ETH zürich

Institute of Science, Technology and Policy

ISTP Colloquium Spring Semester 2021

A Collection of Reports Written by ISTP Students

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This collection contains reports about the ISTP Colloquia talks in the Spring Semester 2021 written by our Master's students. Find out more about the ISTP Colloquia series: *www.istp.ethz.ch/events/colloquia*

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The role of economic geology research in the 21st century

by Najmeh Karimian-Marnani and David Metzger
based on an ISTP colloquium talk by Prof. Dr. Cyril Chelle-Michou

Prof. Chelle-Michou kickstarted the year 2021's first colloquium at the ISTP. His insightful lecture covered the increasing demand for mineral resources and the geological plausibility of solving this problem. We would like to warmly thank him for his time and for sharing his research with us.

Demand for mineral resources is increasing exponentially due to population and economic growth. The vast amount of different products we consume rely heavily on metals and minerals obtained from the ground through mining, which has enormous environmental, and also economic, costs. Research estimates that an average person uses 50 tonnes of metals and 500 tonnes of industrial minerals in their lifetime.

The transition to a low carbon society to halt climate change, laid out in international climate agreements, needs technologies that also rely heavily on metal and mineral use, which unfortunately presses for a greater increase in demand. As it gets increasingly more expensive to find and build new extraction sites, accurate geological estimation gets more important.
Chelle-Michou and his Group of Mineral Resource Systems are doing research on the factors that determine the size and location of copper deposits. They found that the magma's chemical composition is much less important than previously thought, and are exploring new avenues of research by looking at the temperature evolution during the pluton formation, combining knowledge from different earth science disciplines.

By how much should mineral resource extraction increase to meet the demands of consumption and the transition to a low-carbon society?

To meet the demands of the Paris Agreement, an increase in 1000% of Lithium (needed for batteries) is required. Copper, a metal that requires a comparatively lower increase, needs a 7% increase to meet the zero carbon demands, not counting the amount needed for general economic growth. This 7% translates to producing 1 billion tonnes by 2050 and 2 billion tonnes by 2100. Over the last century, the biggest copper mine has only produced 35 million tonnes. This is minute compared to the projections and raises the question of whether, with current methods and technologies, the projected demand is possible to achieve. It also shows the urgent need for changing our ways of producing and consuming: we need to close resource cycles, make repairable products, and perhaps even degrow our economies, to lead more fulfilling lives with less material throughput.

How can the supply of metals and minerals be increased?

It is clear that the mining industry must address and overcome the challenge of increasing the production of metals and minerals, while also reducing costs and environmental impact. One way to do this is by opening new mines. However, there are strict criteria for doing this, namely the geology of the region, the local conditions and its political/societal impact. As a result, new mines are also more economically, socially and environmentally costly - in terms of infrastructure, pollution, accessibility (deep crust), as well as increased political and societal resistance. Therefore, it is very important to not only determine the occurrence of copper deposits, but to also accurately predict the size of these deposits, evaluating whether the benefits of a new mine outweigh the costs and risks.

Chelle-Michou and his Group of Mineral Resource Systems are working on this knowledge gap by:

1. Quantifying the role of various geological processes in modulating the formation and size of mineral deposits

2. Critically and quantitatively reassessing existing paradigms

3. Looking for a way to estimate the size of mineral deposits as early as possible in the exploration process.

What are porphyry copper deposits?

Over 60% of copper comes from porphyry copper deposits. This type of deposit is formed by a magmatic-hydrothermal expulsion of overpressured fluids through porphyritic rock, or in layman's terms, there is some water in the magma which is forced to flow through granite rock at a specific location and at high pressure and temperature, which leaves behind copper-rich minerals in the rock in the process. Typically these deposits form at the boundary of tectonic plates (subduction zones).

Size, temperature and time - a new way forward to identify large deposits?

Dr. Chelle-Michou and his group found that the magma's chemical composition is much less important than previously thought. They are finding new insights is by looking into the physical conditions under which large deposits have formed, namely magma chamber size and temperature over time, for example to determine if the magma has cooled gradually or if the temperature has oscillated over the cooling process (on the time scale of millions of years).

