers have different perceptions of climate change risks, report different impacts of climate change on maple sap yields, and have different levels of willingness to use adaptation strategies ranging from tapping more trees to adopting new production technologies. In multivariate ordered logistic regression models controlling for producer age, education, and political affiliation, we consistently find the strongest correlates of attitudes towards climate change risks - and the willingness or ability of producers to adopt different adaptation strategies - are country of residence (with preferred adaptation strategies varying across Canada versus the U.S.A.) and producer scale (with larger producers adopting more adaptation strategies). We conclude that more detailed and up-to-date information on the different types of maple operations - including effects of climate change on maple sugaring and available adaptation strategies across geographies and across scales of production - is needed to help maple producers, maple producer associations, and policymakers understand how the maple industry is evolving and how best to prepare for the future.

10. Biourbansim - a resilience game plan for 21st century cities

Anthony McGregor

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An interdisciplinary concept founded on landscape architecture, urban design, and ecological sciences, Biourbanism is a city planning and urban design platform that assists mayors, city leaders and planners create healthier, more resilient cities.

Put simply, the research-led platform asserts that cities must be considered a form of nature in response to global climate challenges. Developments in environmental science have underlined humanity's impact on the planet, signalling earth's entry into a new epoch called the Anthropocene - a point in evolution where the planet's wild places have been radically altered by humans; wild places and complex biological systems upon which we dearly depend.

Comprising ten systems managed mutually through data, a paradigm shift in thinking will allow us to quickly decarbonise our cities and transform urban environments into healthier, vibrant, more climate resilient places that are better able to support the needs of their citizens.

Biourbanism is centred around five urban and five bio systems that analyse city health: Economy, Energy, Mobility, Structure, Technology, Water, Food, Waste, Landscape, and Humanity. Case studies of Biourbanism in practice, quantified through a resilience index, demonstrate realistic roadmaps for cities and communities to achieving resilience.

Poorly designed, congested, polluted cities are deadly to their residents; great cities nurture prosperity and wellbeing and have magnetic gravitas. It is these great cities that we need to create if the world is to prosper.

11. Adaptation action and sustainable health outcomes: insights from rural Southern Africa

Admire Nyamwanza

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This presentation emanates from a 2019-2022 study which was focused on evaluating nutritional and psychosocial health impacts of selected prominent climate adaptation actions in rural Southern Africa, using the case of Zimbabwean communities in the mid-Zambezi Valley. Whilst various studies have assessed different aspects of adaptation actions in rural Africa, a focus on understanding explicit health

outcomes of adaptation actions has not been appreciated. This study therefore sought to close this gap by investigating the dietary, nutritional, physical, and emotional health impacts of two main adaptation actions: shifting from predominantly maize farming to drought tolerant crops in main dryland fields; and increased reliance on indigenous knowledge vis-à-vis the consumption of wild fruits during drought periods, and the prediction of rainfall and drought patterns using unique meteorological, insect, and atmospheric indicators. The study used a mixed-methods approach combining qualitative and quantitative data collection techniques, including a household survey, key informant interviews, and stakeholder workshops. Questions in various instruments were informed by generic impact evaluation criteria i.e., effectiveness, efficiency, impact, sustainability. Furthermore, specific tools like the Household Dietary Diversity Scale, and the Minimum Dietary Diversity Scale for Women were instrumental in assessing nutritional health impacts, whilst self-reported survey indices like depression, anxiety, social support and happiness were key in assessing psychosocial health aspects. The study found significant positive and negative health impacts associated with the adoption of the two adaptation actions - linked to such aspects as food availability, the consumption of an acceptable nutritional diet, increased/decreased levels of anxiety, becoming happy or easily annoyed or irritable, pride and/or contentment in finding solutions during adversity, and a sense of control over one's life despite climate challenges. The study advances various recommendations directed at policy makers, non-state actors, and academic researchers vis-à-vis sustaining the positive health impacts and addressing the negative ones.

12. Government capital distributions in Europe given the multi-stage optimal flood-risk mitigation scheme

Anna Timonina-Farkas

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An essential part of stresses and risks for societies and their environments is imposed by natural disasters. The research devoted to finding optimal strategies for risk-management of catastrophic events is motivated by different needs of people on international, national and local policy levels. Countries in central Europe are very vulnerable to flood risk due to their geographical position with a highly interconnected network of river basins. This connectivity makes severe flood events in Europe influence multiple regions at once. For example, floodings in July 2021, caused by extreme rainfalls, affected Danube and Elbe regions and made rivers across the area to break their banks. Affected countries included Austria, Switzerland, Czech Republic, Germany, Hungary and Slovakia. Such strong interdependency in flood risk between European countries brings forward the necessity to account for risks in neighborhood areas already in the local decision-making.

Following the path presented in the work of Timonina *et al.*^[1], we estimate probability distributions describing the economic consequences of flood events for different countries in Europe. Differently from the framework presented in^[1], we, in this work, demonstrate distributions which could arise in countries,

CASEPRA is a research project that seeks to identify and analyze the aid provided by parents of children with intellectual disabilities related to a rare disease, including those with a rare disability. Indeed, rare diseases and rare disabilities are often associated with the scarcity of expertise and available aid, with the combination of numerous solutions for compensating the disability, but also with uncertainty and a significant amount of time spent wandering in diagnosis. All of these elements are likely to influence the configurations of aid between informal aid and formal/professional aid and the employment situation of the parent-caregiver.

The poster presents this 30-month project by describing the stakes, the methodology exploratory qualitative phase, the quantitative investigation phase based on an online survey, the qualitative phase, and

if they were to take optimal decisions for governmental expenditures and for extreme risk (re)insurance. For this, we combine hierarchical coupling methodologies for accounting for regional interdependencies with optimal multi-period decision-making under uncertainty. As a result, we present capital distributions for different countries in Europe given an optimal (re)insurance scheme against floods. The optimal scheme is computed based on the constructed multi-period optimization model, which allows to strategically incorporate interdependencies between time periods.

[1] Timonina A, Hochrainer-Stigler S, Pflug G, Jongman B, Rojas R. Structured coupling of probability loss distributions: assessing joint flood risk in multiple river basins. *Risk Anal* 2015;35:2102-119.[DOI:10.1111/risa.12382]

13. The emergence of New Space: a grounded theory study of enhancing sustainability in space tourism from the view of Finland

Annette Toivonen

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The excitement of public space exploration was for decades captured only in Hollywood productions, until the 2010s saw the emergence of the New Space industry, combining the space activities of private space companies and governmental actors. As a sector of New Space, recently emerged New Space tourism industry aims to satisfy the postmodern traveller's desire for new experiences, and is forecast to develop as a multi-billion tourism sector in the future (Toivonen, 2022).

The global megatrend of sustainability was furthered by the Intergovernmental Panel Climate Change report's (2018) concerns over the future impacts of climate change on Earth. The growth of modern tourism has indeed led to a significant increase in its environmental impact, which can no longer be ignored in the current era of climate change, and thus the need for more sustainable focused future planning in the tourism industry. Apart from being an energy- and emissions-related driver for new technological developments, sustainable development has brought responsibility and ethics to the ways of global tourism operations, and influenced the creation of global regulations. Rapidly advanced technological developments also contributed to Finland becoming a new space nation in 2017. One of the objectives of Finland's space strategy is to provide a sustainable environment for space-related business, and the country's recently established space legislation advocates such future points of action.

Recent academic findings (Toivonen, 2022) suggest that future sustainability in New Space tourism industry could be supported through three alternative future scenarios; through the planning of global space regulations, through improving global fairness and through the implementation of virtual and technological innovations. However, there is a strong need to expand the global academic research on the environmental impacts caused by the New Space tourism industry as it is currently still very limited.

