



**Rethinking Value –  
Resources for  
Planetary Wellbeing**

4 – 6 September 2023, Geneva & online

# Book of Abstracts

WORLD RESOURCES FORUM 2023



## **2. Comparative studies of climate smart agricultural practices in peripheral and host communities of protected and conservation areas in Ghana and Deutschland.**

Aminu Bonifacio

Massive Vision Enterprise, Accra, Ghana

### **Abstract**

The shea nut tree is one of Ghana's most important resources. For many women, especially in the northern parts of Ghana, it is a relief and security. When everything else fails, the shea tree is an opportunity and hope, because they can produce traditionally self-made shea butter out of the shea nuts. In many parts of the world shea butter gets very famous these days. It's used in the pharmaceutical industry, in food preparations, such as margarine and chocolate and often even in premium beauty products in the cosmetic industry. But concerning the women's lack of knowledge of running the production business including technical aspects as well as economic problems like distribution, and international standards certifications they cannot meet the increasing demand of shea products at both local and international markets. Massive Vision Enterprise has researched and identified shea to have huge potentials, and can make positive change in our society, in improving the standard of living and contribute in reducing poverty in deprived communities. In the year 2012, we won the most sustainable and partnership project for award. Our vision is empowering the rural people in our communities in Ghana to have a better and more sustainable source of livelihood through partnership and investment. And therefore looking forward to partner other organizations to learn and share experiences and also expand its research and community outreach projects to other peripheral deprived communities in the Upper West Region. There is a high demand for organic cashew products in Europe. Therefore, there would be a premium if the farms could be converted to produce certified organic cashews, thereby helping to lift the smallholder farmers out of poverty. However, there is a lack of knowledge concerning the appropriate use of organic fertilisers to replace the inorganic fertilisers and in the use of mulches to control weeds. Therefore we are looking experts and collaborators who could investigate and experiment to identify organic amendments (e.g. cashew nut shells and leguminous plants) that can be used as mulches or composted to provide quality organic fertilisers for the cashew plantations that will restore the degraded soils and facilitate conversion to certified organic farming.

### **Keywords**

circular economy , bio economy , sustainable land use management, Nature Based Solutions , Climate Smart Agriculture Practices

### **3. A circular economy approach to the municipal solid waste management in Paris**

Jean Pierre Doussoulin

Université Gustave Eiffel, Paris, France. Universidad Austral de Chile, Valdivia, Chile

#### **Abstract**

In the most recent decade, economists have welcomed the “circular economy” theory, which aims to minimize resource input, waste production, and energy leakage. Various scholars claim to draw inspiration from this new outlook. However, our critical examination reveals that there are very few studies on the relationship between the circular economy and the Sraffian ecological economics theory. This paper uses the Sraffa theory in an entropic universe to calculate the relative prices and the profit rates of the resources on municipal solid waste (MSW) management in Paris. Our results suggest that the negative profit rates justify a system of subsidies for recycling and recovery on MSW. The results are supported by the analytic determination of dimensions. To the best of our knowledge, this is the first paper that analyses factors involved to criticize the foundation of circular economy and their justification as a solution in waste management by using Sraffian theory.

#### **Keywords**

Circular economy, Waste management, Sustainability, Sraffa theory, Paris

## **7. Combatting illicit financial flows toward sufficient resource revenue for host nations**

Leezola Zongwe

University of Cape Town, Cape Town, South Africa. Stadio University, Cape Town, South Africa. AfronomicsLaw  
Southern Africa Academic Forum, Cape Town, South Africa

### **Abstract**

Designing a fool-proof fiscal strategy that will significantly boost gains and minimize losses is by no means a walk in the park. The activities within the extractives sector have distinct characteristics with complex features. These complex features are prone to abuse and are often manipulated to facilitate revenue leakages and to avoid and evade tax obligations. In this regard, the Tax Transparency Initiative estimates that U\$50 to 80 billion in illicit financial flows ('IFFs') are channeled out of Africa annually. Over U\$40 billion of these IFFs are suspected to be from tax evasion; other types of revenue leakages are estimated to be U\$22 billion.

This essay discusses two avenues to prevent revenue leakage in the extractives sector. First, at State level, this paper considers how a government of a resource-affluent country can enhance its fiscal strategy and prevent revenue leakage. The discussion will venture into how the proposed strategies will address each revenue leakage issue, such as tax evasion, tax avoidance, onerous tax incentives, transfer mispricing, and corruption. Finally, the strategies discussed will also include considerations such as state participation and production sharing, royalties, rents, license fees, contract fees, and tax administration. This discussion culminates in considering the change needed, in law or practice, for countries to focus on commercial IFFs.

Secondly, at Industry level, this paper advances the creation of peer-to-peer accountability mechanisms through industry reports and corporate sanctions. The company and executives may bear the penalties of the envisaged sanctions, jointly or severally. This discussion considers how the penalties for such a mechanism will be enforced. Further, the mechanism must lobby governments to join transparency and beneficial information-sharing initiatives. Membership of companies to the mechanism must be public and afford them preferential treatment when bidding or applying for extractive licenses, credit facilities, or sourcing investment.

Discovering minerals or hydrocarbons is most countries' best-case scenario. This is primarily because resource affluence is perceived to ensure that a country is wealthy and prosperous. Wealth by natural resources is created through various fiscal measures; these measures are implemented and enforced by the government and imposed against the companies that explore for and extract the resources. Achieving the prosperity that ought to come with wealth requires the good and sustainable governance of these natural resources, their taxes, and revenues. Considering this, this paper's final discussion focuses on taxation administrative and management strategies that ensure the sustainable employment of gains.

### **Keywords**

illicit financial flows, revenue leakage, peer-to-peer accountability mechanism, State level, Industry level

## **8. System of Networks of Technological Waste Companies in Panama**

SAUL ARDINES

AMARILIS DE LEON, PANAMA, Panama. ANGEL ZAZO, SALAMANCA, Spain. MARIA PAZ, PANAMA, Panama. VIRGINIA JUAREZ, PANAMA, Panama. ISAAC PERDOMO, PANAMA, Panama

### **Abstract**

The present study is an exploratory research. Ten companies of the thirteen detected were analyzed, of which nine companies were able to complete the study. The relationships between Panamanian companies dedicated to the management of technological waste with public institutions and other organizations were evaluated in order to identify their profile in the recovery and recycling process based on a questionnaire. For the exploratory analysis of the questionnaire, Network Coincidence Analysis was used, which consists of a series of techniques used to detect which events (objects, attributes or characteristics) are more frequent in a set of scenarios and with what other events. They tend to occur together. In data processing, the NetCoin tool, specially designed for analysis, was used to generate three global networks to be determined: the profile, the collection and recycling processes, and the collaboration and motivation relationships of the companies surveyed. The results show that the companies are constituted by Panamanian capital; they are managed with their own financing; they have a medium number of personnel with little technical and/or university education; they have very little relationship between themselves and other entities; low motivation due to poor disclosure, lack of laws and regulations on technological and organizational waste, and excessive bureaucracy in administrative processes. It is essential to establish strategies to raise awareness among the population, support and training for organizations dedicated to the management of technological waste and establish laws and regulations that encourage the proper treatment of this waste.

### **Keywords**

Technological waste , Collection and recycling, Network Coincidence Analysis, Panamanian companies, UNIVERSIDAD DE PANAMA

### **13. Methodological Framework to Assess Climate Neutrality and Circularity with dynamic LCA - Case Study e-Trucks**

Gerfried Jungmeier

JOANNEUM RESEARCH, Graz, Austria

#### **Abstract**

Climate neutrality and circularity are two main challenges for a sustainable development. Circularity and climate neutrality can only be addressed by the methodology of dynamic Life Cycle Assessment (LCA), where GHG emissions, resource demand and material recovery are calculated and assessed over the life time from construction, operation until the end of life management of a product or service.

In the Technology Collaboration Program (TCP) of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV) experts from 20 countries cooperate on LCA of electric vehicles since 2010, where currently in Task 46 (2022 - 2024) the focus is on LCA of trucks, buses and 2-wheelers. A methodological framework to assess climate neutrality and circularity is developed and applied in a case study to compare trucks with different propulsion&fuel combinations, e.g. battery and catenary electric trucks, diesel, e-diesel and H2 trucks. All systems except fossil diesel use renewable electricity and the e-diesel uses CO2 from air.

The GHG emissions are calculated over time showing the possibilities towards climate neutrality at a certain time in the life cycle of a truck using renewable electricity; the GHG emissions of the additional renewable electricity generation plant are considered in the construction phase of the overall systems incl. the trucks and charging infrastructure. Based on the resource and material flows in the life cycle a circularity index (0-1: no circularity to 100% circularity) is developed which ranges for the different trucks between 0.5 and 0.95, mainly depending on the amount of recycled material used in the construction phase and of material and energy recovery in the end of life phase. Based on this the necessary framework conditions for climate neutrality and circularity based on dynamic LCA can be addressed.

#### **Keywords**

LCA, climate neutrality, circularity, trucks

## **16. Contents of metallic trace elements and pollution parameters in the soils of the Komabangou gold mining area in Niger**

Soumaila ALASSANE BOUKARI<sup>1</sup>, Yaya SORO<sup>1</sup>, Abdourahamane TANKARI DAN BADJO<sup>2</sup>

<sup>1</sup>Laboratoire des Procédés Industriels de Synthèse, de l'Environnement et des Energies Nouvelles (LAPISEN), Institut National Polytechnique Félix HOUPHOUËT-BOIGNY de Yamoussoukro, Yamoussoukro, Côte d'Ivoire.

<sup>2</sup>Université Abdou Moumouni de Niamey, Niger, Faculté d'Agronomie, département Science des sols, Niamey, Niger

### **Abstract**

The trace metal content and pollution parameters of the soils in the gold zone of the Komabangou locality in Niger were determined. Soil samples were collected from 3 sites in the gold zone, 2 sites in the peripheral zone and 1 site for the control sample. A total of 26 soil samples were collected at depths of 0-5 cm, 5-10 cm, 10-20 cm, 20-30 cm and 0-30 cm. The concentrations of trace metal elements in the soils were determined with an X-ray fluorescence spectrometer and with ICP MS spectrometry. The results of the analyses showed that at the cyanidation site where gold panning activities take place, the trace metal elements in soils have contents of 20.78 mg/kg, 9.25 mg/kg, 114.40 mg/kg, 207.71 mg/kg, 285.38 mg/kg, 10.77 mg/kg, 443.92 mg/kg, 53.21 mg/kg and 14255.53 mg/kg on the sub-surface parts respectively for As, Cd, Co, Cr, Cu, Hg, Mn, Ni and Zn. At the same time, at the cyanidation site, the samples taken at depth have pollution indexes greater than 1 and the pollution parameters have indicated very high contamination of Cu, Co, Cd, Hg and Zn. These high levels of trace metals indicate soil contamination from gold panning activities.

### **Keywords**

Metallic trace, elements,, Pollution parameters, Komabangou, , Gold mining

## **17. Conceptualizations of Discourses on Circular Economy's Social Impacts in the Global North versus Global South: a Critical Review of Similarities and Differences**

Ilaha Abasli, Farhad Mukhtarov

International Institute for Social Studies, Hague, Netherlands

### **Abstract**

Recent academic and policy discussions on the Circular Economy (CE) gained traction in sustainability and social sciences literature not only in the context of highly industrialised countries but also in the Global South. They attempt to bring an alternative model to replace the current linear production-consumption model through more extended material use and staying within planetary boundaries.

Natural sciences and engineering scholars have mainly articulated the concept of CE. By contrast, social science has criticised techno-optimistic conceptualisations and the lack of empirical and contextual knowledge from the Global South. Critical scholars called attention to the circular economy's privileging of neo-colonial and neo-liberal approaches to development. The focus on Global North demonstrates an emphasis on well-being, decoupling benefits, and high-technology solutions and predominantly focus on circulating high-value materials in the Global North. By contrast, the focus on Global South by scholars and practitioners in the Global North points to promoting 'green growth' through waste management jobs, focusing on certain types of material circulation practices, such as installing recycling plants for hazardous and low-value materials and neglecting the social implications for the informal sector in the Global South.

Such divergence in conceptualisations and academic discourses on the Circular Economy concept and especially on its social and justice implications instrumentalises the Circular Economy as an International Development tool in the context of the Global South. It frames it as a sustainability model with the benefits of addressing climate change and transforming lifestyles and social-economic-environmental relations in the Global North. However, these divergent conceptualizations potentially re-produce and replicate pre-existing inequalities in development and create silos on equity and justice considerations of the Circular Economy concept.

This paper conducts a critical narrative review of selected academic and policy literature published from 2010 through 2022. It investigates fundamental conceptualisations and discourses around the Circular Economy while attempting to find out how and to what extent such conceptualizations differ in the context of the Global North and Global South. The paper contributes to the developing critical scholarship on the Circular Economy from the angle of socio-ecological impact.

### **Keywords**

Global South, climate justice, circular economy, informal sector, social impact



## **18. Curbing Illicit Financial Flow Risks in Ghana's Crude Oil Sales: Legal and Other Policy Options.**

Jennifer Hall<sup>1,2,3</sup>, Adzo Baku<sup>1,2,4</sup>

<sup>1</sup>Swiss Program for Research on Global Issues for Development (r4d programme), Bern, Switzerland. <sup>2</sup>Institute of Statistical, Social and Economic Research, Accra, Ghana. <sup>3</sup>University of Ghana School of Law, Accra, Ghana. <sup>4</sup>University of Saskatchewan, Saskatoon, Canada

### **Abstract**

Resource-rich countries like Ghana tend to lose a lot of valuable revenue to illicit financial flows (IFFs). As such, there have been lots of concerns about how Ghana can maximize revenues from its nascent oil discovery for sustainable development. Over the years, some progress has been made in ensuring that the state's upstream oil activities are regulated to address IFFs. This progress notwithstanding, the risk of IFFs associated with crude oil sale transactions remains an area of great concern in Ghana's efforts to eliminate IFFs to finance the Sustainable Development Goals (SDGs). Although in comparison to other countries, Ghana is one of the most transparent on commodity trade reporting, many opaque areas which present avenues for revenue loss through IFFs exist. Consequently, the paper identifies some legal and regulatory gaps that enable IFFs in the country's crude oil sale transactions. In particular, the dangers of merging oil sales with other official transactions, corruption, rent-seeking in the oil trades, and transfer pricing by private oil corporations operating in Ghana are evaluated, and recommendations to prevent these are provided. Over the years, resource-rich nations have used prepayment agreements, crude-for-petroleum-product exchange agreements, and oil-backed loans to exchange their crude oil deposits for revenue. In light of this, an oil-backed loan procured by the Government of Ghana is highlighted and analyzed. The risks of corruption associated with choosing a buyer to trade the producer country's oil wealth, negotiating the sale terms, and transferring the sale earnings to national treasuries are also examined. Upon critically assessing the issues identified, the paper suggests the parliamentary oversight of resource-backed loans, reform of oil-sale pricing options, and the formulation of specific regulations on the buyer selection process as well as the formation of an independent buyer selection team free from political influences. Further, the amendment of Ghana's Income Tax Act 2015, Act 896 and Petroleum Revenue Management Act 2015, Act 893 to include specific clauses on the management and regulation of resource-backed loans and the payment of taxes on hedged income is recommended.