A longer, oscillating cooling process might be associated with increased mineralisation during the pluton formation, but more research is needed in different locations to confirm this hypothesis.

Economic geologists are used to looking only at the deposit itself, but they need to work with geologists, volcanologists, petrologists and geophysicists in an interdisciplinary effort to gain more insight into the formation process.

2

Sustainability of global food systems – from understanding to actions

by Marina Ivanović and Qianwen (Vivian) He
based on an ISTP colloquium talk by Prof. Dr. Alexander Mathys

Food systems are at the heart of the UN's Sustainable Development Goals (SDGs), and thus it is crucial to understand and conduct the actions in this field. Moreover, it requires an interdisciplinary approach due to its technical, social and ethical complexity. In the light of these issues, Dr. Alexander Mathys presented the system-oriented approach of his Sustainable Food Processing group at ETH, together with the results that could lead us to more sustainable global food systems.

Multi-indicator sustainability assessment

Focusing on a system-oriented approach and considering the total value chain in food production, Dr. Mathys presented a multi-indicator sustainability assessment that takes all three important dimensions into account -- economic, environmental and societal as the most challenging one. Particularly, together with his research group, he analyzed 156 countries, applying 25 sustainability indicators across seven domains. These domains span from ecosystem stability, across societal aspects, to resilience, which was particularly important for the food systems during the Covid-19 crisis.

As one of the seven domains, they suggest Food Nutrient Adequacy, which includes nutrition and the outcomes of nutrition. For this case, they use the Nutrient Balance Score (NBS), developed by Nestle Researcher and Dr. Drewnowski, which addresses the completeness of a diet. Further, they analyze how the Food Nutrient Adequacy varies across the countries and show that countries in Europe and North America have a relatively good diet thanks to the animal-based compounded diet. However, they show that the Ecosystem Stability is rather low in these countries. Finally, their analysis shows that high-income regions perform very well on the social aspect but very poorly on environmental, food waste and health-sensitive nutrition indicators. On the other side, low-income regions have significant challenges with food safety but perform much better on food waste than many high-income countries, like Switzerland.

In the other study, which also addresses different dimensions of sustainability, they analyzed human health, nutrition, environmental and economic aspects, conducting a case study for a sustainable Swiss diet. They use the current diet in Switzerland as a reference, followed by the Recommendation of the Swiss Society of Nutrition (RSN), Vegan, Vegetarian and many others. According to their model, the RSN diet is the most sustainable and the cheapest option, which can help reduce the environmental footprint by 36% in comparison to the reference. Furthermore, they analyzed yellow pea integration into bread, cereals and pasta, partially replacing wheat in different proportions. For instance, yellow pea is a more complete nutritional ingredient and needs less fertilizers, which means that this would lead to a higher NBS and reduced carbon footprint. Most importantly, this could be done immediately in the industry, and as such could be a short-term solution for more sustainable food production.

Global food waste

The Food and Agriculture Organization (FAO) estimated that around one-third of food was wasted or lost annually in the world. Thus, to achieve SDGs, we should also raise awareness of the global food waste issue. Dr. Mathys introduced their findings of nutritional and environmental losses embedded in food waste among 151 countries. The research concluded that the embedded environmental footprint in daily food waste on average per person is 124 g CO2eq. Additionally, the Country-specific Wasted Daily Diets (WDD) embedded in national per capita per year food waste was introduced with an average value of 18. The WDD represents the days for which a person can be fed a healthy diet meeting the daily required nutrient intake of all 24 essential nutrients and calories.

In order to tackle the food waste problem, intervention policies and actions can be considered in the food system, including prevention, multiple R-strategies (reuse, recycle and recovery) and disposal. Waste hierarchy illustrated the rank of potential approaches based on the evaluation of environmental protection and energy consumption. Among these actions, prevention is the most favorable one, aiming to avoid food surplus and waste throughout the food supply chain.