14. Carbon and oxygen isotope ratios in cork rings: novel physiological indicators of water stress in *Quercus suber* L

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Cork oak (*Quercus suber* L.) produces narrow and ill-defined wood rings, contrasting with wide and sharp cork rings. In dendroecological studies, the width and density of cork rings have been extensively analyzed to address the impacts of climate change on cork yield and quality. However, an approach through stable isotopes, widely applied to tree rings to understand tree physiological responses to environmental changes, has not yet been made.

Cork oak is a drought avoiding sclerophyllous species and reduces growth during the Mediterranean summer due to water shortage. We determined the isotopic composition ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) of cork rings in trees growing at two sites with different summer water availabilities and evaluated, for the first time, the suitability of such markers to fingerprint changes in this species' physiological processes. Using well-established mechanistic models for tree rings and statistical relationships with climate variables, we highlight some cautions in the interpretation of stable isotopes signatures in cork rings.

Cork isotopic compositions differed between sites. At the wettest site, cork rings are enriched in ^{18}O and depleted in ^{13}C , indicating, respectively, shallow groundwater as the water source for physiological processes related with biosynthesis of non-photosynthetic secondary tissues, and a weak stomatal regulation under high water availability, consistent with non-existent $\delta^{13}\text{C}$ - climate correlations. In contrast, trees at the drier site use water from deeper layers, depleted in ^{18}O , and strongly regulate stomatal conductance under water stress, thus reducing photosynthetic carbon uptake and probably using stored carbon for growth. Alternating between carbon pools (current assimilates and stored carbohydrates) for cork formation is consistent with the significant $\delta^{13}\text{C}$ - climate correlations found for this site. Thus, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ signatures in cork rings appear as promising proxies to assess the physiological and ecological effects of extreme climate events and carbon starvation under drought stress, in dendroecological studies of cork oak.

15. A new approach for the mandatory application of the thermal regulation of construction (RTCM) in the future Moroccan buildings

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Our study had objective to retrace the major stages in the implementation of thermal regulations for buildings while placing them in their global and regional framework. This regulation, which was born following the crucial energy consumption experienced by the building sector and which has prompted countries to take regulatory steps to combat this scourge. Morocco is also committed to this approach by setting up the Moroccan Construction Thermal Regulation (RTCM), in order to guarantee energy efficient buildings. Following the comparison with the Thermal Building Regulations of Tunisia (RTBT), a country enjoying a comparable climatic and economic framework, our study also allowed us to underline the similarity of approaches in the two countries but also the delay experienced by Morocco in this implementation, which fortunately is in the process of filling it by accelerating the procedures. The purpose behind our work is in line with this perspective, by making it possible to highlight the steps taken in the establishment of this RTCM and those that remain to be developed, refined or adapted to the country context. In this sense, a broad consultation of stakeholders (decision-makers, prescribers and professionals) through a survey, allowed us to elucidate the reasons for the delay in the implementation of this RTCM, and the skepticism of both sides to its consideration favoring by far its voluntary aspect of its application.

This consultation has especially enabled us to enrich this regulation for a better adaptability to the

Moroccan context, ensuring at the same time a flexible transition from a voluntary application to a compulsory application. In addition, we have reviewed the high-performance insulation materials to be offered for both building envelopes and their structures. Moreover, for better performance, we have proposed the integration of certain Moroccan standards in digital simulation tools for thermally insulating buildings and which will be developed in the next work.

16. Modeling approaches to better understand the cost-effectiveness of restoration initiatives prior to implementation

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From global to local levels, land use decisions and policy instruments can affect landscapes and livelihoods in heterogeneous ways. Several countries, governments, and partners are seeking to develop their own forest landscape restoration actions to respond to the sustainable development goals. Understanding the cost-effectiveness of restoration initiatives is critical for their successful implementation. In this context, this study aims to discuss three modeling approaches to estimate the cost-effectiveness of different forest landscape restoration strategies for achieving multiple restoration goals (biodiversity, carbon stock, soil) in a strategic region in the Brazilian Atlantic Forest Biome, the Paraíba Valley in São Paulo State. The first approach uses alternative statistical models to understand the relationships between potential explanatory variables and the natural regeneration process. The second one uses an allocation model to estimate the amount of natural regeneration potential, allocate forest increments, and estimate the cost-effectiveness at the end of the process. It elaborates forest restoration scenarios that consider different Payments for ecosystem services (PES) programs to specific areas. The last one is an optimization model that allocates forest increments based on the maximization of environmental benefits while minimizing the cost. This third approach considers scenarios based on the Brazilian Forest Code, whose restoration costs are based on different PES mechanisms. Each approach has advantages and limitations. In general, scenarios with restricted rules (such as PES mechanisms based on National Policy for Payment for Ecosystem Services) allocate forest increments in areas with lower natural regeneration potential. As a consequence, it increases the need to use the active (and more expensive) method for restoration. Concerning environmental benefits, the constrained scenarios present higher soil benefits but lower carbon and biodiversity benefits. These results reinforce the importance of using modeling approaches to better understand if a given proposed restoration initiative might or not fulfill its intended outcomes.

17. A new factor in the equation? The role of hydrogen in Africa's energy transition

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Around the world, a clean hydrogen rush is underway, and many companies, investors, governments, and environmentalists are increasingly unifying in their view of low-carbon hydrogen as an energy vector that could foster the global energy and industrial transitions. The necessity of curtailing greenhouse gas emissions, the declining costs of renewables, and the feasible applications of hydrogen in energy and industrial sectors (particularly in the hard-to-abate sectors), is shifting the pursuits and potential growth of low-carbon hydrogen upwards in political and business spheres. In the African continent, low-carbon hydrogen production is also emerging as a 'new' factor in the pursuit of energy transition, fostered by several new international and regional partnerships and cooperation. In this paper, we explore the diverse roles and governance of this "new" factor in the equation of existing pursuits for energy transition and its

implications in the continent, discussing its geographies, opportunities, and risks.

18. Strategies to improve sustainability: an analysis of 120 microenterprises in an emerging economy

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Global small and medium enterprises represent 90% of global business, creating and maintaining 50% of employment, and in emerging countries, formal Small and Medium Enterprises (SMEs) provide 40% of the national gross domestic product and the gap of productivity is approximately 7% of global gross domestic product with respect to large firms. However, their process generates an elevated environmental footprint, which requires green transformation to achieve sustainable development. The purpose of this study is to describe the intervention process in 120 micro-enterprises with the aim of improving environmental and sustainability performance working in four categories: sustainability, water, energy, and solid waste management. The project included five stages: the postulation, selection, and enrolment of 120 micro-enterprises; sustainability diagnosis; action plan formulation; the results of implementation and evaluation; and the feedback of results. This study demonstrated the importance of integrating sustainability into the business to improve productivity, competitiveness, and access new markets; in many cases, the micro-entrepreneur is unaware of all the possibilities offered by having environmentally friendly processes, which was shown with evidence throughout the process. Approximately 242 action plans were implemented, achieving multiple results that involved knowledge of their processes and equipment to measures to improve their environmental performance by reducing or making more efficient consumption of water and energy, reducing waste, an awareness of the importance of caring for the environment, and measuring variables, among others. The findings of this study are important to demonstrate that micro-enterprises have an important role in the economy and have the potential to achieve sustainability and environmentally friendly processes requiring adequate support and financial programmes that should be designed and implemented by policymakers with the aim of strengthening this sector and in developing countries to decrease poverty and promote sustainable economic growth and development.

19. Supermarkets: the missing link in the recycling chain

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The tremendous impact of plastic on environment is clear by far. With the new policies, Europe will probably be able to cope with the ever-growing wave of plastic that the consumer industry puts on the market in great danger of reaching the environment and polluting it.

But what about the rest of the world? What happens in the countries that import and distribute products packaged in plastic containers and that have neither the economic capacity nor the political strength to impose the dictates of the EPR?