### **Keywords**

Illicit financial flows , Natural resource governance, Oil and gas , Commodity trading, Sustainable development Goals

## 19. Advancing the sufficiency paradigm with digital product passports

Marta Santos Silva

Research Centre for Justice and Governance, Braga, Portugal. Maastricht European Private Law Institute, Maastricht, Netherlands. Centre for European Law and Politics, Bremen, Germany

### Abstract

Under the EU Green Deal framework, Europe set the objective of becoming the first climate-neutral region by 2050, which was followed by a series of initiatives aimed at improving the sustainability of production processes.

According to the European Commission (EC), up to 80% of a product's lifecycle environmental impact is determined at the design stage. To reduce such a high impact, as well as to increase the durability and improve the reparability and recyclability of products, the EC released a Proposal for an Eco-design for Sustainable Products Regulation (ESPR) in March 2022.

One of the key regulatory elements of such a proposal is the Digital Product Passport (DPP). It consists of a machine-readable identification number that will allow tracing the origin of all materials and components used in the manufacturing process of everyday consumer goods.

The implementation of digital product passports in supply chains is designed to support sustainable product production, by enabling the transition to a circular economy and thereby increasing material and energy efficiency, extending product lifetimes, and optimizing product use.

Through the Proposal for an Eco-design for Sustainable Products Regulation, the EU's existing ecodesign rules, currently applied to electric appliances only, shall apply also to textiles, construction materials, industrial and electric vehicle batteries, and at least one other of the key value chains identified in the Circular Economy Action Plan such as consumer electronics, packaging, and food.

One of the most mentioned advantages of the DPP in the literature is that, by allowing a more efficient sharing of information across value chains, it enhances transparency, allowing consumers, producers, and other stakeholders to become aware of the environmental impacts of products and adapt their transactional decisions accordingly. However, the potential of the DPP for advancing the transition from a linear to a sufficient economy is, to date, still unexplored and the present paper purports to fill in this gap.

### Keywords

digital product passport, transparency, sustainable production, circular economy, premature obsolescence

## **20. Community Experiences with Mining –Induced Compensation and Resettlement in the Adansi Districts of Ghana.**

Robert Tanti Ali

Center for Social Impact Studies, Obuasi, Ghana

### **Abstract**

Background: Multinational gold mining companies who operate in mineral-rich developing countries continue to profit from their activities while the nexus amongst company profits, socio-economic and environmental outcomes in the local communities within which they operate are weak. Community inhabitants lose lands, cultural sites, cultural identity, income-earning assets and sources, networks and social ties due to resettlement. Additionally, community inhabitants face several challenges which includes resettlement problems, environmental degradation and human rights abuses. Communities are shortchanged because they have no or little capacity to negotiate with multinational companies. To deal with some of these issues, the 1992 constitution and the Minerals and Mining Act, 2006 (Act 703) the Minerals and Mining (Compensation and Resettlement) Regulations, 2012 (LI 2175) have been promulgated to address issues of fair, adequate and timely payment of compensation claims and resettlement related issues. Despite this regulation, the current legal and regulatory regime fails to compensate lands and for the use of common resources in communities. Also, the adequacy of compensation has been questioned by community inhabitants. Due to this, work needs to be done to understand power dynamics, processes, actions and community experiences regarding what the law states and what is practiced.

Objective: This study sought to find out the dynamics at play at the community level in processes leading up to, during and after negotiations around resettlement and compensation, including identification of the actors, their roles and their power to influence the process.

Method: The study used a mixed method approach. This comprises four key approaches namely, a desk review, a Focus Group Discussion (FGD), Key Informant Interviews (KIIs) and a survey. The desk review was begun in June 2022 while FGDs, KIIs and the survey were conducted in July 2022.

Findings: Most residents of the impacted mining communities are unaware of the applicable laws governing resettlement and compensation, and those who are aware of the laws have little or no understanding of the legal frameworks. Linked to this, their lack of understanding negatively impacted how they engaged with mining Company. Gaps also existed in the company's resettlement and compensations procedure and what was implemented. There were indications of nifty and unfulfilled promises, involuntary displacements and little or no resettlement support systems to persons and families.

Conclusion: Civil Society Organizations should empower communities seeking resettlement on compensation and resettlement provisions, key State institution involved, negotiation skills, compensation principles, policies, procedures and compensation rates.

### **Keywords**

Compensation, Resettlement, Mining, Community, Payment

## 22. Transforming traditional waste management in cities into zero waste cities, through the digitization of municipal plans for integrated management of urban solid waste. Case study in Florianópolis

[Gustavo Rittl](#)<sup>1</sup>, Fabio Braga<sup>2</sup>, Lucas Arruda<sup>3</sup>, André Sartori<sup>4</sup>, Murilo Wirtti<sup>5</sup>, Karina Souza<sup>6</sup>, Ulisses Laureano Bianchini<sup>7</sup>, Diana Andréia Bastezini<sup>8</sup>, Simone da Silva Hillesheim<sup>9</sup>, Leticia Rech Debiasi<sup>9</sup>, Francisco Henrique de Oliveira<sup>10</sup>

<sup>1</sup>Social Scientist, Florianópolis, Brazil. <sup>2</sup>Municipal Secretary for the Environment and Sustainable Development, Florianópolis, Brazil. <sup>3</sup>Deputy Secretary for the Environment and Sustainable Development, Florianópolis, Brazil. <sup>4</sup>Systems Analyst - At CTMGEO, Cascavel, Brazil. <sup>5</sup>Civil Engineer at CTMGEO, Cascavel, Brazil. <sup>6</sup>Sanitary and environmental engineer PMF, Florianópolis, Brazil. <sup>7</sup>Waste Management Superintendent, Florianópolis, Brazil. <sup>8</sup>Collection Planning Manager, Florianópolis, Brazil. <sup>9</sup>Sanitary and environmental engineer, Florianópolis, Brazil. <sup>10</sup>Departamento de geografia, UDESC, Florianópolis, Brazil

### Abstract

The article reports the first digitalization experiences of the integrated management plan for urban solid waste [PMGIRS](#), in the municipality of Florianópolis, Santa Catarina, Brazil. This is the legal urban planning instrument for cities to plan and manage urban solid waste in accordance with the principles and objectives of the National Solid Waste Policy Law [12305\2010](#).

The municipality of Florianópolis is known in Brazil as one of the most advanced cities in urban solid waste management. The local government has [decreed](#) to become a zero waste city by the year 2030, and has been demonstrating some initiatives and innovations in the sector. Proof of this is the [residueometer](#), a first digital experience, the result of this work, which tries to digitize some essential indicators of the program, such as a) diversion of waste from the solid landfill, b) the total of recyclables collected, c) the total of organics collected, d) total CO2 emission avoided, e) value saved by diverting resources from the landfill and f) percentage of landfill diversion.

Even so, the municipality is far from innovative models of management, articulation and promotion of public policies in the sector, proof of which is the fact that it has not achieved the goals stipulated by the National Solid Waste Policy L 12,305.

One of the initiatives of the local government has been the attempt to digitize, not only the internal processes of the local government related to PMGIRS, as well as to provide digital services to citizens, companies and organizations that have a direct relationship with the value chain of generation and management of urban solid waste. Thus, this article aims to show the evolution of the residueometer to the new version that is being developed, applying geotechnologies, management principles and territorial planning and digitization of processes.

Initially, a direct impact on the management, planning and response speed of the local government to waste management demands is observed. The [Floripa Lixo Zero platform](#) is intended to be a planning, management and multi-user interface tool for all actors in the urban solid waste value chain, in order to collaborate with the implementation of the Floripa Zero Waste Capital program, with the objective of zeroing sending natural resources to the landfill by the year 2030. The article presents the first development methodologies, results and perspectives presented by the interested parties in the project.

### Keywords

digitalization, zero waste cities, geotechnologies, natural resources, innovation in governments

## **24. Designing digitally enabled collaborative business models for a plastic circular economy in the UK**

Adeyemi Adelekan, Maria Sharmina

Tyndall Centre for Climate Change Research, University of Manchester, Manchester, United Kingdom

### **Abstract**

While digital technologies can enable the development of new business models and collaborations for the circular economy (CE), there is limited knowledge on its application to the plastics sector that contribute 54% of the global mass of waste from human activities, causing greenhouse gas emissions and marine litter. Also, as the circular economy requires firm and system level approaches, there are increasing calls for system-level studies with emphasis on exploring the application of digital technologies in developing collaborative business models. Our study employed a multi-step qualitative approach to explore these issues, taking the case study of a consortium consisting of actors across the UK plastic supply chain. The consortium aims to develop collaborative business model for a One Bin system for managing plastic waste in the UK. We collated data from fifteen plastics sector actors primarily through interviews, design workshops and audio-visual materials. Our findings highlight the value retention and data-as-a-service business models that could be enabled by digital technologies in the UK plastics sector. We describe the business models in detail and the value that could be created for multiple stakeholders to capture commercial, social and environmental value. Our findings also highlight the important but less explored issue of governance of collaborative business models. We argue that tensions among stakeholders, likely to arise during the design phase, might delay experimentation with circular business models and enacting collaborations at the systems level. Our study sheds light on specific tensions arising from incentivising digital technology investments, control of access to system outputs and outsourcing of digital asset management, while also highlighting the need for a safe space for cost-free or budget-friendly experimentation as a potential means of addressing collaborative tensions.

### **Keywords**

Digital Technology, Systems level, Circular economy, Business models, Plastics

## 26. Measuring the Doughnut: Is a good life for all possible within planetary boundaries?

Hauke Schlesier<sup>1</sup>, Malte Schäfer<sup>2</sup>, Harald Desing<sup>1</sup>

<sup>1</sup>Empa – Swiss Federal Laboratories for Materials Science and Technology, Technology and Society Laboratory, St. Gallen, Switzerland. <sup>2</sup>Institute of Machine Tools and Production Technology (IWF), Technische Universität Braunschweig, Germany, Braunschweig, Germany

### **Abstract**

Despite tremendous economic developments, parts of the human population are still deprived of decent living. At the same time, humanity is collectively continuing a path towards ecological instability that threatens the livelihood of current and future generations. Researchers like Raworth postulated a safe and just operating space for humanity where social foundations and planetary boundaries are simultaneously met. However, evidence on the achievability of such a state for maximum expected population size and current or improved technologies is lacking. Here, we present theoretical evidence on the existence and size of the safe and just space. For this, material and energy requirements for the satisfaction of basic needs are identified and a life cycle assessment is carried out determining impacts on planetary boundaries. The difference between impacts scaled with the expected world population and planetary boundaries demarcates the safe and just operating space. Furthermore, a contribution analysis is applied to derive a sufficiency-based allocation key for nine resource segments and eleven impact categories. This allows estimation of a sustainable resource base for a steady-state circular economy. The results show that decent living within eleven boundaries for 8.0 (10.4) billion people is possible with at least 81% (73%) probability – if basic needs are satisfied via fossil free provisioning systems, diets are essentially vegan and cropland expansion is halted. To create an operating space beyond sufficiency, agricultural practices need to be transformed to be less CO<sub>2</sub>-, N- and P-intensive. We see future research potential in modelling such circular, more sustainable agricultural processes.

### **Keywords**

safe and just operating space, sufficiency, doughnut economics, resource budget, planetary boundaries

## 27. Decarbonisation to drive dramatic increase in mining waste – Options for reduction

Eleonore Lebre

The University of Queensland, Brisbane, Australia

### **Abstract**

Global demand for energy transition metals is expected to lead to an intensification of mining activities and an increase in associated land disturbance and mine waste volumes. This research forecasts global mine waste generation for four metals needed in batteries: copper, lithium, manganese, and nickel, and finds that waste volumes are likely to rise exponentially. Waste generated by the extraction of these four metals is predicted to amount to 953 Gt over the 2020–2050 period.

Alternative extractive processes are required to achieve consequent waste reduction. Beneficial reduction outcomes include (1) smaller volumes and footprint area, (2) lower toxicity and chronic contamination, and (3) lower risk of catastrophic tailings dam failures. This research reviews six mining, processing and waste management innovations that, if taken in combination, may achieve the needed reduction: mine waste (re)processing, environmental desulphurisation, dry-stacking and co-mingling, preconcentration and coarse particle flotation, ore-sand co-production, and in-situ recovery. None of these innovations can tackle the mine waste challenge individually but, together, they provide promising alternatives to the current, increasingly wasteful mining practices. Great potential lies in pairing and concurrent implementation of these six methods.

We stress that the feasibility and suitability of these innovations are highly site dependent. Feasibility is primarily concerned with the balance of cost and revenue which should be based on valuation models that place a realistic cost on the riskiest forms of waste rock and tailings. Suitability considerations are further concerned with adapting mine planning to local social, cultural, political, economic, and ecological conditions. A given geography dictate what is suitable for a particular mine site.

We may be moving towards a time where purely economic considerations around mining practices will be overridden by regulator and community demand, and where stakeholders will no longer allow the kind of mining expansion forecast in this research. A decrease in waste-related impacts may make it easier to permit new operations in the time frame required to meet the metal demands of future decarbonisation.

### **Keywords**

Waste, Tailings, Energy transition, Circular economy, Mining practices

## **28. Phosphorus recycling from wastewater – The funding measure RePhoR (Regional Phosphorus Recycling) of the German Federal Ministry of Education and Research (BMBF).**

Sophia Schüller, Johannes Pinnekamp, Kristoffer Ooms

FiW e.V., Aachen, Germany

### **Abstract**

As a natural element of the earth's crust Phosphorus is an essential and non-substitutable component in all living organisms. Most importantly, it is required as phosphate in fertilizers for agriculture. The largest deposits of phosphate minerals are found in Africa (Morocco, Western Sahara), in China and in the USA. However, the economically exploitable deposits are finite. Many large deposits are underwater or have heavy metal contamination, which makes them uneconomical to mine. From this point of view, the so-called primary phosphorus is a critical raw material, so that it is necessary to develop and establish recycling technologies and organizational forms to enable a phosphorus circular economy close to the places of use and to significantly reduce the dependence on imports. Technologies to recover phosphorus from wastewater are known, but currently hardly implemented on a large industrial scale, so that little scientifically based knowledge and practical experience under real conditions are available.