Environmental impact of protein sources

In sustainable food processing research with a focus on insects, the Sustainable Food Processing group uses sustainability methodologies on the product and service level. Particularly, they use the Life Cycle Assessment (LCA) framework, calculating the midpoint environmental and endpoint impact potentials around resources, ecosystem quality and human health.

For better sustainability in the food system, we need to reduce animal-based consumption, which further needs suggesting alternatives. For that issue, they compared some final results of the environmental impact of protein sources. For instance, they show that lab-grown, which is very popular, has a huge environmental load and is very costly so far, as it is at an early stage of the innovation cycle, with many optimization opportunities. On the other side, soybean meal is very optimized and has a highly scaled value chain. And finally, insects have a very beneficial performance, according to these results.

Further, their research assessed the environmental impacts of plant-based and insect-based products through attributional and consequential LCA approaches, indicating lower environmental impacts than established animal-based food. Besides, insect products potentially offered more sustainable protein, fertilizer and lipid production, which might be environmentally preferable compared to animal-based food and use less water and land compared to plant-based proteins. This crucial analysis could help us identify potential applications and suggest protein alternatives for more sustainable food systems.

Sustainable food supply chain

In the light of previous sustainable food processing research, Dr. Mathys presented two case studies to show more sustainable food supply chains using alternative sources of proteins, microalgae and black soldier fly. After being cultivated in algae bioreactors, the proteins and lipids in microalgae can be disintegrated and processed into quality food. Similarly, the protein of insects can be separated and made into quality food/feed. Besides, a comprehensive pulsed electric field (PEF) system was created to improve the efficiency of microalgae processing, which could enable potential applications for increased cell proliferation, targeted release of intracellular valuables, cyclic protein extraction of living microalgae, and microbial inactivation.
However, some people showed concerns about the acceptance level of insect-based food. Dr. Mathys replied that they focus a lot on fishmeal replacement as aquaculture feed and Asians seemed to accept insect products more easily because insects already existed in their recipes. Additionally, the insect industry is growing rapidly in EU countries with relative consumers' concerns.

In the end, Dr. Mathys also shed light on the globalization of the food supply chain after the impacts of the pandemic. He considered the global food systems were very resilient during the global health crisis, although food transportation was influenced by movement restrictions and other factors for a short period. People might tend to choose local food and support local businesses more in the future.

We would like to thank Prof. Dr. Alexander Mathys for the interesting and insightful presentation.

3

Revenge of the plastic bag: how unregulated trash management affects health

by Jasmin Krähenbühl and Andreas Felderer
based on an ISTP colloquium talk by Prof. Dr. Elizabeth Tilley

Having just recently moved back from Malawi to Switzerland to start her Assitant Professorship at D-MAVT, Professor Elizabeth Tilley gave a very insightful talk about the problems of Solid Waste Management in Malawi. We want to warmly thank her for providing many first-hand insights and a perspective that was concerned with the societal dimension while also having a technical mindset.

With a GPD per capita of around US$400, Malawi belongs to the poorest countries in the world. Compared to European countries, consumption is much lower and the infrastructure is less developed (e.g., electricity, access to water or sanitation). While this means that there is a much smaller amount of garbage in total, this amount is increasing with rising industrialization and more imports of consumer goods.

Since Malawians have to meet basic needs (e.g., nutrition, medical facilities) first, managing garbage does not have a high priority. The problems of Solid Waste Management (SWM) can be conceptualized by structuring them into three main areas: air, soil, and water pollution. The improvement of SWM is closely related to three UN Sustainable Development Goals: Sustainable cities and communities (goal 11), responsible production and consumption (goal 12) and life below water (goal 14).

Air Pollution

The major problems of air pollution, stem from the burning of solid waste. A striking example is the Queen Elizabeth Central Hospital, Malawi's largest hospital located in Blantyre. Because the garbage incinerator broke down repeatedly, the garbage is burned openly on the hospital grounds. Thus, severe air pollution is caused by fire smoke (in terms of particulate matter [PM2.5 and PM10]). In several locations of the hospital, the thresholds set by the US Environmental Protection Agency are frequently exceeded.