Since 2014, I'm proposing a paradigm that can allow monitoring and accounting for 100% of future plastic waste adding the information of plastic (kind and weight) into the barcode and including supermarkets within the recycling chain. This way, we would be able to create a new accounting for commercial-plastics-soon-to-be-waste: just as money enters the cash register which allows it to be accounted for, the same cash register could record outgoing plastics. Nevertheless, supermarket chains have always been reluctant to

admit their environmental responsibility, so why should they join the initiative?

Today oil giants have taken their responsibility for plastic pollution and have begun to invest heavily in a variety of chemical recycling technologies, greatly expanding the recycling capabilities of mechanical recycling, addressing also the need to recycle flexible wrap packaging and films. This gave to plastic waste a worth that would be unimaginable before.

The creation of a new plastic accounting can pave the way for a redistribution of the economic benefits that come from the new value given to plastic waste, now considered secondary raw material. In a planetary analysis, it is easy to realize that in the absence of recycling infrastructure, territories are very often equipped with supermarket chains. With an appropriate and secure reverse logistic, supermarket can be transformed into very effective collection systems. The benefits would be significant: from an economic point of view, supermarket chains would be integrated into the plastic life cycle; from an environmental point of view, very high percentages of residues would be recycled; the need for oil in the plastic production would decrease, as would the risk of spills; in the transition to renewable energies, it is conceivable that plastic, duly refined in refineries, could replace certain needs for hydrocarbons or for plastic itself, thus favoring the definitive elimination of the residue and a real circularity of the material.

20. How sustainable procurement is key according to the current climate challenges and how such a policy can generate value towards internal and external stakeholders?

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Sustainable value creation is a term that is widely used in sustainable business model literature, and it is gaining importance in other management fields. While there is still confusion on the meaning of this concept, researchers encourage studies that take a network perspective to generate new knowledge and a better understanding of it. In this talk, we address this call by taking a supply chain perspective, which is a type of network, and by focusing on one specific supply chain activity: procurement. Through a single case study of a French multinational, we investigate who creates sustainable value and for whom, taking a stakeholder theory lens. The case study is based on an inductive and qualitative-driven mixed-methods approach, involving interviews of key procurement and sustainability employees, ethnographic observation, and content analysis to provide new knowledge in both the sustainable business model and sustainable supply chain management fields. The findings provide empirical data that show, in the case of the firm studied, that the procurement function has a key role to play to create sustainable value for multiple stakeholders within and outside the firm. Sustainable procurement creates sustainable value for the firm, suppliers, clients, investors, municipalities, schools, NGOs, and associations. This value relates to economic, social, environmental, and ethical dimensions. To our knowledge, this is the first study that clearly underlines the role of sustainable procurement to create sustainable value, which is relevant to guide researchers in digging further the importance of the procurement function and the supply chain lens in the sustainable business model field. The findings also highlight the need for top management and supporting functions such as finance to build capacity among the procurement department to develop sustainable procurement practices as, with a long-term perspective, it improves the sustainability performance of the firm and its supply chain partners. Overall, this study invites firms to integrate buyers and procurement managers at the core of their strategy to facilitate the operationalisation of their sustainable development goals.

21. Raising awareness on climate change through social media, a way to spread knowledge about Antarctica collapses and reflecting about sustainable action

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Sudden ice-sheet collapses and the fast retreat of glaciers are changing ice dynamics, affecting the pelagic and benthic ecosystems, and influencing processes like sedimentation, fauna distribution and food availability. Physical disturbance impacts benthic organisms like the spatial distribution and diversity of communities in shallow nearshore habitats and on the continental shelves. Benthic organisms are a sink of carbon and nitrogen, and an essential part of the recycling material is relevant to the environment. Since benthic fauna is very vulnerable and is a key component of food webs in Antarctic waters, they are considered indicators of climate-induced perturbations. The study of benthic communities from Admiralty Bay, Maxell Bay, Marian Cove and Larsen has been helped to understand the engagement and benthic role in the structure of ocean communities. The data contributes to the construction of an ecological model that shows what can happen to the oceans with increased climate change and people have the right to know how the changes in the Antarctic and its communities affect human life. Raising awareness of the public about the need to protect the planet and spreading knowledge about Antarctica becomes more than necessary. The best way to teach the population is through educational programs and/or through media programs. The “Gelo na Bagagem” Institute (Ice in the Luggage), the first Antarctic education and entertainment platform, exists to create that environmental awareness to help people take the first steps as well as intensify in sustainable actions. The institute offers courses and lectures on the theme, in addition to making free content available on Instagram and YouTube with a playful and fun language reaching audiences of various ages and providing understanding and reflections about how human actions interfere with the environment. The material produced by the institute has already been used in schools in Brazil and Portugal.

22. Detecting active fires from airborne images using deep learning algorithm

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As the acceleration of global warming, dry regions are getting drier which is a good condition for a fire to break out easily. More wildfires are occurring all over the world and the size of the fires are getting larger. There were huge wildfires in Australia September 2019 to February 2020 and in California, USA July 2020 which had burned 124,000 square kilometers and 8903 square kilometers each. Wildfires can cause enormous damage to human and also to the environment. Greenhouse gases generated during combustion affect climate change. To reduce damage from wildfires, it is necessary to detect wildfire in the early stage. In this study, I had compared three deep learning segmentation models, U-Net, U-Net++ and DeepLab V3+, to find the best model for active fire detection. FRAME (Fire Luminosity Airborne-based Machine learning Evaluation) datasets were used to train and test the object detecting algorithm. It contains 2003 RGB images and 2003 label images corresponding to RGB images. The study was progressed according to following order: (1) preprocessing RGB and label images; (2) data augmentation; (3) split data into train, validation, test sets; (4) train models using U-Net, U-Net++ and DeepLab V3+; and (5) evaluate each model. Among three models, DeepLab V3+ showed the best results: accuracy: 0.9737, precision: 0.8968, recall: 0.7960, f1-score: 0.8265, mIOU: 0.7239.

23. The impact of climate change on Southern African cereal production calls for sustainable measures

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Background: The presentation provides some understanding of the dynamics of cereal food production in Southern Africa to identify causes that contribute towards volatility in food availability. A disproportion cereal production output is not only a systematic challenge in Southern Africa, but an opportunity to play a role in innovation, trade, health, wealth and geopolitical relations.

Methods: A balanced panel dataset for the period 1961-2019 was analysed for Botswana, Eswatini, Lesotho, Namibia, and South Africa, to produce a balanced stacked panel of 290 observations. Multivariate causes of production, climate, environmental and socio-economic data were used to discover impacts on regional food self-sufficiency among countries. The dynamic panel data model analysis showed that population, governance, rainfall, the land surface under cereal production, national income, and yield have significant impacts, both on short and long-run self-sufficiency of cereal production.

Lesson Learned: Results implies that variables converge to the long-run equilibrium and that modeling without considering all variables points to countries' less self-sufficiency in cereal production. Dynamic drivers explain the cost of gaining sufficient cereal supply. Disaggregation points out that sets of different drivers explain individual country-effects. The effect of climate change was further assessed, by adjusting the observation periods, showing that the dynamic fixed approach proved to be robust, with changing the magnitude of some coefficients.

Conclusions: The findings on climatic variables call for the adoption of climate smart technology to safeguard against rainfall variability affecting the carbon footprint and impacting on agricultural productivity. Countries in southern Africa should double their efforts on good governance, geared towards effective policy implementation to minimise inequality, especially in Lesotho, Eswatini and Namibia, and to monitor impacts, where food self-sufficiency is concerned. Only through effective and harmonised policies can future cereal production be secured.