The German Federal Ministry of Education and Research (BMBF) has therefore launched the funding measure "Regional Phosphorus Recycling (RePhoR)" as part of the BMBF strategy "Research for Sustainability (FONA)". By increasing the use of secondary phosphorus, Germany's dependence on phosphorus imports is to be significantly reduced.

Within the implementation phase, seven collaborative projects have started in July 2020. Different phosphorus recyclates are to be recovered from the various material streams of wastewater, sewage sludge and sewage sludge ash in (large-scale) technical plants. For the locally produced sewage sludge, innovative regional recycling concepts are being developed that close the gap between P-recovery and P-recycling and thus return the recovered phosphorus to the nutrient cycle via agriculture or as a raw material to industry. The addressed regions for P-recycling differ in size, sewage sludge generation and structure (e.g., rural regions and metropolitan areas), so that transferability of the results to other regions is possible. In the face of global challenges and rising prices, business and pricing models for recyclate distribution and acceptance need to be rethought. The results will be combined in a transfer and accompanying project which also identifies and considers cross-cutting issues such as legal questions and life cycle assessments.

### **Keywords**

Phosphorus recycling, Secondary resources



### **31. Measuring trade mis-pricing in Ghana's International Commodity Trade: a case of Bauxite and Manganese**

Angela Alu, Joshua Abor, Mohammed Amidu, Ama Ahene-Codjoe

University of Ghana, Legon, Ghana

#### **Abstract**

This paper contributes to the limited empirical analysis of the volumes of Illicit Financial Flows through trade mis-invoicing recorded from Ghana using two of Ghana's top export commodities which are operated by a single operator; namely bauxite and manganese.

The paper adopts a mixed method approach and thus conducts a value chain analysis to qualitatively identify the risks for IFFs in the sector. This shows that risks for IFFs arise mainly from transfer pricing due to multinational firms' international trade operations.

The study quantitatively estimates the IFFs in the selected commodities using both the Price Filter method and the Partner Country Trade Gap method.

The estimates of trade mis-invoicing generated using the transaction level data from Ghana Customs with the price filter methods indicate that: 18.87% of bauxite exports and 0.65% of manganese exports were undervalued while 4.7% and 2.4% of bauxite and manganese exports respectively were over-valued over the period from 2011 to 2017. Similarly, the Partner Country Trade Gap estimates also show undervaluation of exports. Overall, the results indicate the presence of trade mis-pricing in Ghana's commodity exports.

The study recommends that policymakers need to prioritize the development of institutional expertise to map, control and block the sources of the resulting tax base erosion as a result of trade mis-pricing.

#### **Keywords**

Commodity Trade, Ghana, Trade Mis-pricing, Bauxite, Manganese

## **32. Maturity management on resources efficiency in small and medium enterprises: a Life cycle approach**

Daiane Silva, João Victor Salla, Marina Silva, Antônio Farrapo, Ana Carolina Albino, Diogo Silva

Sustainability Engineering Research Group, Federal University of São Carlos, Sorocaba, Brazil

### **Abstract**

Small and medium-sized enterprises (SMEs) account for about 90% of the enterprises and more than 50% of the jobs generated worldwide. In Brazil, SMEs represent 99% of the establishments and were responsible for 54.4% of the jobs in 2018. At the environmental level, SMEs tend to generate relevant pollution and carbon emissions, which are poorly explored in the current literature. The aim of this study was to analyze the maturity of SMEs in Brazil from the perspective of life cycle management (LCM) in the efficient use of resources. For this, we used a self-assessment tool developed by Green Industry through the I-GO initiative (<https://igosolution.org/>). This tool provides a framework that helps managers to measure the maturity of their companies and to increase the efficiency of their resources. The study was conducted with nine Brazilian companies from different sectors: food processing (1), manufacturing (3), digital services (4), and agricultural services (1). About their size, four were characterized as small-sized, two as medium-sized, and three as large-sized companies. The results pointed out that 55.6% of the companies do not have any type of action focused on the resource efficiency strategy, energy management, and efficiency in the use of materials. In addition, 66.7% of the companies do not have any type of action aimed at saving water, and 33.3% of them do not have activities for waste management. Thus, only 11.1% of the companies analyzed have advanced/very good maturity in terms of the resource efficiency strategy, energy management, and water-saving categories. In contrast, for the material efficiency and waste management categories, the advanced maturity status was obtained by only 22.2% of the companies. The best results (advanced maturity), which include an LCM perspective, were found in large companies, while the beginner/intermediate maturity results stood out more among the SMEs. Therefore, to advance in the maturity of SMEs, more efforts are needed in the systematic audit and/or the periodic monitoring system of resource efficiency in companies. Lastly, we provided a simple step-by-step procedure to start developing/including resource efficiency strategies based on eco-innovation theory and tools to sustain innovative and circular business models in SMEs.

### **Keywords**

Eco-innovation, Resource efficiency, Life cycle management, Sustainable development.

### **33. The need for design-for-recycling of paper-based printed electronics – a prospective comparison with printed circuit boards**

Akshat Sudheshwar, Nadia Malinverno, Roland Hirschler, Bernd Nowack, Claudia Som

Empa, St. Gallen, Switzerland

#### **Abstract**

The present study compares conventional printed circuit boards (having glass-fibre and epoxy substrates and etched copper circuits) with paper-based printed electronics (offering flexible, bio-based, and biodegradable substrates with circuit design printed using silver-based inks) and assesses the relevance of e-waste recycling to the latter's sustainability. Therefore, a comparative life cycle assessment between these two options has been undertaken and the global warming impacts were calculated.

The impact assessment results underscore that printed electronics offer a consistent sustainability advantage over printed circuit boards only through recycling of silver in the former at the end-of-life. Hence, design-for-recycling and recycling as e-waste are crucial to the sustainability of the current generation of printed electronics. Other foreseen waste treatment options for paper-based printed electronics, such as composting, and paper recycling, are likely to limit the sustainability advantage of printed electronics to circuits with small conductive areas.

#### **Keywords**

Printed electronics, Sustainable electronics, Recycling, WEEE, Carbon footprint

## **36. Identifying the needs for a circular workwear textile management – A material flow analysis of workwear textile waste within Swiss Companies**

Nadia Malinverno<sup>1</sup>, Mélanie Schmutz<sup>2</sup>, Bernd Nowack<sup>1</sup>, Claudia Som<sup>1</sup>

<sup>1</sup>Empa, St.Gallen, Switzerland. <sup>2</sup>MyClimate, Zürich, Switzerland

### **Abstract**

The textile sector with its linear management leads to environmental damage and high amounts of postconsumer waste. Circular economy has been identified as a promising solution. Workwear is assumed to have high potential for circularity because of its high, constant, and uniform material quality and quantity. There is little research on categorized material waste flows of workwear. To fill this gap, workwear flows of eight Swiss companies in 2019 were collected and analyzed. The results show that 1.6 kg/y/worker of workwear are procured. Concerning waste management, 0.6 kg/y are reused, 0.7 kg/y are incinerated, and 0.3 kg/y are recycled. According to the extrapolation, 0.4 kg/y/capita of workwear were consumed. The most weight-represented material type is mixed material, dominated by polycotton. Natural material, is the second biggest category, followed by synthetic and cellulosic materials. This study emphasizes the importance to monitor workwear flow data to enhance cooperation throughout the textile value chain and initiate circular management.

### **Keywords**

Workwear, Textile waste, Material flow analysis, Circular economy, Waste management

## 37. Implementing circular economy in EU regions – a policy Delphi study

Sanja Arsova<sup>1,2</sup>, Andrea Genovese<sup>2</sup>, Panayiotis Ketikidis<sup>1,3</sup>

<sup>1</sup>South-East European Research Centre, Thessaloniki, Greece. <sup>2</sup>Sheffield University Management School, The University of Sheffield, Sheffield, United Kingdom. <sup>3</sup>CITY College, University of York Europe Campus, Thessaloniki, Greece

### Abstract

Regions are the most important administrative units of the EU's development policies and regional funds allocation and so far, have been widely used for devising and attaining strategic priorities. Nevertheless, when it comes to regional implementation of the circular economy (CE), there is lack of systematicity both in academic literature and policy documents. Therefore, this study is proposing regions as the optimal scale for CE adoption; due to their controllable economic systems, tactical intermediate position between national and local levels, their deep knowledge and understanding of their local territories, capacities and ability to mobilise relevant stakeholders. Within this context, this empirical study is focusing on the implementation of CE policies at the regional level. More specifically, to investigate whether Smart Specialisation Strategies (S3) influence the adoption of CE policies at the regional level and explore the influence of institutional pressures on the implementation of regional CE policies. In order to address the main aim, a three-stage policy Delphi study was designed, targeting regional policymakers and experts in the field of CE and S3. Additional knowledge was mobilised with the involvement of prominent academics and higher-level experts in the EU and UN policymaking process. A brief online survey was initially distributed and 42 participants representing 32 different EU regions responded. Afterwards, 17 semi-structured individual interviews followed, and the findings were validated in a final focus group. This study has found that generally, the EU measures will need to take into account the protagonist role of the regions in many vital aspects of the CE transition. The emerging findings point out to the importance of effective multi-level governance mechanisms and supportive institutional environment as conducive for the development and realisation of the CE initiatives. Additionally, the incontestable links between S3 and CE were corroborated, as well as the strong arguments for adopting a place-based approach for the CE transition. However, the S3 and CE nexus proved to be less deterministic, as concerns regarding the potential risk of regional lock-ins and path dependency issues were also raised. Alongside the theoretical contribution, the findings of this research will have practical implications as well; findings which could be of interest for policymakers at different levels, in terms of decision making and devising regional policies, as well as for practitioners for encouraging bottom-up actions for future implementation of the CE at the territorial level.

### Keywords

circular economy, regional policy, smart specialisation strategies, institutional pressures, policy Delphi study

## 39. Material Consumption and Climate Change – The Case of Switzerland

Heinz Boenji<sup>1</sup>, Cecilia Matasci<sup>2</sup>, Marcel Gauch<sup>1</sup>

<sup>1</sup>Empa, St. Gallen, Switzerland. <sup>2</sup>University of Lausanne, Lausanne, Switzerland

### Abstract

In order to conserve our resources for future generations and overcome the climate crisis, material consumption must be reduced; goods must be reused and material cycles closed. With an annual consumption of 10 tons per person, material consumption in Switzerland is very high. Greater efforts are needed to achieve the climate targets.

In the study "MatCH – Material- and energy flows and associated environmental impacts in the Swiss Economy" commissioned by the Federal Office of Environment, we developed a material and energy flow model which allowed to simulate stocks and flows of the Swiss economy. The model was built up combining the three main sectors of the economy: construction, mobility and production and consumption. Methodologically a material flow analysis was combined with a simplified life cycle assessment. With this, the model allowed us to determine the environmental impacts induced by material consumption and the related direct and indirect energy flows and GHG emissions. With different scenarios for measures taken by individuals, government and industry, the future reduction pathway of GHG emissions could be modeled.

Looking at the material flows, concrete accounts with around 40 million tons for almost half of Switzerland's annual material consumption. This is followed by the mayor energy sources fuels and electricity (converted into oil equivalents) with a total of 17 %. In third place is food for humans with 10 %. The high share of food shows impressively what the inhabitants of Switzerland "metabolize" each year.

Comparing material flows with their environmental impact, the picture shifts significantly in some cases. If CO<sub>2</sub> emissions are used as a measure, fuels and combustibles are the front-runners with half of Switzerland's CO<sub>2</sub> emissions. This is followed by food for humans with a share of 18 percent. Concrete, on the other hand, falls well behind with a still modest 3 per cent. of

The analysis of different consumption patterns of individuals taken within their sphere of influence revealed that even if all Swiss citizens would act as the 20% with the most climate-friendly consumption behavior, the national GHG emissions would only be reduced by an estimated 16%. This underlines the fact that consumption behavior alone cannot bring anthropogenic GHG emissions down to zero. The socio-economic systems determine the limitations of individual behavior. Strong and concerted strategies and measures taken by governments and industries are needed to reach our climate goals and to combat the climate crisis successfully.

### Keywords

Climate Change, Circular Economy, Consumption patterns, Material Flow Analysis, Life Cycle Assessment

## **40. Life Cycle Sustainability Management (LCSM) in SMEs – Learnings from electronics in the developing economies**

Sonia Valdivia<sup>1</sup> · Robert Reinhardt<sup>2</sup>

<sup>1</sup>WRF, St. Gallen, Switzerland. <sup>2</sup>UNEP, Bonn, Germany.

### **Abstract**

Introduction. Small and Medium Enterprises (SMEs) play a major role in most economies, particularly in the developing ones (contributing to GDP with over 55% and to job creation with over 65%). The focus of this paper is on SMEs from the electronics sector. SMEs involved in electronics in the developing economies represent a majority. Moreover, typically, these SMEs are not electronics components producers (e.g. printed circuit boards, transistors, li-ion batteries) but assemblers importing components e.g. from Asia. Another feature of the downstream value chain of electronics in the developing economies is the high composition of micro-enterprises and individuals subsisting with the end-of-life management of e-waste (individuals doing subsistence activities are also defined by some legislations as informal workers).

Moreover, in these countries, the end-of-first-life management is further developed and expanded with accessible expertise required (e.g., for repairing and refurbishing, software upgrading, etc.). There is a growing market for used electronics.

Method and aims. Five pilots were conducted in 2021–2022 in Colombia and Peru to investigate the social and environmental hotspots along the life cycle and improvement measures, namely, LCSM actions. The pilots based on the UNEP/WRF Supplement for Electronics (2022) (<https://wedocs.unep.org/handle/20.500.11822/41519>)

Results. Social hotspots identified link to two stakeholder groups: workers (e.g. exposure to chemicals of concern and questionable ergonomic conditions for women in certain conditions) and suppliers upstream and downstream (e.g. poor working conditions if individuals are engaged in subsisting activities). Environmental hotspots relate to impacts on land and water (e.g. from e-waste and packaging due to poorer waste management infrastructures available) and on resource depletion (e.g. of critical raw materials such as lithium and cobalt).

Measures cover improved chemicals management along the value chain by enhancing cooperation with components producers, eco-design of packaging, extended producer responsibility programs, and new business models for allowing the lifespan extension of electronics.