Professor Tilley proposed multiple options to address the air pollution in the Queen Elizabeth Central Hospital. An easy approach to reduce pollution is waste collection and separation. The prime solution, however, would be to repair the incinerator – but to do so, large investments are needed. Just throwing money at the problem is difficult because with its limited budget, the hospital needs to cover other services first.

Soil Pollution

To better understand the impact of solid waste on soil, Professor Tilley and her colleagues studied a landfill next to Moto village. They found that one of the major problems of waste dumps is the risk of injury by (potentially contaminated) sharp objects like needles and shards, which Informal Waste Pickers (IWP) face when they separate recyclable materials from waste. Furthermore, many IWP's get injured during the arrival of trucks on the landfill since some of them try to climb onto the trucks to get the most valuable materials first. Here, already basic personal protective equipment such as boots or gloves could reduce the injury risk. An interesting result of the studies was that the soil was not as badly poisoned as expected. Even more interestingly, the maize grown on the dumpsite had unexpectedly low concentrations of poisonous heavy metals and comparably high concentrations of useful nutrients. While the maize grown on the landfill would not meet up to European standards, it seems to be not the worst solution when facing severe shortages in the food supply.

Lastly, Professor Tilley showed that more than 60% of the waste in Malawi is organic and therefore could be used for compost and soil enrichment. However, the organic waste is often interspersed with non-organic waste such as plastic bags (e.g., due to lacking separation in food markets). It can be shown that the profits from organic waste are a function of plastic content and waste volume. The larger the plastic content, the more waste is needed to break even. This is a problem, as most of the waste management in Malawi is done by private firms or entrepreneurs and thus needs to be profitable.

Water Pollution

The final subject of the talk was related to water pollution. Professor Tilley brought forward the example of Lake Malawi, an upcoming tourist destination. Although the Lake Malawi region is a National Park, the water and land are increasingly polluted from the tourist's plastic waste and the inhabitant's fishing nets and fabrics. It is not possible to transport the waste away from the remote region, and the energy supply is not good enough to build a recycling plant. Hence, more responsible SWM, sustainable tourism and the enforcement of national park status seem to be realistic options.

Lastly, Professor Tilley focused on the management of sewage sludge. In urban areas, many of the pit toilets cannot be moved after the pit has filled up, simply because space is too scarce. This means that the pits have to be emptied such that the toilets can be used again. A major problem is that many people also throw their garbage into the pit. Garbage in the pit makes it much more difficult to pump the sewage sludge out of the pits and is also more difficult to treat. Many entrepreneurs invent simple and robust technical solutions. However, it is crucial that public awareness about the importance of not using the toilet pit as a waste dump rises.

4

Digital innovation for a circular built environment

by Stefano Amberg and Jonathan Sedding
based on an ISTP colloquium talk by Prof. Dr. Catherine De Wolf

With 39% of global GHG emissions, the building industry is in a deep need to take a shift from a linear to a more sustainable and circular economy. Prof. Dr. Catherine De Wolf of Circular Engineering for Architecture at ETH Zurich highlights three core areas - data, design, and management – where digitalization could play a key role in this crucial transition.

The construction sector mines 40 billion tons of sand and gravel per year, produces 39% of global GHG emissions, and roughly 30% of all waste produced in Europe can be attributed to this industry. Still, there are various examples like the curved glass roof of the Centre Pompidou's hallways in Paris that show how (parts of) old buildings can be reused and serve as urban material mines for new structures instead of treating them as waste products. In this case, the glass was repurposed as a partitioning divider in other buildings. However, this process is more often the exception rather than the rule since an efficient reuse framework of materials still faces many barriers. This is exactly where new digital technologies can help streamline and simplify these processes enabling the much-needed paradigm shift towards a circular economy.