24. Land degradation in Bihar, India: an assessment using rain-use efficiency and residual trend analysis

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Land degradation, a major environmental problem, poses threats to agricultural, social and economic stability of many regions of the world. In India, ~37 percent of the total land area is estimated to be degraded. Although assessment of land degradation in arid and semi-arid regions of India has advanced through remote sensing time-series analysis such as Rain Use Efficiency (RUE) and Residual Trend analysis (RESTREND), the sub-humid and other regions mostly remain unexplored in this respect. In this study, land degradation in Bihar, a sub-humid state, was quantitatively assessed through RUE and RESTREND from 1995 to 2011. RUE is the ratio of aboveground net primary productivity to precipitation and has been widely used as a measure of land degradation. RESTREND, on the other hand, examines the trend of NDVI residuals, which is the difference between observed NDVI and predicted NDVI from rainfall data. Results

indicate that RESTREND effectively estimated the extent of human induced land degradation in Bihar as 4.73 M ha. Agro-climatic zone III, the driest zone, has the highest percentage of degraded lands (33%), while Zones I and II each account for 25% of the degraded lands, most of which is affected by waterlogging and salinity. Although other land degradation databases have also indicated a rapid increase in land degradation across Bihar, it needs more ground-based data collection to substantiate it. The problem, however, may further aggravate with global warming, which calls for policy interventions such as adopting agroforestry, practicing sustainable agriculture and making shifts in cropping patterns.

25. Community of stingless bees in two contrasting climatic regions of Nigeria

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Stingless bees abound in Nigeria and forage on a wide range of food plants. The foraging activities of stingless bees provide crucial ecological service of pollination upon which sustainable crop production depends. The biodiversity of stingless bees is influenced by climate which impact on the ecological services of these species. Stingless bees tend to occupy regions that are most suitable for their physiological and behavioural adaptations. The climatic extremes in montane ecosystem could limit the species of stingless bees inhabiting the region. Knowledge of the climatic preferences of stingless bees could help in tracking the effect of climate change on the distribution and in conserving the species. The objectives of this study were to assess the species composition and climatic preferences of stingless bees between montane and tropical rainforest ecosystems of Nigeria. The biodiversity of stingless bees from two contrasting climatic regions of Nigeria - Jos, a montane ecosystem, with mean temperature ranges of 12-22.9 °C and elevation of 1400 m above sea level and Nsukka, a tropical rainforest ecosystem, with temperature ranges of 24-28.4 °C and elevation of 430 m above sea level was assessed for one year. The stingless bees were collected from ornamental trees and their nests, identified using taxonomic keys, comparing with museum specimen, and DNA barcoding. Six species of stingless bees: *Hypotrigona gribodoi*, *Liotrigona bottegoi*, *Dactylurina staudingeri*, *Meliponula bocandei*, *Axestotrigona ferruginea* and *Axestotrigona nigerrima* were recorded in the study areas. All the six species occur in Nsukka while only three *A. nigerrima*, *A. ferruginea*, and *H. gribodoi* were recorded in Jos. Species richness is 6 in tropical rainforest and 3 in montane ecosystems. The results indicate that stingless bees prefer warmer temperatures and lower elevations of the tropical rainforest ecosystem.

26. Could the reduction in boreal sea ice affect the climate in South America?

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Satellite data have enabled the Intergovernmental Panel on Climate Change (IPCC), through its Report V, to show that the regional distribution of sea ice has been reduced in the high latitudes of the Northern Hemisphere. The present study assimilated this reduction into a general circulation model of intermediate complexity in order to simulate the tropical rain response. The simulations of the Northern Hemisphere tropospheric winds showed an evident similarity with the negative phase of the Northern Annular Mode. Mainly, the meridional wind anomalies in the Ferrel cell of the Northern Hemisphere suggest that the additional energy from the boreal sea ice reduction results in an increase in the amplitude of the Rossby waves, thus connecting the polar zone to the tropics. The vertical motion at 500 hPa and the distribution of rainfall in the tropical belt show a southward shift of the Intertropical Convergence Zone as well as the

South Atlantic Convergence Zone. Although several studies indicate that the Intertropical Convergence Zone is shifted to the warmer hemisphere by climate change, the apparent disagreement with the results of this study can be understood if we consider that some continental sectors in the northern midlatitudes have been cooling in recent years, probably in response to the decrease in boreal sea ice.

27. Management and rehabilitation of coastal habitats and biodiversity for climate adaptation and sustainable livelihood in Gulf of Munnar, Tamil Nadu, India

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Coral reefs provide billions of dollars in ecosystem services every year globally but are in fast decline in the face of rising climate and anthropogenic disturbances. The coral reefs of many coral ecosystems in the world including the gulf of Munnar is facing extreme climate stresses like variation in sea surface temperature, sea level rise, increase in cyclone intensity, storm surges, variation in nutrient profile *etc.*, Gulf of Munnar encompassing 21 islands is a marine hotspot of east coast of Tamil Nadu, The project carried out the climate change vulnerability studies of coastal communities and ecosystems along the 364.9 KM coastal line of Kariyachalli and Vilanguchalli Islands of Gulf of Munnar. The project activities resulted in enriched biodiversity and increased population of fish which will ensure a steady income for fishermen throughout the year. Further coral reefs will also act as barriers to coastal erosion and prevent further submergence of islands. The coral reefs were started rehabilitating and in turn increases the biodiversity in the area. Enhancement of live coral covers provided habitat for fishes & other diverse species. The rehabilitation of sea grass ensured the habitat creation for several corals, fish and associated species which will lead to protection of islands against the impacts of climate change.

28. Chemical and mineral composition of bottom ash from forest and agri-food biomass produced under low and high combustion conditions

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The transition to renewable energy sources is a leading direction set by the EU. Biomass is a promising source in the energy transition of countries such as Poland, whose main fuel is hard coal. However, the combustion of this type of raw material produces biomass ash, which is currently waste and is landfilled in municipal waste landfills. About 0.5 billion ashes are sent to landfills, almost $\frac{3}{4}$ of the total production. The present study includes the analysis of 8 biomass samples - 4 forest - alder and beech chips, cherry pellet, briquettes of coniferous and deciduous sawdust, and three agri-food - apple pomace, walnut shells, and sunflower husks and the determination of their mineral and chemical composition by instrumental methods - elemental analysis, ICP-MS/OES, XRD and SEM at 400 and 850 °C. The properties of the biomass fuel, i.e., chemical composition, calorific value, moisture content, volatile matter, and ash content, significantly impact the ash's quality. Biomass ash contains mainly Al, Na, P, Ca, Mg, K, Si, Fe, S, Mn, and Ti, and potentially toxic elements (e.g., Cu, Zn, Pb, Cr, Cd, As, Hg). The highest Pb, Zn, and Ag contents were detected in the high-temperature apple pomace biomass samples, while sunflower husks and wood birch had the highest Mn presence in the tested. Given the higher mobility of elements in biomass ash compared to coal ash, it is, therefore, necessary to determine the mineral composition in ash. In particular, the combustion temperature is also an essential factor influencing ash formation and parameters. Determining the chemical and mineral composition of ash from biomass combustion can give an initial

indication of the directions for its management, especially for low-temperature ash, especially as bottom ash is not as well studied as fly ash.

29. An LSTM modeling for prediction of fine dust using s-dot data in Seoul, Korea

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Due to problems such as rapid urbanization, industrialization, population growth, and changes in human life worldwide, the level of air pollution is intensifying and the concentration of fine dust is deteriorating. Through many previous studies, it was confirmed that the weather factor and the concentration of fine dust were related. The fine dust prediction method can be largely divided into (1) numerical prediction modeling to predict fine dust concentration by mathematical equations; and (2) statistical-based modeling to predict fine dust concentration by deriving statistical correlation with various causes. In addition, research on applying artificial intelligence techniques has been actively conducted recently. In this study, a study was conducted to predict and evaluate the concentration of fine dust with a deep learning LSTM model by using weather factors and fine dust as time series data. Based on the LSTM model, fine dust and ultrafine dust prediction modeling was performed using data from devices with observed wind speed data among Gangseo-gu, Seoul, which has the much fine dust in spring. After that, cancer blindness evaluation was performed using verification data sampled from the modeled LSTM model in advance. The 7 days of fine dust or ultrafine dust, temperature, relative humidity, and wind speed were used as input variables of the LSTM model, and the next series of fine dust or ultrafine dust was designed to be output. PM10 was MAE(z) = 0.3385 MSE(z) = 0.2101, RMSE = 0.4584, -score = 0.7100, PM2.5 was MAE(z) = 0.2846 MSE(z) = 1.511, RMSE = 0.3887, and -score = 0.860.