### **Keywords**

LCA, sustainability, eco-innovation, social hotspots, environmental hotspots

## **43. Visions and perspectives on climate change in mining companies in Latin America**

Sandra Carrillo

Pontificia Universidad Católica del Perú, Lima, Peru

### **Abstract**

The mining sector is highly relevant to the world's energy transition, given the demand for critical minerals required to achieve ambitious climate goals. As recognized by the International Council on Mining and Metals (ICMM), most green projects require the extraction of natural resources. This is a very interesting opportunity for Latin America and at the same time requires that the mining sector be prepared for this multidimensional process.

Faced with this context, this paper seeks to understand to what extent this demand towards the mining sector will be consistent with a robust climate vision in these companies, considering the impacts derived by this activity on territories rich in biodiversity. This study is highly relevant bearing in mind that the anticipated high demand for critical minerals that are extracted in Latin America, without strategic sustainability management, can generate trade-offs for local ecosystems.

This paper seeks to characterize the vision of Latin American mining companies on climate change. Specifically, it seeks to answer: 1) how present is climate change in the discourse of CEOs and in the public reports of mining companies? 2) What is the scope of climate change strategies for mitigation and adaptation? And 3) To what extent are you focusing on ecosystem restoration as part of the climate change vision?

This paper is based on the hypothesis that the level of understanding of the challenges of climate change is still underestimated at the level of senior management of mining companies. With the data collected in this study, derived by interviews with CEOs and sector leaders, as well as the review of annual reports, it will be possible to identify the gaps at the level of strategies and subsequent investments in ESG management of mining companies in the coming years.

### **Keywords**

climate change, mining, energy transition, critical minerals, ecosystems



## **44. Sustainability Assessment of neighborhoods in a national Sustainable Building perspective: Approaching sufficiency measure integration**

Annika Hock

Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR), Berlin, Germany

### **Abstract**

In the setting of climate and energy crises, climate neutrality as a term is widely introduced for outlining development goals. Regarding the built environment, Germany's national climate targets approach the building sector covering the energy supply needed during building operation. Renewable energy supply and energy renovation strategies combine efficiency and consistency measures, while the integration of sufficiency in climate neutrality concepts appears to be necessary, but underrepresented. In the built environment, this implies inter alia the inclusion of embodied energy by a full life cycle perspective and a deeper understanding of buildings in a spatial relation. To develop sufficiency strategies as measurable assessment criteria, Sustainability Assessment (SA) offers a tool to holistically approach impacts commonly in respect of ecological, economic as well as socio-cultural dimensions. SA of buildings is already widely spread within the national context, a buildings broader spatial perspective and positioning towards climate neutrality, however, is inconsistent. Accordingly, this investigation approaches national sustainability targets for buildings and their spatial relation by a determination of sufficiency criteria and a qualitative analysis of their representation in existing neighborhood SA tools. Further, outlined criteria come under relevant actors, time of implementation and connected regulations. Neighborhood criteria are determined based on energetic, constructional, social and regional relations, while system boundaries regarding assessment and implementation are approached by closer criteria specifications. The findings provide a systematic approach of neighborhood sufficiency assessment. In an upcoming case study, sufficiency reference objects will exemplary approach a practical examination.

### **Keywords**

sufficiency, neighborhood, climate neutrality , building stock

## 45. Mobilising materials for the energy transition

Harald Desing

Empa – Swiss Federal Laboratories for Materials Science and Technology, Technology and Society Laboratory, St.Gallen, Switzerland

### **Abstract**

The increasing urgency to prevent dangerous climate change above 1.5°C heating necessitates fast energy transitions in all sectors. The material demand of these transitions (e.g. to build wind turbines, electric vehicles and electrolyzers) is expected to be several times the current annual supply for many technology metals and a significant share of bulk metal supply. At the same time, transition models are usually "energy and materials blind", i.e. do neither account for the availability of materials nor energy investments necessary to build the required infrastructure. The mobilisation of materials in sufficient quantity and quality is critical to fast transitions.

This presentation will introduce the material mobilisation framework, developed for including the dynamic feedbacks and interconnectedness between energy and materials in energy transition modelling. Different mobilisation routes are identified: repurposing existing in use stocks, diverting current primary production through increased circularity and reduced demand in the existing economy, increasing primary production by opening new extraction routes from the environment, and remining losses such as tailings, landfills, and past emissions. All these routes have different energy costs, i.e. the mobilised material flow requires energy, which itself depends on the quality of the source stock (e.g. ore grade of mining deposits, contamination of wastes) and the size of the flow. Furthermore, time delays are in some cases unavoidable—e.g. the time required for exploration, obtaining permits and opening mines; or the point in time when fossil infrastructure becomes obsolete.

### **Keywords**

energy transition, circularity, mining

## 46. Liberation: a new paradigm for a planet compatible and equitable society

Harald Desing<sup>1</sup>, Fabian Takacs<sup>2</sup>

<sup>1</sup>Empa – Swiss Federal Laboratories for Materials Science and Technology, Technology and Society Laboratory, St.Gallen, Switzerland. <sup>2</sup>University of St. Gallen, Institute of Management & Strategy, St.Gallen, Switzerland

### Abstract

Our collective appetite for more, relentless economic growth has navigated the global society into multiple environmental and social crises. Ongoing efforts to change our predicament under the current cultural paradigms—such as green growth, efficiency, and gradual technological change—are failing. For example, greenhouse gas emissions are still rising faster than ever, despite 27 COPs, ambitious national commitments, and exponential growth in renewable energy installations. Simultaneously, the urgency for action is increasing by the minute, requiring incredibly more ambitious plans.

The current sustainability debate centres around supposedly opposing principles of efficiency, technological change (consistency), and sufficiency. All of them cannot deliver the required transformation alone: efficiency is usually offset by increased consumption (e.g., rebound effect) and can only reduce, but not avoid impacts; technological change will either be too slow when demand keeps growing or carries unpredictable or unintended adverse side effects (e.g., nuclear power, bioenergy); and sufficiency, i.e., shrinking the human enterprise through behavioural and preference adjustments with the aim of reducing, will have a hard time being accepted and will not be sufficient on its own to finally stabilizing the climate.

However, society should realize that one principle is not enough, as we need to both expand and minimize anthropogenic activities on planet Earth simultaneously: expand to (i) build renewable energy infrastructure fastest, which requires unprecedented amounts of energy, materials, and skills; and (ii) clean-up the atmosphere from accumulated CO<sub>2</sub> to avoid triggering tipping cascades. This is only feasible if the final demand from society remains constant or, better, even declines; a more equitable distribution implies that the rich 20% have to reduce consumption considerably (minimizing). All of this combined requires an integrated paradigm, which we call **liberation**. It is about the liberation from the constraints of our prevailing mindset and cultural guideposts, which then allows to liberate from fossil path dependencies, the curse of past emissions, and inequality.

### Keywords

Sufficiency, Transition, Inequality

## 47. ICT and clean cooking fuel adoption: the case of urban households in Cameroon

Armand Totouom

University of Dschang, Dschang, Cameroon

### **Abstract**

despite the effectiveness of clean cooking fuels in reducing household air pollution and its other harmful consequences, numerous households still rely on solid fuel and kerosene for cooking and heating. Worldwide, around 2.6 billion people still cook using solid fuels and kerosene in open fires and inefficient stoves. Most of these people are poor, and live in low- and middle-income countries (WHO, 2021). In Cameroon, nearly 80% of the population lives in households using solid fuels for cooking, while 3% uses kerosene and 16% uses clean fuels (NIS, 2015). Such low clean cooking fuel adoption raises questions on the factors driving household fuel choices. Though the analysis of factors driving household to switch to clean fuels has received growing attention from scholars during recent decades, little is known about the contribution of ICTs. This study remedies this by assessing the effect of ICT measured by mobile phone and internet penetration on clean fuel adoption in urban Cameroon. Given the importance of ICT in disseminating information on health benefits of using clean fuel and the availability of alternative cooking fuels for instance, understanding the relationship between ICT and clean fuel adoption would provide important insights for policy-makers as to what sorts of interventions might be effective in reducing urban pollution through clean fuel adoption. Using data from the Cameroon Multiple Indicator Cluster Survey, results from our recursive bivariate estimations show that information disseminated through ICT significantly increases the likelihood of using clean fuels for cooking among urban households. They also suggest that city size matters when assessing the impact of ICTs on fuel choice. Specifically, the positive effect of internet on clean fuel adoption significantly decreases with city size. Our results call for the implementation of measures to facilitate the diffusion of ICTs to households. These measures imply the improvement of household access to new ICTs through broad network coverage of areas not yet covered. In addition, there is a need to intensify communication on issues relating to cooking fuels such as the health benefits from using clean fuel. This can be done through text messages and good web contents.

### **Keywords**

Information and communication technologies, clean cooking fuel adoption, Cameroon

## **49. Investigating sustainable options for end-of-life lithium-ion batteries in the South African context**

Thokozani Jr Mzileni

University of Johannesburg, Johannesburg, South Africa. EMPA, St Gallen, Switzerland

### **Abstract**

There is global revolution from fossil fuel energy to more sustainable sources of energy, especially in electric vehicles and other small electronics like smartphones and laptops, with the use of lithium-ion batteries (LIBs). This means that there is an anticipated influx of LIBs that are expected to reach their end-of-life (EOL) in the next 10 – 25 years and enter the waste stream. State of health (SOH) estimation of EOL LIBs plays an important role in sorting this waste in a sustainable way. When LIBs reach their EOL they are not always destined for recycling, some are still healthy enough for a second and third life. Therefore, that makes SOH a vital tool in sorting out EOL LIBs into the most suitable options after they are first life. Multiple companies around the world have set up EOL LIB recycling plants and management systems, aimed at dealing with this waste. However, South Africa is left behind in establishing an EOL LIB management system, as they have no recycling facilities and no material flow data about the EOL LIB situation of the country. The present study designed a SOH protocol that can be used to assess EOL LIBs and assist in determining an alternative, after a battery has finished its first life. The protocol is simple to follow, as it was designed from multiple experiments on EOL LIBs of all form factors, with the use of an i-charger device. The i-charger discharges and charges the cells through multiple charge cycles then records and displays the SOH of the cell through a log-view software. The protocol produced by the study is easy to follow, which caters greatly for informal waste pickers. For this reason, they are significant actors in the management of e-waste containing LIBs in South Africa. This paper aims at discovering e-waste recyclers around South Africa, offer them a SOH protocol that can potentially be integrated in their current EOL LIB waste plan. This will also offer EOL LIBs more options, other than being disposed in landfills as they are currently being managed after their first life.

### **Keywords**

Lithium ion batteries , End of life , Recycling , South Africa , State of health

## **50. You are the People You Surround Yourself With: The Journey of Sustainability Reporting and Supply Chain Readiness**

Jamie Wallisch<sup>1</sup>, Daniel Zamora<sup>2</sup>

<sup>1</sup>ESG and Responsible Sourcing Expert, Washington, D.C., USA. <sup>2</sup>ESG and Responsible Sourcing Expert, Ottawa, Canada

### **Abstract**

A looming precedent in most businesses today is a need to comply with ESG (Environment, Social, & Governance) and regulatory reporting obligations. The expectations to comply with reporting requirements and meeting due diligence standards in the sustainability space is moving from voluntary to mandatory. The broader reporting market expectation is shifting from investigating operational impact, scope 1 and scope 2, to also include scope 3, your supply chain impact. Reporting at this scale becomes a daunting task when the impact from your supply chain is wildly unknown, it shifts your business to focus on the potential critical hidden issues. This session will articulate how to grapple with supply chain unknown risks in a curated data process and help develop your visibility into riskier business areas and meet regulatory obligations. The session will provide a clear baseline for ESG engagement including the various methods, including responsible sourcing engagement, available for data collection and the tools within these methods to support companies in analyzing 3rd party risk and completing supply chain risk disclosures. The session will review methods used within the market to understand the internal controls of your suppliers and how you can hold them accountable to walking the talk. Furthermore, the session will articulate how a workflow approach between these two methods simultaneously deliver awareness into behaviors and organizational internal controls of the entities in your supply chain.

### **Keywords**

Supply Chain Transparency, Supply Chain Technologies, Sustainability Compliance, Due Diligence, Responsible Sourcing

## 52. What drives companies to source responsibly? An investigation of renewable energy manufacturers' motivations for responsible sourcing

Marie-Theres Kügerl<sup>1</sup>, Michael Hitch<sup>2</sup>, Katharina Gugerell<sup>3</sup>

<sup>1</sup>Chair for Mining Engineering and Mineral Economics, Montanuniversität Leoben, Leoben, Austria. <sup>2</sup>WA School of Mines: Minerals, Energy and Chemical Engineering, Faculty of Science and Engineering, Curtin University, Bentley, Australia. <sup>3</sup>Institute for Landscape Planning, Department of Landscape, Spatial- and Infrastructure Sciences University of Natural Resources and Life Sciences Vienna, Vienna, Austria

### Abstract

With increasing demand for mineral resources required for a successful transition from fossil fuels to renewable energy sources, impacts from mineral supply chains take environment, climate, and people to their limits. Human rights violations in polysilicon production or increases in land disturbance for copper supply, are only some of the issues related to mineral resource extraction crucial for renewable energy technologies. These issues lead to increasing calls for sustainability and justice in the energy transition. As the EU is heavily dependent on imports of mineral resources, responsible sourcing (RS) is intended to prevent the European energy transition from being associated with negative impacts elsewhere. In recent years, the EU has therefore introduced various directives and regulations including the Conflict Minerals Regulation and the upcoming Directive on Corporate Sustainability Due Diligence. While these initiatives have a significant impact on companies operating in the EU, their impact on sustainability is questionable. To prepare for these measures and improve transparency of their mineral supply chains, companies have introduced RS initiatives. Even though RS literature on mineral resources has been increasing, renewable energy technology manufacturers (RETMs) are yet to be covered in detail. To address this research gap and improve the understanding of RS drivers and barriers in the energy transition, this study investigates what drives RETMs to source responsibly, key enablers and barriers, and the role of justice in RETMs' RS efforts.

To answer these research questions, the authors conduct semi-structured expert interviews with industry representatives, a well-established method for in-depth analysis of complex processes. A variety of research fields have already applied semi-structured interviews including justice aspects of the renewable energy transition as they allow for some flexibility and participants can explore themes that are important to them. The interview guidance and codes for the analysis were developed using a deductive approach based on research on drivers and barriers for RS in other sectors such as biomass as well as mineral resources in general. The interview results are analyzed using a qualitative content analysis supported by MAXQDA. The research follows the hypothesis that similar to RS for mineral resources, RETMs are mainly driven by trying to ensure access to raw materials. When regulations or local acceptance threaten this access, RETMs can be enticed to change their behavior.