Data

The first area of interest is data. Currently, a lot of potential raw building materials that stem from existing but unused buildings or structures that are about to be demolished cannot be used because they do not appear in material databases. Here, material tracking through RFID chips or QR codes, advanced scanning methods and VR technology can help to build more extensive databases where engineers can have access to a wide range of materials that they can reuse and repurpose. Additionally, these databases can also be analyzed and visualized to get a deeper insight into key metrics like Global Warming Potential (GWP), which is measured by Embodied Carbon Coefficients (ECC) and Structural Material Quantities (SMQ).

Design

A key interest area in design where technologies like 3D printers can be of assistance lies in the development and understanding of interlocking mechanisms and joints that do not rely on glue or in-situ casting (i.e. non-dry connections). This could facilitate the disassembly of large structures as if they were constructed out of modular blocks. Using robotic fabrication can also help with disassembly and reassembly. Another important design aspect lies in the understanding of more sustainable use and reuse of concrete. Also, in this case, a modular, reusable system has shown promising results.

Management

When transitioning from a linear to a more circular economy, management structures need to be rethought as well. To really enable reuse as a common practice, competencies between all different stakeholders need to be forged from architects to suppliers and from engineers to contactors and storage facilities. Products as a service could emerge as a new business model where suppliers oversee maintenance and materials. Matching processes of materials via AI algorithms and connecting material flows in a transparent way through blockchain technology are all currently being pioneered, making the reuse of materials a substantially more local process than the global supply chains needed to manufacture new buildings from scratch.

All these examples only scratch the surface of what can be possible when innovative technology is brought into the construction sector with the goal of sustainable circularity. We want to thank Prof. Catherine De Wolf for her insightful presentation at the ISTP and we want to wish her all the best for further research in this field!

5

Microplastic regulation should be more precise to incentivize both innovation and environmental safety

by Michael Andres
based on an ISTP colloquium talk by Prof. Dr. Denise Mitrano

Prof. Dr. Denise Mitrano from the Department of Environmental Systems Science at ETH Zurich focuses her research on the distribution and impacts of anthropogenic materials in technical and environmental systems. The talk exemplifies this in the case of microplastics and the resulting implications for the regulation of such materials.

Plastic pollution is often talked about in the media. A special focus has been on microplastic, which is used in cosmetics and found in the environment as residues of the breakdown of larger plastics items, such as mismanaged plastic waste. However, there has been no clear assessment of the harms and risks of those materials and regulations have not slowed the global trend of exponentially increased use in plastics. Prof. Mitrano calls for the scientific world to engage in more detailed research about the risks to lay the foundation of regulations that are rooted in facts and can prioritize issues accordingly.

Origin of Microplastics

While the public focus has been on microplastics, which are less than 5 mm small polymer particles, in their primary form, e.g., in cosmetics, the vast majority that is found in the environment comes from degrading plastics emitted to the environment. Since most of this material is littered or discarded, such as in landfills, a rise in the use of plastics in throwaway products directly increases the pollution by microplastics. Recycling is often not possible and also downgrades the quality of the material, and is therefore not viable as the only solution for the sustainable use of plastics. Additionally, microplastics are often essential to other sustainability measures, like in agriculture. From its various origins, there may be microplastic released from wastewater treatment plants, contamination of soil, and take up in plants.

Evidence

In general, it is difficult and time-consuming to directly analyze the concentration of microplastics, their fate and transport, as well as their impacts on organisms, partly due to other similar particles which naturally occur in the environment. This has led to a limited understanding of its implications. However, in laboratory-based systems using a conservative tracer in the plastics, proxies, such as metals, can be used, which turn out to allow faster and more precise measurements.

The primary purpose of wastewater treatment plants is to treat water and reduce the loads of nutrients into receiving waters. During this process, solid organic particles are largely removed from the water stream and only a small proportion of microplastics are released to the environment via this route. Further reduction can be achieved with already known techniques usually applied to suspended solids, which however is expensive and thus not universally applicable.