30. Evolving land use and planning laws under climate change

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Cities worldwide have been simultaneously struggling to adapt to the changing climate and to mitigate carbon emissions. Along with technological innovations, legal tools have been applied to address these challenges. One focus of legal efforts is land use and planning laws. Almost all adaptation and mitigation policy involve changes to existing land use and requires a holistic view of planning rather than piecemeal adjustment. However, surprisingly, land use and planning law frameworks in most countries have remained almost unchanged for the past several decades. This paper uses the island nation of Taiwan as a case study to demonstrate the challenges of existing planning law frameworks in this era of climate change. The paper reviews how current national climate change policies interrelate with land use and urban planning decisions, looking specifically at solar panel siting and flood adaptation planning. This case study suggests that flexibility and balance are crucial elements of effective planning laws. Given the uncertain nature of climate change, land use regulations require flexibility. This flexibility contains two axes of support: horizontal interagency coordination among the flood mitigation, energy and land use sectors and vertical cooperation between local and central government agencies, especially as they move toward decentralization. Climate policies often include government interference with land-use decisions; this interference inevitably restricts or exploits private property rights. Therefore, balance between climate change goals and individual rights is also required. Building flexible and balanced land use and planning laws is thus a core value when building resiliency. Land use laws have long been overlooked as people seek technological innovation to reduce carbon emissions. This is a critical moment to ensure that relevant laws are more flexible and balanced, and at the same time to build resilience into cities. This case study of

Taiwan can shed light onto other similarly situated locales.

31. Summer production of lettuce grown in a hydroponic system using wastewater

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Population growth leads to an increasing need for food production, which causes negative impacts on the environment, namely a higher use of water, and fast depleting land. The search for more efficient technologies in the agricultural sector aims for sustainable production, reducing water consumption and waste, inducing wastewater reuse, and the use of soilless cropping systems as an alternative to traditional agriculture. The aim of this study was to evaluate the growth of lettuces in wastewater from an urban treatment plant in a small hydroponic system, without recirculation, during the summer period, when the scarcity of water is higher thus increasing the impacts of crop production with soil. The crop growth was studied under three different conditions: wastewater (after primary or secondary treatment); wastewater with potassium supplementation; and synthetic medium, as control. Physical and chemical parameters of the wastewater, crop growth, and the environmental conditions of the greenhouse were monitored. At end of the assay the crop fresh weight was determined, and toxicity analysis were carried out through cell viability assays with the Caco-2 cell line. Results point to a limited crop growth in the wastewater with a secondary treatment, due to low nutrients concentrations, which affects the plants fresh weight. Solids load, pH value and nitrite concentration in wastewater seem to affect crop growth. Wastewater with a primary treatment had a large organic load, and the system allowed the removal of over 98% of BOD₅ and the removal of over 68% of COD. The system provided an improvement in the wastewater quality, allowing the removal of the nutrient load (minimum value) of 43% N, 53% K, and 46% P (total phosphorus). For extract percentages up to 1% (w/v) there is no evidence of toxicity associated with the lettuce culture from the hydroponic system. The reuse of urban wastewater in hydroponics seems to be a sustainable promising technology that may complement the lack of crop production in soil due to water scarce.

32. Nanoparticles as a novel generation of fertilizers for sustainable agriculture during a time of climate change

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Climate change is significantly affecting sustainable agriculture. Droughts, floods, melting permafrost, and rising sea levels are triggering dyshomeostasis in the soil substrate required for sustaining vigorous crop growth and productivity. Not only are the physico-chemical properties and microbial fingerprint of soil modified, but also its ability to retain essential nutrients quintessential for plant growth and performance. Urgent and innovative technologies are hence required to enable the sustainable production of high-quality crops. Furthermore, the development of cost-effective crop production methods negating the use of chemical fertilizers responsible for environmental eutrophication are warranted. This presentation will focus on introducing the potential of nanoparticles as a novel generation of macro and micronutrient nanofertilizers to boost plant growth and performance. The synthesis of nanoparticle nanofertilizers using

green technology will be discussed as well as their morphological, functional, and phase characterization combined with their multidimensional effect on seed performance, plant nutrient and water uptake and distribution, as well as plant performance using multidisciplinary techniques including nuclear i.e. neutron activation analysis and micro-proton induced X-ray emission. Preliminary data indicate that green methods for synthesis of nanoparticles representing nanofertilizers delivered a set of nanoparticles with unique physico-chemical properties. Seed imbibition with selected nanofertilizers resulted in increased growth vigor and metabolism in correspondence with an increase in specific plant growth performance parameters. The presentation will further focus on nanofertilizer application routes, toxicology considerations, and advantages over chemical fertilizers. In conclusion, the potential of nanofertilizers as a revolutionary technology in achieving sustainable agriculture during a time of climate change will be discussed.

33. Communicating conservation messaging appeals and solutions for consumption reduction of sambal stingray in Singapore

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This paper provides an overview of the recent findings from surveys done among consumers of the sambal stingray dish in Singapore. It outlines the key results of the two levels of qualitative and quantitative surveys, the first of which was done amongst 629 Singaporeans of varying age, educational background, occupations and socioeconomic status, with regards to sambal stingray consumption habits and patterns. Insights on specific reasons behind consumption of sambal stingray, solutions towards consumption reduction that were popular and types of messaging to influence consumers and the government are primarily addressed in this paper. I suggest combining results of both surveys to promote holistic and scientifically-sound strategies for reducing sambal stingray consumption in Singapore through: (1) a tri-sector (policy, private, public) approach of promoting seasonal catching, importing and eating; and (2) Supporting research and mass access to cell-based seafood for Singapore-based companies and consumers; (3) Simplifying and sharing of science-based information on the problems with certification of sustainably caught seafood and the negative knock-on effects of total importation bans for the white spotted whipray and holistically, certain species of seafood as well; and (4) Use of a combination of emotional appeal, scientific knowledge enhancement and regulating the industry to prevent exploitation through increasing price of stingray, and ultimately all seafood, in order to structure the messaging about species commonly eaten for sambal stingray and for further work alongside NParks in spreading the messaging and working towards implementing the proposed solutions.

34. Is climate fueling increased wildfire variability in Barbados?

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Abstract: With the increasing drying and hotter climate trends predicted for the Caribbean, the importance of establishing wildfire monitoring and early warning systems (EWS) for Barbados and the Caribbean becomes increasing more critical. Few studies examining fire variability in the Caribbean exist and more integrated research is strongly desired. Methods: We assessed wildfire incidence in Barbados for 2006-2020 to characterize wildfire frequencies and spatial distribution across Barbados and to relate wildfire variability to climate data (rainfall, humidity, windspeed and temperatures). Using linear regression, the association of climate factors and wildfire (grass, sugarcane, ratoon, and rubbish fire) incidence was investigated. Estimations of associated water demand (wildfire fighting) and economic costs (man-hours) were also

conducted. Results: Grassfires were the most prevalent wildfire type observed followed by rubbish fires, sugarcane, and ratoon fires. The trend over Barbados reveals a primary peak in February-March, coinciding with months of minimum rainfall. A significant association of rainfall, humidity and windspeed was observed for rubbish fires ($r^2 = 0.62$), rainfall, humidity, and maximum temperature for grassfires ($r^2 = 0.53$) and rainfall, humidity and windspeed for sugarcane fires ($r^2 = 0.37$). Positive annual trends in southern and southeastern Barbados (Christ Church and St. Philip) were statistically significant and may support an increased drying trend evolving over southeastern Barbados and collaboration with Barbados Water Authority on measures to facilitate water access for firefighting purposes during the dry season and low groundwater levels. A reduction in wildfire events has been observed from 2018-2020. Estimates of potable water demand and economic costs for firefighting were conducted enabling trending of water demands and economic costs with potential future considerations for firefighting, strategic reclaimed water reuse and distribution planning.