### Keywords

responsible sourcing, renewable energy, mineral resources, natural resource justice, resource governance

## **53. A South African Circular Economy Platform – Insights on breaking silos and accelerating a Circular Economy**

Katharina Gihring<sup>1</sup>, Maré de Witt<sup>2</sup>

<sup>1</sup>African Circular Economy Network, Johannesburg, South Africa. <sup>2</sup>African Circular Economy Network, Cape Town, South Africa

### **Abstract**

South Africa is a country with plenty of natural resources as well as abundant human capital; however, it faces many interlinked systemic challenges. Those include but are not limited to high unemployment, gender discrimination, crime, daily rolling energy blackouts, a looming water crisis, wasteful production and consumption patterns, and biodiversity loss. The circular economy (CE) has been identified as a concept and systemic way of thinking to solve these challenges.

In terms of developing a circular economy, South Africa has been amongst the knowledge leaders in Africa and beyond, considering the many stakeholders already embracing CE principles and various initiatives across different regions and sectors. However, a silo approach where initiatives are not necessarily connected is common, leading to fragmented efforts that don't go beyond "pockets of excellence" and are marked by largely, disconnected public, business and industry sectors and is hampering upscaling.

Circular economy stakeholders are active but also very focused around either a topic, such as waste or a geographic region such as the Western Cape. Thus, there is a massive gap in bringing in other very important stakeholders, such as National Treasury or the mining sector, to capacitate and understand the opportunities and challenges and to coordinate and implement systemic and integrative solutions.

Developing a circular economy platform, called Circular South Africa (CSA), has been identified as a tool to counteract a silo approach and as a way to connect and capacitate the different stakeholders in South Africa while also unlocking both local and foreign investment opportunities. The African Circular Economy Network (ACEN), in cooperation with Holland Circular Hotspot, conducted an exploratory study for such a platform in 2021. Results from the combination of the survey, workshop and one-on-one interviews indicated that the majority of the stakeholders engaged would want to participate actively in CSA and are willing to contribute to its development. From the stakeholder engagement, it became apparent that the platform should have the following desired functions: raising awareness, building capacity, creating engagement and matchmaking between stakeholders and creating partnerships between the public and private sectors.

ACEN started the development of the platform at the beginning of 2023, which is anticipated to be completed by July 2024. The aim of the presentation at the WRF2023 is to share the results of the exploratory phase and the challenges and successes of CSA's implementation up to October 2023, as well as future steps.

### **Keywords**

circular economy , collaboration , partnership, systemic change



## 54. Implementation of a concept for the valorization of organic waste in a municipality in Costa Rica

Jacques G. Fuchs<sup>1</sup>, Sandra Méndez<sup>2</sup>, Urs Baier<sup>3</sup>, Susy Lobo<sup>4</sup>, Victoria Rudin<sup>4</sup>, Alvaro Murillo<sup>5</sup>, Randall Varela<sup>5</sup>

<sup>1</sup>FiBL, Frick, Switzerland. <sup>2</sup>Skat Consulting Ltd, St. Gallen, Switzerland. <sup>3</sup>ZHAW, Wädenswil, Switzerland. <sup>4</sup>ACEPESA, San José, Costa Rica. <sup>5</sup>Municipality of Perez Zeledon, Perez Zeledon, Costa Rica

### Abstract

At national level, Costa Rica promotes composting of organic wastes as one of the major alternatives to advance its national principles on sustainability, circular economy, and climate change mitigation. Through a multiyear project, an international consortium identified and improved the value chain of “organic waste to fertilizer” of the Municipality of Pérez Zeledón, from source segregation and selective collection to the treatment and use of the products.

The project was based on four elements:

- Selective collection of the municipality’s organic waste streams. Local project partners were successful in communicating with the population and in implementing an efficient collection system.
- Setting up a composting facility with a quality assurance system. In addition to the establishment of the technical infrastructure, in-depth trainings of the plant’s employees and the installation of a field laboratory added to the project’s success.
- Elaboration of a concept for the use of the compost produced and implementation of field demonstration trials for agricultural product use by farmers. This resulted in successful sensibilization of farmers on crop-specific compost use.
- Quantification of the project’s environmental impacts, in particular on greenhouse gas emission reduction.

The greatest challenge encountered was the supply of high-quality input material for an optimal process. A clean collection of municipal organic waste with as little plastic as possible is crucial to product quality. In addition, sufficient supply of woody substrates is tantamount to a structured starting mixture which allows efficient circulation of air for the composting process.

The success of this project was made possible by the close collaboration between local partners in Costa Rica. These partners were involved in the project from the beginning of its development, and throughout all its stages and thanks to their motivation, they were the driving force behind the project.

Thanks to the relevant achievements with the project, the municipal team and the operators of the plant in Perez Zeledón become experts and multipliers of the processes in several other municipalities in the country. This fact clearly demonstrates the strengthening of the local empowerment through this cooperation. The concept of Perez Zeledón serves as a pilot project, it is visited by many interested parties, and the experience gained is passed on to other municipalities.

### Keywords

organic waste, composting, selective collection of organic waste, quality management of compost, climatic impact

## **55. Sourcing Responsible Gold: Spatial Data Science for Systematic ESG Assessment of Gold Mines**

Patrick Laube, Pascal Ochsner, Tomasz Orpiszewski

Zürich University of Applied Sciences, Zürich, Switzerland

### **Abstract**

While the regulations and guidelines on mining and sourcing of gold highlight the environmental and social considerations, to date there is no system that allows to compare all gold mines across the sector with regard to specific ESG criteria. In this research we attempt to provide consistent measurement of deforestation and social well-being around the mines across 10 countries and over 200 mines.

For this purpose, different spatial analysis methods (buffer and administrative unit annotation) were tested on a large number of mining locations for various environmental variables such as deforestation in Bolivia, Brazil, Congo, Indonesia and Peru. In contrast to other studies, not only were the coordinates (localizations) of mines considered, but also their spatial extent.

The results show that the intensity of deforestation in the proximity of gold mines is significantly higher than elsewhere and that this effect decreases with rising distance from the mine. However, such observations differ from region to region and depend strongly on the choice of the environmental variable.

In parallel we employ spatial data to analyze the social aspects in the proximity of mines such as population development, poverty, health, and access to services. Through multi-source data collection, including remote sensing and statistical socio-economics data, and spatial data science techniques we are able to assess the social dynamics around the mine over time.

The methods and workflows are scalable throughout the sector and provide a strong basis for consistent measurement and rating for 10'000 gold mines regarding their environmental and social impact in the future. We display the results in form of an interactive webpage.

### **Keywords**

Responsible Gold, Responsible Sourcing, Spatial Data, ESG , Deforestation

## 57. Resources for Planetary Well-Being – scaling back to sufficiency for all-beings.

Robert Perey<sup>1</sup>, Andre Reichel<sup>2</sup>

<sup>1</sup>University of Technology, Sydney, Australia. <sup>2</sup>ISM International School of Management, Stuttgart, Germany

### **Abstract**

The current state of the planet is marked by ecological crises of unprecedented scale and severity, from climate change and biodiversity loss to zoonotic diseases. While there has been increased awareness of the crucial interdependence between human societies and the natural world, there remains a fundamental assumption that nature is fundamentally different from us, and that our production and consumption patterns need not be drastically altered. Even the increasingly popular circular economy concept assumes that economic growth can continue indefinitely, so long as resources are used more efficiently.

In order to truly transition to a more sustainable future, we must move beyond the fixation on economic growth and embrace a post-growth economy. The implication is that we must radically scale back our consumption of resources and re-evaluate what it means to live well. This is particularly relevant for a circular economy, which relies on maintaining our current patterns of consumption and production, rather than truly rethinking our relationship to the planet.

However, the shift towards a post-growth economy must be grounded in a deeper transformation of our values and beliefs, particularly with respect to how we view ourselves in relation to the natural world. This includes the recognition that we are not separate from nature, but rather deeply interconnected and interdependent with all living beings. Moreover, it requires us to view non-human entities as equal partners in the web of life, not merely as resources for human use; for us to live well, they too need to live well.

For all living beings to live well, means we have to rethink value in this context, particularly how we measure, value and relate to natural resources. It highlights the importance of valuing the non-monetary contributions of nature, such as the intrinsic value of biodiversity and the ecosystem services that sustain all living systems, which includes human societies. This entails development of new metrics and indicators of sufficiency to ensure all living systems can access the resources they need to maintain their well-being.

Ultimately, the transition towards a post-growth economy and a truly sustainable future requires a fundamental reimagining of our relationship to the planet, and a reorientation of our values and priorities towards the well-being of all living beings. Such a shift will require concerted effort and collaboration across different sectors, but it is imperative if we are to secure a liveable and thriving planet for generations to come.

### **Keywords**

post-growth economy, degrowth, sustainability , living systems, eco-system services

## 59. Green Terrace: A learning-by-doing model to empower sustainable practices in communities in Bogota, Colombia

Sandra Mendez Fajardo<sup>1</sup>, Oviedo Blanca Elvira<sup>2</sup>, Luis Alfonso Canedo<sup>3</sup>, Verónica Duque<sup>4,5</sup>

<sup>1</sup>Skat Foundation, St. Gallen, Switzerland. <sup>2</sup>Pontifical Javeriana University, Bogota, Colombia. <sup>3</sup>Parrish San Marcelino Champagnat, Bogota, Colombia. <sup>4</sup>Ecopartner Ltd., Uttwil, Switzerland. <sup>5</sup>Ecopartner Ltd., Bogota, Colombia

### Abstract

**Organic waste** represents between 50 and 70% of the municipal solid waste in **Latin American** countries. The most common strategy for waste disposal is the use of sanitary landfills, where in general more than 90% of the litter generated arrives; even in some countries, open dumps are still used as a (unsustainable) solution. To prevent the impacts that the decomposition of these materials is causing in landfills due to the amounts of leachate and gases, including methane, some governments are implementing policies and legislation that promote principles such as zero waste and circular economy. This holistic management logic demands structural changes in **citizens' habits** that enable successful programmes and the effective and efficient functioning of infrastructure implemented for recycling and transformation of materials such as organics.

The **behavioural change** leading to a better practices of waste separation, use and transformation, requires permanent communication and environmental education strategies, for which it is difficult for municipal administrators to allocate resources. An alternative solution is the creation of spaces for **cooperation** between **various actors** in society, both locally and nationally, as well as internationally. In this context, the concept of the **Green Terrace** was born in 2019, initially implemented in 2020 by the San Marcelino Champagnat Parish in Usme, Bogotá, Colombia, with the support and advice of the Skat Foundation from Switzerland; in 2022 the Pontifical Javeriana University joined the project through its social programme PROSOFI, and from 2023 two social organisations are also part of the local allies, the Comabaquinta Corporation and the Sisters of the *Hermanas del Apostolado del Sagrado Corazón de Jesús*. Resources for this cooperation have come from Swiss donors such as Swiss Agency for Development and Corporation (SDC), the Catholic Church of St. Gallen, the Municipality of Maur and the Canton of Schaffhausen. Each local organisation has contributed with economic and human resources, locations, scientific knowledge, and experience.

The **Green Terrace** concept consists of creating a series of spaces for **learning-by-doing** source separation and treatment of organic waste through composting or vermiculture, generation of seeds and planting organic food. The reflection and training activities also include topics such as healthy food, preservation of ecosystems, recycling, among others. Additionally, community cohesion is also strengthened. With this three-years project, more than 1000 people have strengthened their capacities for environmental preservation and food production, which in turn emerges as an important contribution to food security issues, especially in the vulnerable communities reached.

### Keywords

organic waste, food security, behavioural change, learning by doing, urban gardens

## 60. Digitalisation in the mobility system: challenges and opportunities

Tommaso Selleri<sup>1</sup>, Inge Mayers<sup>2</sup>, Saskia Van der Loo<sup>2</sup>, Bruno Van Zeebroeck<sup>2</sup>, Sebastiaan Boschmans<sup>2</sup>

<sup>1</sup>European Environment Agency, Copenhagen, Denmark. <sup>2</sup>Transport & mobility Leuven, Leuven, Belgium

### Abstract

Digitalisation plays an ever-increasing role in our mobility system. Increasingly complex, capable and affordable digital technologies are shaping the evolution of the sector and how we address mobility in our society. The drivers behind this ongoing transformation are often associated with technological innovation, increase in efficiency, development of new markets, societal benefits and cultural changes. In some cases, the drivers also relate to sustainability – and whether or not that is the case, nearly all digital technologies have implications, positive or negative, for the environment and climate.

In this contribution, we explore how and to what extent digitalisation can be instrumental in reducing the environmental impacts of both passenger and freight transport in urban and non-urban settings. To do so we discuss nine digitally-enabled technologies currently central in mobility-related policymaking: teleworking and virtual mobility, autonomous passenger and freight transport, multimodal services, smart logistics, digital tools for demand management, air traffic management and digital monitoring solutions for greenhouse gases and air pollution emissions.

In all these domains, digitalisation has the potential to support a sustainable transition of the mobility system, promoting positive behavioural shifts, fair business models and system(s)-wide optimisation. At the same time, it has also the power to deepen the pressures exerted on the environment, increasing demand for transportation due to improved efficiency and reduced costs, making less sustainable personal mobility modes more attractive. To realise the potential digital technologies could bring, it will be fundamental to keep a steady view on potential impacts; only in this way a sustainable and just transition could be achieved.

### Keywords

mobility, digitalisation, policy, environment, EEA

## 62. Capacity Mapping: The Material Value of Inclusion, Participation and Transparency

Monica Ospina

O Trade, Toronto, Canada

### **Abstract**

Companies must garner social approval to obtain land access agreements and demonstrate best practices in risk management and environmental, social, and governance (ESG) factors to secure funding from investors. Businesses often strive to maintain smooth partnerships with the local and Indigenous communities affected by operations. However, success in achieving social approval from these communities largely depends on the company's effectiveness in implementing solutions related to inclusion, participation, and transparency.

In remote areas, operational productivity is directly impacted by socio-economic issues and conflicts frequently escalate due to fears based on historical vulnerability, mismanaged expectations, and an inattentiveness toward community needs. Therefore, the private sector is often called to act on solutions governments are far from addressing. In the era of the energy transition, this stress is higher for mining and renewable energy industries.

Companies implementing ethical practices founded on the three core tenets of inclusion, participation, and transparency are in a better position to manage social risk and mitigate conflict. At the 2023 World Economic Forum (WEF) Annual Meeting, leading global companies shared that inclusion is key to tapping into underserved markets and agreed that resilience and sustainability are top priorities. Additionally, recent studies indicate that higher ESG scores can reduce the cost of capital by 1.14–10%.