The majority of microplastics entering a wastewater treatment plant thus remain in the sludge solids. In many countries, this sludge is used as a nutrient amendment to agricultural soils and so microplastics may enter the environment from this pathway, as microplastics often remain in the soil. The size of and morphology of plastics (e.g., nanoplastic vs. microplastic fragments and fibers) can impact their mobility in the soil. The impacts of microplastic on soils are still being investigated, but it may be possible that their presence can influence soil function, such as decreased ability to retain water and in general less usability of the fields.

Nanoplastics have the potential to be taken up by plants, and in laboratory studies have been found in the roots as well as in the shoots. To date, their presence in grains (i.e. food sources) has not yet been confirmed. The nanoplastic mostly affected the stress response of the plants as opposed to classical phytotoxicity measurements of plant growth, such as the wall thickness in the epidermis and increases in the level of carbohydrates.

Policy and regulation

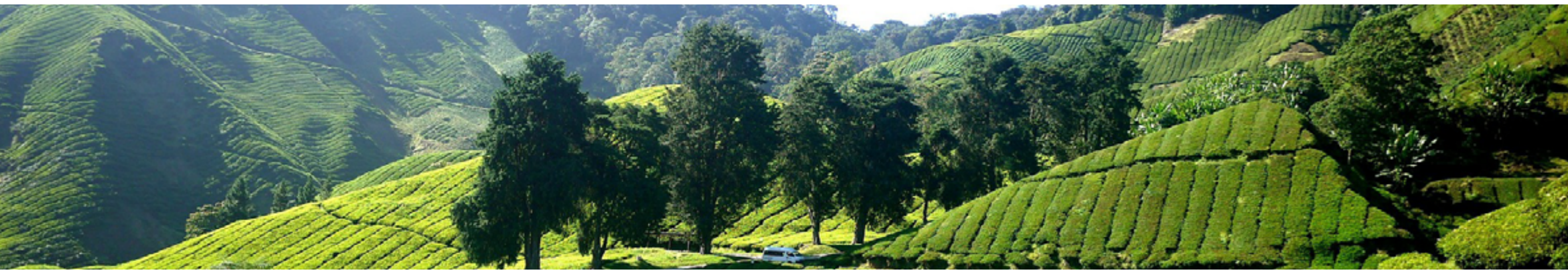
It must be noted that microplastic describes a multitude of different polymers that have different characteristics, uses and effects. Thus, Successful regulation has to be multi-faced and evaluate the risks individually. It should also prioritize cases that pollute a lot, like throwaway plastic products, and incentivize innovation and replacement in other areas where microplastics are harmful. Because of analytical difficulties with measuring plastics, current regulation is difficult to enforce. Industries' practices need to be made transparent to avoid superficial signaling. Additionally, solutions, such as biodegradability, may be more costly for consumers. The foundation for impactful regulation has to come from the scientific community by measuring the risks for the various alternatives in use.

We thank Prof. Denise Mitrano for the highly interesting talk and for advancing the important research in this area.

6

Agroforestry: constraints and potentials for sustainable food systems

by Marion Meyers & Tom Spencer
based on an ISTP colloquium talk by Prof. Dr. Johanna Jacobi



Prof. Johanna Jacobi recently appointed Assistant Professor of Agroecological Transitions in the Sustainable Agroecology group, joined us to give a colloquium talk entitled Agroforestry: Constraints and Potentials for Sustainable Food Systems. The talk explored agroforestry, a land use technique combining elements from agriculture and forestry, and its potential for enabling environmentally and socially sustainable food production with a focus on Bolivia. The starting point for the talk was the unfolding crisis in contemporary food systems, composed of interlinked crises in water use, soil degradation, agrobiodiversity and climate change. Everywhere planetary boundaries of biogeochemical flows and biosphere integrity are being crossed, with monocultural food systems as a prime driver, but Bolivia provides a particularly stark example of the devastating impacts of unsustainable agriculture.