Conclusions: The highest number of wildfires were observed in Southern Barbados, particularly the parish of St. Philip, which is known for its climatological dryness. This is the first ever study providing evidence of climate links with wildfires in Barbados. It suggests that development of an early warning system for wildfires based on climate is possible but the inclusion of other potential anthropogenic co-factors such as solid waste management practices, burning of empty lots and arson may be useful.

35. The fragility of the climate change agreements: interdisciplinary perspectives on targets compliance

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Climate change cannot be solved through the commitment of a minority of virtuous agents. This is an issue that requires a high degree of international co-operation, involving actors as much at global as at local level. However, when we look at nations' behavior, claims are often belied by facts. Indeed, even though nations, from 1992 to 2015, signed 15 different agreements to limit or to reduce greenhouse gas emissions, so far, all the prescriptions have been invariably disregarded, because the greenhouse gas levels in the atmosphere keep growing (WMO, 2018). Said in other words, the international agreements on climate actions are very fragile and the lack of compliance to their targets jeopardizes the environment and humankind.

The aim of this panel is to bring together expert contributions coming from different fields and perspectives and to foster the debate on the lack of compliance to climate change agreements, seen as an urgent issue to guarantee a sustainable future. Contributions focused on the causes of the fragility and on the possible solutions are particularly welcome.

36. Mathematical methods for analysis and interpretation of climate cyclical processes

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Scientific studies of the global climate change problem are inextricably linked with the analysis of observed processes, which often have a cyclical (repeating in time) character. The report develops efficient mathematical methods and intelligent computational procedures that provide processing of cyclic signals, which can be used to analyze and interpret cyclic processes that describe climate change. The proposed approaches are based on a stochastic model of generating a cyclic process according to a reference pattern

that has diagnostic value which by action of internal and external disturbances is distorted from cycle to cycle. As a result of such distortions, informative fragments that characterize the regular features of the process under study can be hidden from the researcher. The proposed mathematical methods and intelligent computer procedures are aimed at solving two problems:

1. Restoration of the form of the reference pattern of the studied cyclic process hidden by perturbations, which has diagnostic value;
2. An assessment of the dynamics of changes in the parameters characterizing the form of informative fragments from cycle to cycle.

To solve the first problem, an original computational algorithm is proposed based on the transition from a scalar signal (a discrete time sequence of the process under study) to its display on the phase plane, followed by averaging based on the Hausdorff metric.

To estimate the dynamics of the parameters characterizing the form of informative fragments of the process under study from cycle to cycle, original computational algorithms are proposed, which are based on the construction of the convex hull of the phase portrait of the permutation entropy and calculation of the Levenshtein distance.

37. Global warming: where on Earth has temperature increased?

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It is well-established that on a global scale, temperatures are rising with many adverse effects. However, an important aspect is to detect where temperatures have risen on a local scale (i.e., where has the temperature increased), and to provide a proper statistical foundation for said analysis.

Our proposed method is based on the popular statistical tool False Discovery Rate (FDR) that we have adapted for continuous domains, such as the surface of Earth.

We have applied this methodology to analyses temperatures 1983–2007 with the aim of detecting which regions that have experienced a significant temperature increase over those 25 years. After doing statistical adjustment, we still find that large regions of Earth have had significant temperature increases, even at a 1% significance level. Notably, the Northern Atlantic Ocean and northern China stand out; indicating that the temperature increase in these particular regions is very unlikely to be a false positive and represents a genuine trend.

38. Nature-based solutions for upscaling adaptation, reducing climate risk and strengthening urban resilience in Malaysia

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Rapid changes in the climate condition attributed by natural and anthropogenic activities in the recent decades, together with exponential growth in urbanizations, are threatening water security, natural

resources and sustainable development. Malaysia, as one of the countries in ASEAN that has the highest population exposed to floods, will be facing greater challenges ahead as disastrous natural hazards and risks are projected to magnify in the future. Maximum magnitude of change of annual precipitation between 24.6% to 45% and rise of sea level ranging from 0.7 to 0.74 m by the end of the 21st century are projected, while high water stress conditions are also predicted to occur in urbanized and highly populated cities such as in the Greater Kuala Lumpur area by 2030. The emerging risk may cause water and food insecurity, resulting in many cascading impacts to the environment and socio-economy. With urbanization rate in Malaysia is expected to increase up to 85% in 2040, and economic losses due to disaster is reported up to 425% in the last decade, therefore a transdisciplinary-based approach is crucial to better reduce future climate risk and increase urban resilience. Given the increasing demands to nature-based solution for climate change adaptation (CCA) and disaster risk reduction (DRR), this paper highlights the strategic policies, action plans and CCA related initiatives, particularly in utilizing ecosystem or nature-based approaches at city levels in Malaysia, towards sustainable and resilient water and climate urban management. This concept is as alternative interventions for addressing climate impacts especially on floods and urban water problems. Co-benefits of ecosystem-based approaches in urban environments are essential to address socio-ecological challenges in cities. It is understandable that the effectiveness of the approaches may not be noticeable immediately, but can be observed in a long-run for improving city and water ecosystem, and promoting equitable resilience in a changing environment.

39. Moving from awareness to action on climate change - a vision for shared prosperity in the Appalachia region of the United States

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The United Nations Sixth IPCC report “Making Peace with Nature” calls for an end to our war on Nature. We must work together to reach a condition that will sustain humanity in harmony with Nature. The laws and policies put in place to support and encourage fossil extractive industries over the last 100 years now stand as impediments to the transformation that must take place if we are to survive and thrive as a species. The technologies to reach net zero greenhouse gas emissions are already available: renewable energy systems, regenerative agriculture, and circular materials management. The laws of Nature are not negotiable. Transformation to a sustainable future requires a moral and ethical commitment to preserving a viable planet for our children, for today and the future.

Demand elected representatives in legislative bodies everywhere to enact these priorities:

- 1. Stop subsidies to fossil extractive industries.** Change the laws. Put taxpayer funds to work on the new solutions instead.
- 2. Use the power of government procurement to promote sustainable solutions.** Adopting government procurement for renewable energy, passive solar design in buildings, re-usable materials and food sourced from regenerative growing practice will drive markets in the right direction.
- 3. Establish the regulatory infrastructure to support and promote sustainable practices -** adopt regulations to support: renewable energy in utility tariffs and micro-grid requirements, restrictions on producing toxic materials, manufacturer accountability laws for plastics, and rescinding the supremacy of mineral rights over surface rights to protect watersheds and fertile lands and forests.
- 4. Invest in communities,** especially those most harmed by the extractive industries, to restore the land and create good jobs for a shared prosperity. The ReImagine Appalachia Blueprint illustrates implementation in a sustainable future. Available from: <https://reimagineappalachia.org>

40. Global warming & extreme weather: are cold extremes on the rise?

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The Global warming/extreme weather (GW/EW) link is presently debated extensively in the media and scientific communities. Warm weather events (WWE) are repeatedly announced by the media while extremely cold events (CWE) are rarely mentioned. An example is the extreme temperature of 49 °C at Lytton, British Columbia on June 29, 2021 compared to epic snowfall in Newfoundland in March 20-21 2020. Such one-sided coverage of extreme events (cold or warm) does not portray the reality of a changing climate. In this presentation, we provide examples of recent cold weather extremes (CWE) in Canada and worldwide to highlight the fact that they are on the rise and often ignored by the media and the scientific community. Amongst recent examples are: (a) the winter season of 2013/14 in North America, one of the longest, coldest and snowiest that had an economic impact of about US\$100-150 billion dollars (U.S.A. and Canada combined); (b) December 2016 when the city of Vancouver on Canada's west coast received over 60 cm of snow inflicting economic damages of over Cdn\$2 billion; (c) January 13, 2021 a storm Filomena in Spain, the most powerful storm in 50 years, brought record cold to parts of Spain bringing businesses to a standstill with 2500 people trapped in cars; and (d) recent news of catastrophic flooding November 13-15, 2021 in British Columbia that was accompanied by blizzards in parts of Saskatchewan and Manitoba; once again pointing to increasing cold extremes.