O Trade's Capacity Mapping™ service empowers companies to build strong relationships with regional stakeholders and lower operating costs by engaging the local workforce. The methodology ensures that businesses operating in the developing world expand the opportunities for employment by identifying capacities in peoples skills, demands, and regional infrastructure. Companies can help community members raise their capabilities and fill the gaps. When mapping capacities, active community participation prevents resentment—the jobs that can be done by local people are understood and demand over the lifetime of the project can be forecasted.

By leveraging social inclusion, participation, and transparency, companies prepare communities prior to operations, building towards operational readiness by facilitating a conflict-free environment. As trust solidifies, the community may feel more invested in the project and inclined to grant social approval in the permitting process. Meanwhile, communities benefit from the guarantee their rights are recognized, opportunities for dignified work, economic influx, and a balanced relationship with the companies in their region. Capacity Mapping™ communicates a company's recognition of the value of individuals: their ability to learn, work, and excel.

### **Keywords**

public-private partnerships, sustainability strategy, social inclusion, Indigenous and community practices, social resilience

## **63. Assessing the sustainability of supply and use of the technology metals antimony, bismuth, cadmium, germanium, gallium, indium, selenium and tellurium**

Harald Ulrik Sverdrup<sup>1</sup>, Ole van Allen<sup>1</sup>, Simon Michaux<sup>2</sup>

<sup>1</sup>Inland Norway University of Applied Sciences, Hamar, Norway. <sup>2</sup>Geological Survey of Finland, Espoo, Finland

### **Abstract**

The technology metals antimony, bismuth, cadmium, germanium, gallium, indium, selenium and tellurium are key elements in the energy transition to prevent global energy scarcity and for limiting climate change. They are needed in new technologies like solar panels, batteries, electrical vehicles, light emitting diodes, computer screens and semiconductors. All of them will become scarce, unless careful strategic management is implemented immediately. For most of them, predicted future demands far exceed what is estimated as extractable amounts.

To assess the sustainability of extraction, recycling and market supply of these metals, the WORLD7 Integrated Assessment System Dynamics Model was used, together with an assessment of available extractable resources and predicted future needs. WORLD7 is based on mass balances, representation of extraction processes and endogenous dynamic market price from supply and demand dynamics. The metals are linked in a complicated network of dependencies and only a systemic approach will do.

The technology metals have in common that their production is dominated by secondary extraction, and that no or very limited primary extraction exists. A large difference between occurrence of these metals in geological deposits and the actually extractable amounts for the technology metals. The major obstacle for their supply is the limited availability of opportunity for secondary extraction, large energy demands of extraction and to have the required technical infrastructure available. Under business as-usual, they will come in short supply 2040–2080. Key technologies may suffer scarcity of supply and limit application in the future. The rate of recycling for all the technology metals, is far too low, making present practice of use wasteful. The future technological transitions in society will not be possible under Business-As-Usual, and require a planning process that can outline and international management plan for these metals.

### **Keywords**

Technology metals, WORLD7, scarcity, In, Ga, Ge, Cd, Se, Te, Sb, Bi

## **64. The final count-down: Estimating the total value of the world's natural resources and tracing the origins and fate of global wealth and prosperity**

Harald Ulrik Sverdrup<sup>1</sup>, Anders Nordby<sup>1</sup>, Ole van Allen<sup>1</sup>, Anna Hulda Olafsdottir<sup>2</sup>, Peter Schlyter<sup>3</sup>, Ingrid Stjernquist<sup>4</sup>

<sup>1</sup>Inland Norway University, Hamar, Norway. <sup>2</sup>Meteorological Institute, Reykjavik, Iceland. <sup>3</sup>Blekinge University, Karlskrona, Sweden. <sup>4</sup>Stockholm University, Stockholm, Sweden

### **Abstract**

The total sales value and the profit value of the annual production and the total recoverable resource stocks of natural resources like elementary metals, materials, synthetic materials, and fossil fuels was estimated. The estimates were combined with earlier studies including estimates for the value of the ecosystems on the earth and estimates of the value of the geosphere and the biosphere to human society. Steady state methods and dynamic outputs from the system dynamics Assessment Model WORLD7 was used. A significant part of value creation by modern civilization depends on the availability of finite natural resources and that the prospect of future prosperity depends on how well these resources are managed. The model results point to the importance of a long-term material circularity, minimizing losses of material and preserving resource quality with time. The availability of natural resources are linked with the climate change issue, as well as how to mitigate these issues. Solving the climate change challenge with an energy transition, creates a demand for a resource transition, which both demand a social transition. The model is used to illustrate how our golden age is dependent on the availability of natural resources, from the beginning and to a predictable end of a golden age.

### **Keywords**

World prosperity, WORLD7, finite resources, sustainability, Golden age



## **65. How large can the global population be in the light of the sustainable use of materials, energy, and phosphate based on the latest data and model simulations.**

Ole van Allen, Harald Ulrik Sverdrup, Anders Nordby

Inland Norway University of Applied Sciences, Hamar, Norway

### **Abstract**

The sustainable global population, based on available ultimately recoverable resources of metals, materials, energy, and phosphorus, considering recycling was determined. The essential metals and materials were selected for their importance in society. The WORLD7 model was used for the assessment. The calculations of critical metal use show that our metal usage is above the sustainable rates, needing a reduction in a net use of more than 95% for many metals. Alternatively, the issue was turned around, asking, if this is the amount of metals available, how many people for how long can be supported with the available materials? This study identified a sustainability gap. To sustain high living standards and material availability for a long time globally, the global population needs to decrease in size to somewhere between 1.5-2 billion. In addition, we need improved recycling efficiency and improved resource use efficiency. How a global population contraction can take place is not discussed. The assessment is based on assuming we need to be sustainable for the next 10,000 years.

### **Keywords**

sustainability, population, planetary, natural resources, phosphorus

## 66. Grassroots understandings of sufficiency: Critique, solutions, lifestyle choices

Tina Nyfors

University of Helsinki, Helsinki, Finland

### **Abstract**

Owing to a lack of 'bottom-up' viewpoints on sufficiency, this study examines understandings of sufficiency in a regional Finnish degrowth/sufficiency network called "Kohtuusliike".

The data consists of 16 semi-structured interviews, a carbon footprint test conducted by the study participants, and participant observation.

Preliminary findings from this phenomenographic study point out that this grassroots movement attaches a multitude of understandings to sufficiency. Categories include understanding sufficiency as (a) critique, (b) solution, and (c) lifestyle choices. "Sufficiency as critique" includes, for example, quite expected views such as disapproval of overconsumption and the growth based economic system, but also questioning individualism, an instrumental human-nature relationship, anthropocentrism, advanced technology, unequal distribution of resources, and work based on exploiting and degrading the so-called natural environment. "Sufficiency as solution" again is about understanding sufficiency via alternatives to economic growth such as degrowth or doughnut economics, consumption oriented towards fulfilling needs, a sense of community, attaining intrinsic value to the rest of nature, ecocentrism, limited use of technology and increased use of muscle power, distribution according to a contraction and convergence principle, and work restoring and supporting the flourishing of the non-human environment. Participants referred to sufficiency as critique and solution at different scales, including, for example, systemic and individual scales. "Sufficiency as lifestyle choices" include a range of actions undertaken by the participants, such as reducing and sharing in areas such as transport, food, housing, and use of products.

Many participants were found to have carbon footprints around, or even below, 2.5 tons CO<sub>2</sub>-e per year, in line with keeping global warming within 1.5 degrees, and all participants had footprints below 5 tons CO<sub>2</sub>-e per year. This is considerably lower than the average Finnish citizen, with footprints around 10 tons CO<sub>2</sub>-e per year. I claim that this gives the participants' understandings of sufficiency broader societal relevance, not only in Finland but with regards to other affluent countries as well.

### **Keywords**

sufficiency, grassroots, degrowth, consumption, phenomenography

## 67. “Seeing is believing”: (Dis)Trust and value control in Peru’s artisanal and small-scale gold mining (ASGM)

Alejandra Villanueva Ubillús<sup>1,2</sup>, Roy Maconachie<sup>3</sup>

<sup>1</sup>KU Leuven, Leuven, Belgium. <sup>2</sup>Center for Mining and Sustainability Studies (CEMS), Universidad del Pacífico, Lima, Peru. <sup>3</sup>University of Bath, Bath, United Kingdom

### Abstract

Artisanal and small-scale gold mining (ASGM) is the largest source of anthropogenic mercury emissions (38%) (UNEP, 2018). To reduce ASGM’s impact on the well-being of workers, communities, and environments related to the sector, mercury reduction and elimination have been established at the core of policy commitments and voluntary instruments aiming at establishing a more responsible global gold value chain (Selin & Selin, 2022; Sippl, 2015). Among the main suggested initiatives is the shift towards “clean technologies”, i.e., the adoption of devices and techniques that allow gold processing sans hazardous substances. Under the assumption that miners are profit-driven individuals reluctant to change, clean technology interventions focus on the gains in efficiency when opting to “make the jump” toward non-conventional gold processing methods. Yet, the adoption of these technologies is mainly anecdotal (Veiga & Fadina, 2020). While diverse authors have stressed high costs and the lack of technical knowledge as critical barriers for miners to adopt clean technologies (Hinton, Veiga, & Veiga, 2003; Spiegel et al., 2018; Veiga et al., 2018), this body of literature ignores the sociotechnical and political dynamics that mediate what is considered “clean” technology and by whom.

This study focuses on the role of trust as an incentive for miners to opt for chemical-based technology upgrading. In line with Díaz Leiva (2022), we agree that ASGM technologies are socially and geologically embedded, and adapted to local needs and efficiency standards. In this sense, we argue that the value of technical efficiency is not reduced to cost-benefit calculations but that miners’ perceptions of production control and fair agreements also play a critical role. Drawing from our analysis of three Peruvian ASGM constellations (two in the Andes and one in the Amazon), we find three significant sources of distrust that guide miners’ processing practices: 1) security issues and fear of rigged deals; 2) anti-pollution discourses aiming to reduce ASGM expansion, and 3) limited access to stable, profitable, and formal gold markets. In a quest for limiting risk and maintaining control of their production, these sources of distrust will act as incentives for miners to bet for technological upgrading heavily based on mercury and cyanide, despite continued efforts from public and international agencies to build a “cleaner” and more sustainable gold value chain.

### Keywords

ASGM, mercury, global value chains, technological upgrading

## 69. Linking Innovation and Sufficiency: Reviewing Theory and Practice

Indra da Silva Wagner, Bernd Ebersberger

University of Hohenheim, Stuttgart, Germany

### Abstract

**Purpose:** In recent years, the discourse about sufficiency (Princen, 2005) has gained ground in the sustainability research community as it addresses overconsumption and resource waste in both consumption and production. While most studies have conceptualized sufficiency as primarily driven by the demand side, there is an emerging shift in the literature to move beyond behaviorism towards a more strategic framing (Jungell-Michelsson & Heikkurinen, 2022), rendering the role of businesses for sufficiency essential (Niessen & Bocken, 2021). Embracing sufficiency at the firm level calls for new logics of doing business, e.g., through business model innovation (Bocken et al., 2014), frugal innovation (Bocken et al., 2020), or social innovation (Sandberg, 2021). Although innovation is considered a promising means to alter 'business as usual' by adopting alternative pathways and strategies, there is a lack of a consolidated understanding of what sufficiency actually means in terms of innovation. This study explores how innovation relates to sufficiency by identifying sufficiency-oriented innovations.

**Design/methodology:** The methods applied are a literature and practice review. First, following the steps of a systematic literature review proposed by Tranfield et al. (2003), we organize and synthesize the diverse body of empirical literature relating to sufficiency and innovation. Additionally, we consider categorizations and frameworks suitable to define sufficiency-oriented innovations. Second, an innovation practice review is conducted that provides a wide range of examples of innovations that are linked to sufficiency. For this purpose, we collect best practice innovations over a period of 4 months from a proprietary international innovation database. Building on the literature and practice, we develop a comprehensive framework of 'innovation for sufficiency'.

**Findings:** The framework focuses on three analytical dimensions – different, less, and improved – which constitute determining principles for innovations in order to foster or achieve sufficiency (see, for instance, Bocken & Short, 2016).

**Practical implications:** This study supports practitioners with knowledge about areas of application for sufficiency and with tools to take action. Ultimately, producers of goods and providers of services are responsible for actively restricting resource usage and for influencing consumption patterns (Jungell-Michelsson & Heikkurinen, 2022).

**Value:** The analysis lends insights for further analytical approaches by highlighting research trajectories of understanding the sufficiency concept from the perspectives of specific innovation drivers, strategies, or capabilities.

### Keywords

sufficiency, innovation, sustainability, sustainable production, business

## 70. Eco-economy: a paradigm shift from economic growth to sustainable development

WLADMIR MOTTA<sup>1</sup>, Amanda Xavier<sup>2</sup>

<sup>1</sup>CEFET-RJ, RIO DE JANEIRO, Brazil. <sup>2</sup>UFRJ, RIO DE JANEIRO, Brazil

### **Abstract**

The current model of production and consumption has generated an ecological crisis with devastating consequences for the planet and human society, such as global warming, the depletion of natural resources and the decline of biodiversity, among other impacts. The global challenges arising from this ecological crisis require changes in human behavior at all levels, including businesses, governments, communities and individuals. The belief still prevails that in order to meet the basic needs of the population, accelerated economic growth is necessary, despite the fact that there is already a greater dissemination of the ideals of sustainable development. In fact, the term sustainability seems to have become a kind of mantra these days, being repeated almost to exhaustion in all kinds of speeches related to development and economic growth, but its effective implementation is still far from becoming the dominant model as business practice. There is a dilemma or rather a contradiction, which has not yet been resolved, of how to appease the appetite for economic growth, still today based on the gross domestic product, with the urgent and increasingly recognized need to incorporate development practices sustainable broadly. Faced with this challenging contradiction, some proposals have emerged, but they have still been considered as independent silos, being conducted in isolation, creating distinct areas of knowledge and not in an interdisciplinary way, as the complexity of the problem requires. In this way, proposals such as the green economy, sustainable economy, circular economy, economy of functionality and cooperation, among others, have emerged and have been discussed and implemented, but several criticisms and limitations have been pointed out. The present work intends to present an independent reading, free of stereotypes and logos, with an interdisciplinary proposal that seeks to refute this contradiction pointed out between economic development and environment preservation, presenting a broad vision about this new necessary economy, pointed out here as eco-economy. To achieve this objective, this article (i) performs a systematic review of the literature involving the concepts of circular economy, economy of functionality and cooperation, green economy, sustainable economy, bioeconomy, among other related concepts; (ii) identify the congruences pointed out between the concepts; and (iii) explores possible contributions to the proposal of an ecoeconomy as a broad concept, unrelated to these already established silos.