Deforestation and soybean production - the case of Bolivia

The rate of forest loss to fires in Bolivia is increasing, with 2019 seeing record loss. Meanwhile, soybean production has driven extensive deforestation in the Santa Cruz Department and increasing imports of pesticides to Bolivia. Like in other South American countries such as Brazil, Argentina, Uruguay and Paraguay, soybeans are an important commodity. They are either processed locally for direct consumption, sold on international markets as an important cash crop, but most importantly used as feedstock for animal agriculture, with beef production being particularly important in the South American context.

Food system and „fallow crisis“

However, the turn in recent decades to a monoculture-based food system designed to maximise output is severely stressing the natural environment. In particular, there is a „fallow crisis“ in agriculture. While traditional subsistence agriculture has a fallow phase after deforestation and cropping that lets some forest grow back, the increasing pressure on land means this phase is being cut even shorter or removed entirely, with farmers instead of relying on synthetic fertilisers to maintain crop yields.

Agroforestry is an alternative land-use technique with the potential to solve this crisis: maintaining or improving crop yields without using unsustainable practices. Agroforestry means combining two or more species on the same land, usually either trees and crops or trees and livestock. Agroforestry studies have shown improved soil quality and reduced soil degradation, less water stress and conservation of agrobiodiversity compared to monoculture agriculture. Moreover, the livelihoods and food security of smallholder farmers have been shown to be better protected under agroforestry than monoculture food systems. The rest of the talk explored agroforestry in more detail, taking various approaches to assess its potential Technologies of dynamic agroforestry and syntropic agriculture

Technologies of dynamic agroforestry and syntropic agriculture

Prof. Jacobi defined dynamic agroforestry as an „ancient technique combined with modern ecological technology, that builds systems of living organisms that support each other, and consists of productive forests similar to the dynamics of a natural forest.“ She explained that the method has three pillars: (1) high diversity of species, (2) High plant density and full soil cover, and (3) systematic and continuous pruning. The advantages of these methods are that they recover degraded soils and improve water management, micro-climate, biodiversity and climate change adaptation of the ecosystem. (ecosaf.org). Prof. Jacobi then talked about real-life examples of farmers using these methods in different places that she visited. She mentioned silvopastoral systems, tropical lowlands in Bolivia and also flower productions.

Meta-study cocoa monoculture vs agroforestry

Then, she detailed the results of a meta-study from 2020 comparing cocoa monoculture and agroforestry practices using different measurements reproduced in the image below. First, while the cocoa yield was higher in the monoculture, the overall system yield was higher in the agroforestry system because they typically grow a more diverse set of crops. Secondly, we see the three last indicators, i.e. microclimate buffering, carbon sequestration and biodiversity were all higher in agroforestry systems. We see that while the economy, the soil chemical and physical properties, as well as the pests and diseases indicators all have a similar size in both systems, the pests and diseases indicators show that it is different types of pests that are present in the two systems.

Towards a political ecology of tropical agroforestry systems

The last part of her presentation focused on the principle of political ecology and why she believes it to be a necessary outlook to have when considering a transition to sustainable agroecosystems. Political ecology, as defined by Robbins (2012) is an approach that addresses conditions and change in socio-ecological systems with explicit considerations for power relations. In the context of food systems, it often involves looking at the historical developments as well power relations regarding land ownership and land use.

She gave the examples of a narrative present in Bolivia created by soybean producers in which they claim to be central to „food sovereignty" in the country because soybean revenues allow the country to buy the food it needs. In reality, soybean producers are exempted from paying some taxes, and the food the country imports is not healthy.

She used this example of how food systems are inseparable from power dynamics and from their social and historical contexts, to then stress the need for a socio-ecological transition in agriculture. She laid out a set of ecological and social principles that such transition should encompass such as soil health, beneficial biological interaction and the reduction of agrochemicals when it comes to ecological principles, and fairness, increasing self-sufficiency and the co-creation and dialogue of knowledge when it comes to social principles. Additionally, she presented the 5-level food system transition to agroecology presented by the FAO, which consist of (1) Reduction of industrial inputs, (2) alternative practices and inputs, (3) redesign production systems, (4) re-establish connection between consumers and producers, develop alternative food networks and (5) rebuild the global food system so that it is sustainable and equitable for all.