What is the cause of such cold extremes that are occurring with increasing frequency in recent years? Our analysis suggests a linkage to large-scale oscillations like the Pacific Decadal Oscillation (PDO) and the weakening of the Sun as it enters a grand solar minimum in next decade or so. Finally, we present the latest data on northern hemispheric snow accumulations and the implications that increasing CWE hold for economic impacts in the future.

41. Scaling and speeding up private climate action by 2030: how to realize accelerated actions by SMEs in this decisive decade?

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Holding global warming to well below 2 °C and aiming towards the 1.5 °C goal requires significantly stepping up GHG mitigation efforts in all sectors by 2030, including and in particular by the private sector. Recent surveys and mappings of private sector capacities in different regions of the world with a focus on SMEs (i.e., MENA, Africa, Latin America and Asia) reveal knowledge and capacity needs in the areas of risk assessment and management strategies, design and technical issues related to low-carbon and climate resilient products and services as well as with regard to accessing climate finance. There are the required enabling environment and regulatory frameworks to address existing bottlenecks, so that the private sector makes use of the full GHG mitigation potentials. SMEs in particular in the Global South but also in the Global North need to further develop capacities and skills to address the identified strategic, technical and financial challenges to embark on a low emissions development path. Two important elements of the solutions package that allow mobilizing private sector climate action and finance at the roots and on the job - including B2B cooperation and capacity building alongside public (financial) support - are a more sustainable supply chain management and incubation. More sustainable supply and value chains allow for cooperation between companies from the South and the North and capacity development or training on the job. Incubation can support locally grown businesses with expertise from abroad - including South-

South exchange and returners that bring the required expertise, skill sets and business partnerships with them. Aside from the private sector actors themselves there are different actors that need to play important roles for the necessary concerted actions to support scaling and speeding up private sector engagement in climate action: multilaterals, bilaterals, trade associations and academia and research organizations.

42. AI-based water surface detection algorithm for estimating reservoir storage in South Korea using Sentinel-1 SAR data

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This study was carried out to develop classification models for the optimized water-bodies of reservoirs in South Korea using sentinel-1 SAR (synthetic aperture radar) imagery. Understanding remote sensing Technique including radar systems is important in response to climate change, flood, drought that we have been facing with. Most agricultural reservoirs in Korea are sensitive to extreme weather conditions such as droughts due to their smaller amount of water storage compared to those of multi-purpose dams. In addition, considering the specificity of the domestic situation where much of the agricultural land rely on irrigation system by Water Utilization Facilities, it is essential to analysis of impact of the Climate Change on the behavior of reservoirs using satellite images which can detect water surface areas in reservoirs continuously. Therefore, this study presents water body estimations using VV polarization SAR images provided by GEE (Google Earth Engine) based on four different Artificial Intelligence (AI) models; SVM (Support Vector Machine), RF (Random Forest), ANN (Artificial Neural Network) and AutoML (Auto-Machine Learning). In particular, optimization for the hyperparameters of the models was conducted to ensure the best configuration for accuracy improvement. We used drone images as ground truths and RAWRIS (rawris.ekr.or.kr) data providing water storage and water level information on reservoirs to evaluate accuracy, precision, recall, f1-score and ROC values of the results from our models.

43. Impact of climate change on human health in African coastal cities: case study from the city of Durban, KwaZulu Natal (KZN) Province, South Africa

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Abstract: It is now well established that all coastal locations are at risk of climate change effects, such as accelerated sea-level rise, increased global temperatures and changing storm frequencies. The impacts of climate change are likely to worsen many problems that African coastal areas already face - shoreline erosion, coastal flooding, and water pollution. But, according to the Lancet, the impact of changing climate on health is the most serious health threat of the 21st century. The aim of this study is to establish and document the effects of global warming on human health in the City of Durban, the second largest coastal City in South Africa, as a case study, so as to be able to put forward interventions for mitigating the impacts and evolve tangible coping strategies that are adaptable to other African coastal cities.

44. How can we reach climate protection aims until 2035? Energy efficiency, renewables and community action

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Climate change needs urgent and effective Climate. There is a long-time experience in Germany since 1990 in local communities. Some hundred cities are engaged in climate action, working together in the “Climate Alliance” and the European “Covenant of Mayors”. There are good efforts and results, especially in the development of new instruments as energy saving services for low income households as well the design of low energy “passive houses” and low energy high rise buildings in the City of Frankfurt am Main.

There is a broad range of technical measures to reduce energy demand and the implementation of renewable energies, as wind and solar power. District heating with cogeneration is the complementary source of energy for delivering security of supply. Cities and regions have set up “master plans” for their energy future to reach climate neutrality until 2035 exists combining energy saving and efficiency with renewable sources.

But there are many obstacles. The energy laws mainly support the old existing energy structures, based on centralized big companies. New energy dependance will be created from large offshore windfarms and hundreds of kilometers long high-tension power lines. On the other land local energy plans show, that decentralized concepts have lower cost and lower impact on the environment.

The key factor is, the local communities must have a duty for municipal climate protection combined with financing from the state. Cities will be the main transformation level, where different actors, housing and energy companies, associations for social and environmental issues work together. A key factor to change the picture will be the establishment of “renewable energy communities” according EU right, which may produce, exchange and use energy within their group. A new basis of energy supply must be combined with new legislative and regulatory framework to be successful. It is not about acceptance but on participation.

45. Planting one trillion trees to halt climate change: four bottlenecks that hold back geoengineering scale afforestation

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Studies of reforestation potential by the Crowther Lab at ETH Zurich, the JPL-NASA Climate Research Lab, and others have highlighted the potential for our planet to carry billions of acres more forest than it does today. If we were to create 2.4B acres of net new, incremental forest cover in non-albedo affecting regions of the world, the human species would be able to sequester enough gigatons of carbon dioxide from the atmosphere in order to hold off the effects of global warming for decades and give ourselves sufficient time successfully convert our economies and societies to fully renewable, zero-emissions energy sources. Through discussion with the world’s largest reforestation organizations, Terraformation has identified four (4) key bottlenecks that stand in the way of billion-acre scale forestry efforts. These bottlenecks include: (1) regional seed supply of native and endemic trees; (2) training and capacity building for forestry organizations; (3) remotely-verifiable carbon standards that account for full ecosystem carbon mass; and (4) early-stage forest finance. Solving these four bottlenecks will enable a new generation of millions of forest entrepreneurs to create new forests around the world and drive creation of economic growth, ecosystem services, and carbon sequestration at global geoengineering scale.