### **Keywords**

eco-economy, ecological crisis, complex problems, circular economy, economy of functionality and cooperation

## 71. Circular Economy and SDG12: a singular congruence

WLADMIR MOTTA<sup>1</sup>, Marcelo Meiriño<sup>2</sup>

<sup>1</sup>CEFET-RJ, RIO DE JANEIRO, Brazil. <sup>2</sup>UFF, RIO DE JANEIRO, Brazil

### **Abstract**

The need for an environmentally sustainable development comes in response to ecological and moral imperatives, bringing a marked change in the importance of participation not only of governments and industries, but of the entire society in the face of this ecological urgency. Among the 17 goals proposed by the SDGs, the 12th goal demands sustainable paradigm shifts in what had been achieved so far in terms of consumption and production patterns. This transition becomes necessary given the growing recognition that the Earth's resources are finite and that systemic changes in value chains, production processes, business models and consumer behavior will have to occur. A concept that has been gaining more and more attention beyond the boundaries of academia and reaching society in a broader way, having the potential to collaborate directly in meeting this goal proposed by SDG12 is the concept of Circular Economy (CE). The CE proposes a change from the current "linear" model (extract, produce and dispose) to a model that incorporates the main components that constitute the concept of sustainability and translates into a "circular" model that involves closing, slowing down and narrowing the material flow. In this sense, it can be understood that there is a "singular congruence" between what is being demanded by SDG12 and what is proposed to be applied by the CE. The CE is directly involved in the sustainable management of natural resources with proposals ranging from improvements in productive eco-efficiency to business models for sharing and selling the performance of the product and not its ownership. Its concept also incorporates practices of reinserting secondary raw materials (waste) into the production cycle, aiming to expand as much as possible the use of resources extracted from nature in the life cycle of products. Another point of great relevance is related to the participation of consumers who, according to the 9Rs, start to refuse, reject and rethink their purchases. It is perceived that this "singular congruence" brings benefits to the achievement of the challenges imposed to humanity, making both the SDG12 and the CE to be intrinsically connected and that their advances are unique for both. The present study intends to shed light on this discussion through a literature review, analyzing in detail what is presented as CE proposals/concepts and what is required by SDG12, having as final result an accurate note on this "singular congruence" of CE and SDG12.

### **Keywords**

Circular Economy, SDG12, Transition, Sustainable Development, ecological crisis

## **72. Urban symbiosis concepts for increasing the circularity of products containing critical raw materials**

Mona Arnold<sup>1</sup>, Katri Valkokari<sup>2</sup>

<sup>1</sup>VTT Technical Research Centre Finland Ltd, Espoo, Finland. <sup>2</sup>VTT Technical Research Centre Finland Ltd, Tampere, Finland

### **Abstract**

There is a major need to find efficient and innovative solutions on how to stop the loss of resources, including critical materials, in the future economy. High technology products including critical raw materials (CRMs) are not efficiently recycled and their lifetime can be relatively short. Several barriers still hinder the transition towards circular economy and regenerative value chains. More research is needed to recognise the required activities that could ensure more effective material, data, and value flows between different actors as well as novel value co-creation models between the involved actors.

This paper explores new sustainable value creation models in cities for increasing the circularity of selected high technology products, containing critical raw materials (CRMs). In this paper, e-bikes have been selected as a use case. Here CRMs (e.g. neodymium, lithium, chromium, silicon) make essential material components of the battery and motor. Pedal-assisted e-bikes dominate the growing market, boosted both by fast technology development. Especially in congested cities, biking has become a competitive mode of more sustainable transportation which many cities reinforce by providing city-bike service. The concept of city bikes has also extended to e-bikes and in 2020, about 70 cities around different continents have committed to increase the modal participation of cycling. This increases the opportunities for the city to support the circularity of such products.

The research aims to create an understanding on the value optimization and operationalization of the chosen disruptive business models involving public and private organisations and consumers. Such, business model transformation for circularity implies generation of positive effects for all involved actors by creation, delivery and capture of value. Our foci are life extending R-processes at the multi-actor context aiming for closer loops of CRMs containing products. Especially, we explore how such networked business models can benefit from public support and what could be the role of city enabling the transition within ecosystems. Based on the 9R framework (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover) we aim to identify the emerging business opportunities as well as need for novel actors within the current supply chain. Furthermore, sustainability oriented value co-creation has expanded to include environmental and social aspects, which are closely connected with the purpose of public actors such as cities.

This paper recognises a variety of circular supply chain configurations that could support urban symbiosis, and contextual conditions under which proposed solutions are effective.

### **Keywords**

critical raw materials , circular business models, urban symbiosis, e-bikes

## **73. Gender Equity for A Just Green-Digital Twin Transition: A Multi-level Mapping of South Africa's Value Chains and Sectors**

Shamira Ahmed

Data Economy Policy Hub (DepHUB), Johannesburg, South Africa

### **Abstract**

The exponential increase in data-driven digitalisation and the use of digital electronic devices has created numerous techno-socio-political and ecological disruptions. By "greening" technology, data assets, and infrastructures in key industries, the green-digital twin transition can have a positive effect on many value chains and sectors.

While advocates for twin transitions acknowledge that digital technologies and quality machine-readable data can provide a huge and mostly unexplored potential for advancing industrial sustainability objectives, the emerging studies have largely focused on environmental and socioeconomic aspects of sustainable digitalisation in the global North with limited focus on the techno-socio-political and ecological aspects, nor existing systemic political economy and structural issues that hinder an equitable, inclusive, and collaborative digital society in the global Majority – particularly for women, who experience more hurdles to benefit from digitally mediated technological disruptions and are vulnerable in existing value-chains.

Furthermore, beyond the environmental paradoxes, ethical risks, and socioeconomic complexities associated with deploying data-driven technologies such as artificial intelligence (AI) in value chains, various industrial activities in key sectors already perpetuate persistent structural legacies that exacerbate intersectional inequities with multidimensional negative socio-economic and environmental spill-over effects.

For South Africa (SA) there is a dearth of information about the conditions necessary to advance the use of data-driven digital technologies to support a just green-digital twin transition, nor the barriers to scale industry-wide implementation in various value chains and sectors. While the Presidential Climate Commission's (PCC) "Framework for a Just Transition in South Africa" acknowledges the need for gender-sensitive interventions and the disruptive potential of the digital economy, there are little or no considerations of the confluence between data governance, digital development, gender equity, and climate & environmental justice.

Using an interdisciplinary theoretical framework grounded in feminist economics, principles for digital development, and an applied eco-industrial development (EID) approach, this session is based on a forthcoming paper that uses an exploratory case study to map stakeholders, interlinked issues, and drivers and feedback loops required to foster gender-sensitive governance and policy interventions in selected value chains and sectors that suit SA institutional contexts. This research is important to develop a proactive, gender-responsive, and integrative approach for policy interventions that support a just green-digital twin transition. The goal of the session is to provide transversal evidence-based policy-oriented recommendations and suggest areas for future research.

### **Keywords**

Gender, Digital transformation, Sustainability, Twin transition, Value Chains



## 75. Reimagining Slums: A Low-cost Modular Housing Solution for the Bottom of the pyramid

Sana Fatima Khan<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Faculty of Architecture, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### Abstract

This paper proposes modular housing solutions for low-resource settings in developing countries, by assessing the living conditions of people below the poverty line. For the last three decades, the number of people living in extreme poverty had been declining. However, the COVID-19 crisis disrupted this trend, causing poverty rates to rise from 70 million to 700 million in 2020. An estimated 574 million people, nearly seven percent of the global population, are expected to earn less than \$2 a day in 2030. In India, 230 million people live below the poverty line, of which 14 million people live in extreme poverty, leading to homelessness and giving rise to slums or squatter settlements. Slums are densely populated informal settlements with inadequate housing, infrastructure, and limited access to basic amenities. Slum inhabitants face many problems such as improper water supply and sanitation, legal insecurity, and susceptibility to diseases. Hence, there is a need to develop effective policies for providing low-cost modular housing solutions for the bottom of the pyramid.

In this paper, a case study of Bangalore slums is undertaken to study the vectors for the creation of slums and the problems faced by inhabitants. Interviews and surveys are conducted on slum dwellers, government bodies, and NGOs. An extensive literature review is undertaken to study poverty, squatter settlements, and government housing schemes. This study reveals that slums are in deplorable conditions with extralegal issues. To mitigate these challenges, a systemic solution comprising two components is proposed. The first component is the implementation of a Community Land Trust (CLT) policy, where land is managed by a non-profit organization that leases homes. The CLT involves technological aids like GIS software to accurately map land data, GPS tracking systems to prevent encroachment, and cloud-based software to manage the leasing of homes. The second component is the development of community-based housing modules that use lightweight materials, e.g., prefabricated concrete, and recycled construction materials, e.g., recycled steel and glass. Precast concrete comprises pre-engineered components that are manufactured off-site and then transported for final assembly. A virgin photovoltaic (PV) panel is utilized for power generation, while end-of-life PV panels are utilized as structural materials. These housing modules are scalable, easy to replicate, and reduce construction time. To conclude, this paper presents a novel solution to address the housing crisis and is crucial in achieving equitable housing leading to Sustainable Cities and Communities (SDG 11).

### Keywords

Slums, Poverty, Modular housing, Sustainable communities, Systemic solution

## **76. Knowledge Synthesis of the Mine Life Cycle and Mining Value Chain to Address Climate Change**

Qian Zhang, Alireza Gholami, Batur Tokac

Queen's University, Kingston, Canada

### **Abstract**

The growing population and low-carbon transitions are spurring demand for mineral commodities and scarcity of critical minerals. As a result, mining industries are seeking more extraction and discovering new resources. Meanwhile, climate change-related concerns increase pressure on the mining industries to make their ongoing operations more environmentally, economically, and socially sustainable. On a social level, there has been discussion about how mining can better contribute to human and ecosystem well-being. These questions are being answered, but there is no systematic way to assess and monitor mining's contribution to society throughout the project life cycle. Different scholars have proposed and investigated two relevant perspectives: mine life cycle (MLC) and mining value chains (MVC).

Despite the growing importance of understanding the roles of various stakeholders in mining value chains, a systemic review of the relationship between the MVC and MLC is still lacking. Nevertheless, different definitions and applications of the MVC and MLC create misconceptions and knowledge gaps in companies' responsibilities. This review aims to examine these concepts closely and discuss their overlaps and gaps in detail. An evaluation of all open-source papers related to this topic and linked to the mining industry directly or indirectly was conducted in this paper. This review also includes publications from other industries, such as construction and other extractive industries, which contain problem statements applicable to the mining industry. The review concludes by identifying knowledge gaps, explaining how MLC and MVC interact, and suggesting future research directions toward sustainable mining.

### **Keywords**

mining value chain, mine life cycle, climate change, shared responsibility, sustainable mining

## **77. The Biorecover Project: Re-mining biotechnologies to create novel critical raw material value chains**

Sam Whittlesey, Foulques Galloux

LGI Sustainable Innovation, Paris, France

### **Abstract**

BIORECOVER aims at developing and piloting integrated biotechnological processes capable of treating mining waste streams and selectively extracting target metals with the goal of developing a new sustainable re-mining process essentially based on biotechnology. Specifically, the project is investigating techniques to recover rare earth elements from bauxite residues, magnesium from low grade magnesite ores, and platinum group metals from low grade platinum ores. The EU H2020 project involves fourteen international partners from mining, microbiology, chemistry, engineering, metallurgy, sustainable process development, as well as CRM end-users (Alcasabas et al., 2021).

In order to bridge the gap between research results and industrial exploitation, the project includes a study of the impact of its novel biotechnologies on the raw materials value chains in question. The study has mapped out the existing value chains of Scandium, Yttrium, Platinum and Magnesium, and the key European stakeholders working with these materials. It includes an analysis of the financial performance of major corporate commodity producers and consumers to provide insights into different actors pricing power and ability to extract economic rent at different links along each chain. Moreover, the study draws upon expert interviews to explore the major governance mechanisms and public policies structuring each material's value chain, and the critical success factors considered during negotiations between suppliers and clients. This research provides insights into how value chains can be expected to take up the project's re-mining innovations. Finally, new value chains for target materials are hypothesized to account for the ways that re-mining using novel biotechnologies could transform relations between stakeholders and lead to changes in their business models.

### **Keywords**

Circular business models, Rare Earth Elements, Platinum Group Metals, Mining waste, Bioleaching

## **78. Securing municipal drinking water supply in rivalrous settings – an analysis of power resources and equity in cases from India, Spain and the USA**

Laura Turley

University of Geneva, Geneva, Switzerland

### **Abstract**

This paper examines intersectoral water allocation, in particular how cities secure water vis-à-vis rural users, and assesses the equity of this (re)allocation. We use the distribution theory of institutional change, and argue that urban water providers mobilize power resources (positional, financial and informational) to secure water. We adapt the Institutional Analysis and Development (IAD) framework to study this empirically, with case studies from India, Spain and the United States that centre around a large reservoir and its reoperation. Results show the importance of financing power in all cases, and also suggest that cities may lack the positional power needed to implement drinking water priorities. Findings also reveal the diversity of local equity logics that justify rural to urban reallocation, and trade-offs across universal equity principles. Finally, it is fruitful to study power and equity together, as the former generally has profound distributional and procedural implications which are at the heart of equity.

### **Keywords**

municipal water supply , reservoirs, water governance, equity, water policy

## **80. „Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)“: Innovative business models, eco-efficient design concepts and digital technologies**

Celine Schielke, Katja Wendler

DECHEMA e.V., Frankfurt am Main, Germany

### **Abstract**

Worldwide, 95 billion tons of raw materials are currently consumed per year, and the trend is rising. In Germany in particular, annual resource consumption is more than twice the global average at around 16 tons per year. To counteract this development, above all a fundamental transformation of the predominantly linear economy (Produce – Use – Dispose) into a resource-efficient and sustainable circular economy is needed.

The funding measure "[Resource-efficient Circular Economy – Innovative Product Cycles \(ReziProK\)](#)" of the Federal Ministry of Education and Research (BMBF) supported the research and development of innovations for a resource-efficient circular economy between 2019 and 2023. Within the 25 research projects, partners from science and industry developed appropriate business models, design concepts and digital technologies and thus contribute to the implementation of a resource-efficient circular economy. The projects address a broad range of topics and sectors, including the repair-friendly product design of consumer goods, the use of recycled materials in the textile, foundry/steel or construction industry, the extended and more intensive product use of furniture and packaging, the improvement of the recyclability of electric vehicles as well the general development on the topic of blockchain. Likewise, "Digital twins" of components or the automatic recognition of returned products with the support of artificial intelligence are new tools that have been successfully used in the "ReziProK" research projects. The results of the "ReziProK" projects show that there are a variety of possibilities to reduce the high consumption of raw materials.