Finally, she ended her presentation by explaining her future research at ETH which will focus on food democracy. Following the quote „Hunger is not a problem of a lack of production, it is a problem of a lack of democracy", she wants to research how more democratic processes within the food systems could help transition to a more sustainable and equitable agriculture system, basing herself on knowledge from political ecology, deliberative theory and agroforestry.

7

Energy trilemma in active distribution networks design: Balancing cost, emissions and security.

by Florian Dorner and Lucio Tassone
based on an ISTP colloquium talk by Prof. Dr. Giovanni Sansavini

Professor Dr Giovanni Sansavini from the Department of Mechanical and Process Engineering at ETH Zurich focuses his research on Reliability and Risk Engineering. The talk explains a model for the effects of Active Distribution Networks on the energy trilemma between Sustainability, Security and Equity.

Contrasting Japan's success in mitigating power outages after the 2011 earthquake with the 2016 South Australian blackout highlights the positive impact of decentralized energy solutions like Active Distribution Networks (ADNs) and Microgrids on energy supply security. At the same time, the decarbonization of heating and mobility poses an important challenge to Switzerland's grid, as electricity demand could double in the process.

Research question: How is the tradeoff in the energy trilemma affected by active distribution networks?

The study's primary indicators for sustainability, security and equity are greenhouse gas emissions (GHG), the System Average Interruption Duration Index (SAIDI) and costs. Combined with local energy sources, ADNs and microgrids expand the set of possible tradeoffs by enabling flexible adaption to shifts in supply: They can be used within a local grid to dampen the effects of fluctuations in renewable energy supply or power outages affecting the national grid. In addition, they can perform ancillary services like frequency control as well as reliable services, including the provision of electricity to the national grid after a larger scale power outage.

Multi-Objective mixed-integer linear problems to model optimal transition.

The energy trilemma is modelled using Multi-objective optimization to identify the Pareto front in terms of GHG, SAIDI and costs given various constraints on reliability, energy balances and power flow. Input data includes energy demand, as well as characteristics of the grid and different technologies including prices and GHG intensities. To make the resulting mixed integer program feasible, all nonlinear interactions in the model are linearized. Additional computational tricks are applied to deal with the stochasticity of the system and time links due to storage levels. Given the model and inputs, each objective is first minimized independently. Then, the same is repeated multiple times, first constraining one variable to discrete levels and optimizing the others for each level, then constraining two variables and optimizing the last one.

Application.

The model was applied to an artificial benchmark network with the IEEE 123 bus topology. External energy supply was modelled after the Californian distribution grid and calibrated to have similar indicators of supply security. Various paths from current generation networks to more reliable and sustainable grids are identified. Even though GHG targets are the main driver of additional costs, emissions can often be reduced quite cheaply for a given level of supply security. In the optimized scenarios, reliability objectives only become an important source of costs at levels substantially higher than the current Swiss standard. Interestingly, there are some configurations with a little conflict between the indicators (costs, GHG emissions, supply's security). This highlights the importance of fully exploring the search space.

Regarding energy supply, all optimal points in the model do not primarily rely on (local) fossil fuel usage. The preferred Technology to obtain the highest reliability are microturbines, but photovoltaic (PV) does better in term of GHG emissions. Intermediate solutions substitute microturbines by PV and storage. As learning curves for storage technologies were not considered, these solutions might perform better than the model suggests. Most of the optimal choices for local supply rely on renewables and importing electricity from the larger grid, with the role of the larger grid increasing the less renewables there are.

Energy Services and Economic Implications

Active local grids could also perform energy services in the form or grid balancing. Up-regulation can be performed for particularly high-reliability solutions with high battery and microturbine capacity, while down-regulation can be achieved by ramping down microturbines. However, there is very little capacity to downregulate for low GHG solutions that mostly rely on PV. While energy services and power exports to the larger grid might compensate for around 25% of the investment costs, it is insufficient to incentivize investment on its own. As the distributed solutions require higher capital expenditure, new business models for system operators might be required to make them work financially.

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