46. AI-based detection of wildfire smoke plumes from GEMS (Geostationary Environment Monitoring Spectrometer) images

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Wildfires are a globally occurrence. There are various causes, such as climate change and changes in precipitation patterns. As a result of these various causes, larger and more widespread wildfires are occurring. There are various studies on the adverse effects of smoke generated by these wildfires on the human body. Also, smoke can be seen that it is very negative for the Earth's atmosphere. It was hypothesized that smoke from the wildfires reduced the amount of incoming solar radiation reaching the ground, which resulted in near-surface cooling, while smoke aerosols resulted in warming aloft. Various studies are being conducted to cope with air pollution and global warming caused by these wildfires. This study suggests the effective smoke detection technique by using satellite data GEMS. Through previous studies, it was confirmed that smoke had an abnormal difference in the radiance between 340 nm and 380 nm. Based on this, in this study, smoke detection was performed by selecting large-scale wildfires in Korea. And, smoke identification was performed using the detected image. FCC (False color composite) technique was used for smoke detection. And then, smoke classification was performed by using FCC image and other GEMS data through AI model. The data size of the model is 2731 cases. The result of evaluate variable importance from the model, the FCC image took the first place with 32.5%, and the AOD is the second with 32.3%. The mIOU of the model prediction result was evaluated to be 0.981. In this way, it can be found that the model is effectively distinguishing between smoke pixel and non-smoke pixel. In the future, this model will be supplemented to express the potential for forest fire smoke. In addition, various studies are planned for effective expression of disasters.

47. Evaluating global and regional land warming trends in the past decades with both MODIS and ERA5-Land land surface temperature data

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Analyzing temperature trends demands data with high spatial resolution and broad geographical coverage to allow for analyzing trends and changes on a regional scale. Land Surface Temperature data from NASA MODIS with global resolution of 0.05 degree and Skin Temperature data from European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5-Land reanalysis with global resolution of 0.1 degree fulfill these demands. In this study, we analyze the remote-sensing-based MODIS data to estimate land surface temperature change rates over the period 2001-2020 in global, continental, and pixel-wise scales with statistical significance indicated. The model-based ERA5-Land data are also analyzed in parallel, extending the period of analysis back to 1981. These two independently-sourced datasets, one from satellites above the atmosphere and one from combining surface modelling and observations, are shown to produce highly consistent results. It is revealed that the trends in the shorter period 2001-2020 are spatially conforming to the trends in the longer period 1981-2020 despite the shorter time length. For the period 2001-2020, we show that the global average land surface temperature rate of change was 0.26-0.34 °C per decade, with substantially different warming rates in different regions. The Arctic, Europe, and Russia show statistically significant warming in both datasets. The Arctic, in particular, warmed at a rate 2.5-2.8 times the global average, and data in the 40-year period 1981-2020 suggest that warming is accelerating in almost all the continents or large regions. Most noticeably, the two independent datasets both indicate that Arctic permafrost regions had the world's highest warming rate at the onset of the 21st century, reaching more than 2 °C per decade in some areas.

48. Importance of coastal ecosystem assessments in ensuring coastal resilience and climate change adaptation processes

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The coastal areas encounter various pressure due to climate change impacts and human interference. Therefore, assessing coastal vulnerability and the role of coastal habitat in protecting the coastal area is essential for effective long-term planning and sustainable coastal management. The purpose of this study was to model and map coastal vulnerability and explore the role of coastal habitats in mitigating coastal vulnerability in Southern Al Sharqiya and Al Wusta Governorates of the Sultanate of Oman, using InVEST 3.9.1 model developed by the Natural Capital Project. This study assessed the coastal vulnerability spatially, and the results showed areas of highest hazard > 2.667 represented 59% of the coastal distribution, intermediate hazard (ranged between 2.31 and 2.66) represented 16% of the coastal distribution, and lowest hazard (ranged between 1.22 and 2.30) represented 16% of the coastal distribution. In addition, the coastal habitat ecosystems showed evidence in reducing coastal vulnerability by 39%. These results are very critical especially for policymakers to ensure enhancing the protection of coastal ecosystems in achieving coastal resilience. This study buttresses the importance of coastal ecosystem assessments in ensuring coastal resilience and climate change adaptation processes for a coastal country such as Oman.

49. SCORE smart control of the climate resilience in European coastal cities

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Extreme weather events have intensified over the past decades and one of the major challenges is related to water, especially sea-level rise and coastal erosion. These challenges need to be addressed and potential solutions are required to increase climate resilience. Smart control of the climate resilience in European coastal cities (SCORE) brings a new concept of the Living Lab approach to address specific climate challenges, through innovative monitoring systems and sophisticated digital technologies. SCORE is developing a Coastal City Living Lab (CCLL) network in ten European cities providing platforms for innovative ecosystem-based adaptation to increase climate resilience sustainability for coastal cities.

In the first year of the project, IHS Erasmus University, European Network of Living Labs (ENOLL), and NAIDER conducted a 3-day workshop in ten cities, giving relevance to the pilot operational plans of the living lab to take into account when developing and implementing actions. The workshop aimed to contextualise the specific needs, objectives, vision and expected outcomes required for each CCLL to enhance their overall long-term resilience. The living lab methodology consists of co-design and co-creation which are based upon the integrative process, from the problem definition until the deployment space. The poster presentation shows diagrams, images and other information on the CCLL related challenges, the design thinking methodology, integrative processes, and expected outputs based on the workshop.

Several CCLLs are open to new partners and investors as well as sharing their experience in a network setting. Therefore, the Climate Week Conference is a suitable platform wherein SCORE can showcase its best practices and knowledge exchange amongst scientists, policymakers, academia, end-users and other stakeholders that can lead to new processes, functions, or purposes.

50. Raw materials and climate change: opportunities and limitations

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Raw materials relate directly to main challenges our society is facing nowadays, as climate change. This because they are essential for technologies necessary for mitigating climate change, and facilitate the green and digital (twin) transition. Technologies, which complement economic, policy, behavioural and awareness actions needed to reach the carbon neutrality by 2050, as set by the EC.

However, the discussion around raw materials and climate change appears controversial because of the climate impact that extraction and processing of raw materials have. Even though the need of raw materials for renewable energy, energy storage and digital technologies, has been largely investigated in the literature, the topics of raw materials and climate change have rarely being directly associated and reviewed in a broad perspective. The author aim to build a bridge among material scientists, mining experts, engineers and environmental scientists, by reviewing the linkage between raw materials and climate change. For this purpose, the author searches the literature on Web of Science and Google Scholar from 1900 to present. Web of Science results show most of the publications falling in the categories of Environmental Sciences, Green Sustainable Science Technology and Engineering Environmental followed by Energy Fuels, Materials Science Multidisciplinary and Environmental Studies. Furthermore, additional clusters emerge (e.g., transport, building, energy sectors, *etc.*). The author suggests for future development to classifying the finding into two categories: (1) impact of raw materials on climate; and (2) climate change mitigation potential of raw materials. Results show that papers, on the investigated topic, appear to be published starting from 1999 onwards with steep increment after 2016 and a pick in 2020. More than 55% of the papers were published between 2018 and present day. This suggests the increasing importance of understanding the nexus between raw materials and climate change, especially in the light of sustainable development and twin transition towards climate neutrality.

51. AI-based prediction of paddy rice yields in South Korea under extreme weather conditions

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Abstract: Global warming and climate change is emerging as serious problem with continuous human activities and industrialization. Extreme weather and climate change can affect crop yields and can be directly related to the food supply problem. In South Korea, extreme weather such as heatwaves, heavy rains, and droughts has become more frequent, which leads to concern about damage to paddy rice yields. So, the accurate prediction of paddy rice yields under extreme weather conditions is essential for future food security. We conducted an AI (Artificial Intelligence) modeling for the county-level paddy rice yields using meteorological and satellite data for the recent 20 years in South Korea. Input features include solar radiation, air temperature, relative humidity, precipitation, the fraction of photosynthetically active radiation, leaf area index, near-infrared vegetation index, drought index, and so on. We adopted an AutoML (Automated Machine Learning) technique for the prediction experiment. The training and testing by random sampling produced a correlation coefficient of about 0.8, and the accuracy was not significantly different under heatwaves, heavy rains, and droughts. This indicates that our AI model can provide a robust prediction irrespective of extreme weather and climate change. We expect the proposed approach can contribute to developing the prediction of paddy rice yields in South Korea in response to extreme weather and climate change.

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