### **Keywords**

Circular Economy, Resource efficiency, Sustainability, Product cycles, Raw materials

## **81. Measuring Illicit Financial Flows: New Data and Methods**

Rahul Mehrotra, [Gilles Carbonnier](#)

Geneva Graduate Institute, Geneva, Switzerland

### **Abstract**

Illicit financial flows (IFFs) erode domestic resource mobilization and the tax base of developing countries required to invest in sustainable development. The phenomenon has spurred increasing academic and policy debates in the wake of the 2008 global financial crisis, the adoption of the 2030 Sustainable Development Agenda, and more recently the knock-on effects of the Covid-19 pandemic and the armed conflict in Ukraine. Yet the lack of clarity over the scope and legal definition of IFFs remains compounded by poor data and weak methodological approaches have resulted in a lack of consensus on how to define, measure and eventually reduce IFFs. This literature review synthesizes the theoretical and empirical literature on different categories of IFF channels, with a focus on trade mispricing and abusive transfer pricing that account for the majority of IFFs worldwide. Based on a state-of-the-art conceptual framework, this review brings together the evolving law and economics literature on IFFs, drawing on a 6-year international multidisciplinary research spanning three continents and involving both academics and policymakers. This review will fill a glaring gap and provide a key reference for researchers interested in IFFs. It will provide a succinct and yet comprehensive literature review and propose rigorous empirical methods to capture IFFs alongside new data sources. It will discuss ways to address remaining gaps and major avenues for future research.

### **Keywords**

illicit financial flows, sustainable development, financing for development

## **82. SCP-HAT: An online tool to support science-based policy development for sustainable consumption and production**

Stephan Lutter

Vienna University of Economics and Business (WU), Vienna, Austria

### **Abstract**

Sustainable consumption and production (SCP) is an essential requirement for sustainable development. In 2012, at the Rio+20 Conference, Member States adopted the 10-Year Framework of Programmes on Sustainable Consumption and Production (10YFP) as a global platform to accelerate the shift towards SCP at regional and national levels, in both developed and developing countries. The important transversal role of SCP as an integral part of the 2030 Agenda for Sustainable Development was then clearly affirmed with the inclusion of a standalone goal (Goal 12) on SCP.

During the process of designing policy frameworks conducive to transformation and to the shift to SCP, it is a prerequisite to have an objective understanding on the key national economic processes and activities that are generating the most environmental and socio-economic impacts (so-called "hotspots"). A "top-down" assessment of national economies with environmental footprint can pinpoint crucial areas of consumption and production, and drivers of environmental and socio-economic impacts, including the impacts occurring outside national boundaries. This assessment can help prioritize areas for intervention (such as value chains, sectors or product categories), in accordance with national priorities and conditions.

In 2018 the United Nations Life Cycle Initiative together with the One Planet Network Secretariat in UNEP and the International Resource Panel (IRP) commissioned the development of the Sustainable Consumption and Production Hotspot Analysis Tool (SCP-HAT, [www.scp-hat.lifecycleinitiative.org](http://www.scp-hat.lifecycleinitiative.org)), which aims at supporting science-based national SCP policies in countries around the world. The state-of-the-art online tool provides stakeholders of different levels of (policy) expertise with both an overview of a country's performance with regard to SCP-related policy areas as well as empirical evidence of hotspots of (un)sustainable consumption and production activities. The SCP-HAT allows for analysing direct as well as indirect (i.e. supply-chain wide) pressures and impacts, brought about by consumption and production activities of national economies.

SCP-HAT is a prime example of a means to support science-based policymaking, fulfilling two requirements: the scientific soundness of the underlying method, combining multi-regional input-output analysis and life cycle analysis, and the need for simplified results for a broad range of countries and policy applications. The SCP-HAT does so by tackling many policy areas and SDGs. SCP-HAT is now being used by the UNFCCC to support countries in their endeavours to update the National Determined Contributions (NDCs) to achieve the targets agreed upon in the Paris Agreement.

### **Keywords**

Science-policy communication, supply-chain wide assessments, Sustainable consumption and production, MRIO & LCA

## 83. A systematic literature review of strategic and operational ESG challenges in sustainability reporting of the mining industry through the lens of stakeholder theory

Francesco Ghezzi<sup>1</sup>, Eleonora Annunziata<sup>1</sup>, Francesco Rizzi<sup>2</sup>, Fabio Iannone<sup>1</sup>, Marco Frey<sup>1</sup>

<sup>1</sup>Sant'Anna School of Advanced Studies, Pisa, Italy. <sup>2</sup>University of Perugia, Perugia, Italy

### Abstract

**Framing of the research.** The current debate on Environmental, Social and Governance (ESG) factors brings a specific attention to the reliability of ESG disclosures in strategic and critical sectors for addressing sustainability challenges such as in the mining industry, which is well-known for the severe negative impacts on the environment and local communities.

**Purpose of the paper.** This paper aims at building a comprehensive ESG framework for the mining industry. In doing so, it takes also into consideration how ESG challenges have been reported by researchers and companies to identify and analyze which factors drive the differences in reporting through stakeholder theory's lens.

**Methodology.** This paper employs a systematic literature review of ESG challenges in the mining industry and their typologies of reporting. Of an initial database of more than one thousand scientific papers, after a few steps of screening and selection (compliant with PRISMA methodology) 69 were retained and included in the analysis.

**Results.** The paper provides an ESG framework organized by hierarchical layers and containing almost one thousand ESG challenges. Two main typologies of scientific contributions reporting ESG challenges are devised, and a scale-blindness factor is identified, which leads to neglect challenges happening at a different scale from the reporting focus. Stakeholders' influences and concerns, as well as the extension of the licence to operate, are taken into consideration to give an explanation of the phenomenon.

**Research limitations.** The paper does not use primary data on sustainability reports or on-field collected data, concerns exclusively the mining industry, and does not assume a longitudinal perspective.

**Theoretical implications.** The paper identifies two meta-typologies of scientific contributions addressing sustainability in the mining industry, it unveils the differences in how ESG challenges are reported by linking it with a scale-blindness factor. In explaining this factor, it links it with the stakeholders' perspective.

**Managerial implications.** The identified ESG framework can be used by mining managers to practically assess the sustainability profile of their operations, but also to effectively communicate it.

**Originality of the paper.** This paper systematizes ESG challenges from strategic-sustainability reports papers and operational-case studies papers, and addresses the ESG issues' scale, by linking it with the reporting focus of companies and the targeted stakeholders, contributing to stakeholder theory in the mining context.

### Keywords

ESG, ESG reporting, mining industry, systematic literature review, stakeholder theory



## **84. Development of a life cycle–based sustainability analysis framework: Application to the South African plastics value chain**

Taahira Goga<sup>1</sup>, Kevin Harding<sup>2</sup>, Valentina Russo<sup>3</sup>, Harro von Blottnitz<sup>1</sup>

<sup>1</sup>University of Cape Town (UCT), Cape Town, South Africa. <sup>2</sup>University of the Witwatersrand (WITS), Johannesburg, South Africa. <sup>3</sup>Council of Scientific and Industrial Research (CSIR), Stellenbosch, South Africa

### **Abstract**

Impacts associated with plastic supply chains have recently come under increased appraisal. Globally, policy has shifted to transform historically linear models into circular systems by focusing on improving plastics management and reducing plastic pollution to the environment. The South African regulatory space has kept abreast with international legislation by setting targets for increased recycling rates and recycled content with the recently published Extended Producer Responsibility (EPR) guidelines mandating producers to perform Life Cycle Assessments (LCA) for various plastic products. Although local research has progressed to analysing challenges and opportunities for advancing the circularity of packaging and assessing strategies related to the reduction of plastic demand and increased collection and recycling, a life cycle-based model has never been utilised to assess the inevitable consequences of both circular materials use and decarbonisation interventions on a mostly linear South African plastics economy. This study aims to bridge this gap by creating a sustainability analysis framework combining environmental assessment tools such as Material Flow Analysis (MFA) and Life Cycle Sustainability Assessment (LCSA) to analyse various circular economy and decarbonisation strategies and applying them to future models of the South African plastics system. To assess the transition from linear to circular, the local plastics supply chain is mapped, including polymer production, conversion, and end-of-life stages, followed by an analysis of upstream and downstream mitigation strategies including reducing demand by shifting domestic consumption from single-use to reuse and decarbonising the country's energy mix. As the impacts of plastics are not limited to the release of greenhouse gas emissions, the scope is broadened to include circularity indicators as well as indicators of potential environmental and socio-economic concerns, including water scarcity, employment, and plastic persistence. Findings show that the input recycled rate was 40.3% in 2018 with the proportion of recycled content to total plastics produced calculated as 17.7%. Additionally, it was estimated that the South African plastics sector generated 17.9 Mt<sub>eq</sub> CO<sub>2</sub> emissions annually with the local coal-to-liquid polymer production and energy use in conversion identified as major contributors. A model of future flows indicates that an increased recycling rate to fulfil the targets of the South African Plastics Pact can significantly reduce virgin polymer demand and waste to landfill although economic implications would have to be considered. This suggests that recycling activities are likely to significantly improve the sustainability of the local plastics industry before it needs to be supplemented by the other investigated strategies.

### **Keywords**

Life cycle assessment, Sustainability, Plastics, South Africa, Circular economy

## **85. Indigenous knowledge system and practices for forest conservation in Vhembe region in Limpopo Province, South Africa.**

Innocent Sinthumule

University of Johannesburg, Johannesburg, South Africa

### **Abstract**

Over the past four decades, research on the role of indigenous knowledge system (hereafter IKS) in biodiversity conservation has increased significantly. This understanding is also reflected in international conventions, for instance in Article 8(j) of the Convention on Biological Diversity, requires all contracting parties to respect, preserve, maintain and apply the knowledge, innovations and practices of indigenous and local communities that are relevant for the conservation and sustainable use of biodiversity. The aim of this study was to identify and describe the key indigenous practices used to conserve/protect the forests and to examine the attitudes held by local communities regarding the value of IKS in forest conservation. In order to achieve this aim, the study relied on qualitative and quantitative approaches. Key informant interviews with sacred forest custodians (n = 16), household administered questionnaire surveys (n = 240) in four villages surrounding the two sacred forest and field observations were employed to collect data. Data obtained from questionnaires were analysed through Statistical Package for Social Sciences (SPSS) whilst data from interviews were analysed using thematic content analysis. Field observations helped to corroborate the results from both interviews and questionnaires. The study found that the key IKS that is used to conserve forests in Vhembe region includes rituals and customs for the protection of ancient burial grounds. Other important IKS comprises myths and taboos involving a complete ban on activities in the forests other than the above-mentioned rituals. The study also found that the local communities have positive attitudes towards conservation of the local sacred forests. The positive attitudes equated to compliance as local communities were found not to harvest fuelwood or hunt in the sacred forests because of respect for, and fear of, different forms of IKS. These findings confirmed that IKS contributes to the conservation and protection of sacred forests in the study area. In order to ensure that IKS is not lost in communities, this study suggests that it must be part of the local primary and secondary school curricula. This will help to transfer the IKS from one generation to another. Talk shows on IKS on national radios and televisions are necessary with indigenous knowledge experts such as traditional healers and village elders to acquire the knowledge and ensure that it is available for future generation.

### **Keywords**

Taboos, Sacred forest, Myth and rituals, Indigenous knowledge system, Cultural transmissions

## **86. Further strengthening the EU raw materials knowledge base through the JRC's Raw Materials Information System (RMIS)**

Fernando Coelho, Simone Manfredi

European Commission – Joint Research Centre, Ispra, Italy

### **Abstract**

The economy of Europe and the maintenance and improvement of our standard of living depend heavily on raw materials (RM). Thus, one of the European Commission's top priorities is to enhance sustainable and secure raw material sources while promoting high social and environmental standards and minimising the adverse environmental impact of European material consumption. Reliable information and data on primary (extracted through mining) and secondary raw materials (recycled or recovered from waste) are thus essential for achieving these aims.

The Raw Materials Information System (RMIS) of the European Commission (EC) offers a systematic knowledge base platform on non-fuel, non-agricultural raw materials in support of EU policy (Critical Raw Material Act, European Green Deal, the Circular Economy Action Plan, and the 'Industrial Strategy for Europe', among others). The main objectives of the RMIS are to assist (1) the availability, consistency, and quality of knowledge needed by EC services and EU raw materials policies and (2) access to essential raw materials data from knowledge bases inside and outside of Europe.

The RMIS, first released in 2015 (version 1.0) and updated in 2017 (version 2.0), acts as a knowledge and information web hub for the primary and secondary raw materials used in the EU. In its current version (3.0), it gives access to RM's related legislation and policy, knowledge and analyses related to economic and trade aspects (such as governance and RMs monitoring; strategic/priority value chains; material flow/system analyses, security-of-supply, autonomy, criticality, resilience), primary and secondary production (supply/demand, circular economy, critical and strategic raw materials, end-of-life products, waste management), environmental and social sustainability aspects (climate change/sustainability, responsible sourcing, Sustainable Development Goals), as well as knowledge from EU-funded projects.

### **Keywords**

Raw Materials Information System, Raw Materials , Knowledge Gateway , Critical Raw Materials, European Union

## 87. The need for investigating the potential rebound effects of sufficiency-oriented Product/Service-Systems

Elise Andrew<sup>1</sup>, Marina Aguiar<sup>2</sup>, Janaina Mascarenhas<sup>2</sup>, Daniela Pigosso<sup>1</sup>

<sup>1</sup>Technical University of Denmark (DTU), Copenhagen, Denmark. <sup>2</sup>University of São Paulo (USP), São Carlos, Brazil

### Abstract

Sufficiency aims at reducing consumption towards a more sustainable society. While Product/Service-Systems (PSS) hold the potential to facilitate sufficiency through optimized product use, product longevity, and sharing systems, PSS also carry the risk of inducing rebound effects (RE). RE are unintended consequences of sustainability-oriented actions which arise due to induced changes in system behavior, partially or completely offsetting the intended, desirable effects.

This study aims to investigate RE within sufficiency-oriented PSS by means of a Systematic Literature Review comprising 1413 RE-related papers from Scopus, which resulted in the consolidation of 343 RE studies (covering efficiency, effectiveness, and sufficiency strategies). The 11 studies identified as sufficiency-oriented PSS mostly encompass use-oriented PSS related to sharing practices and leasing within mobility (i.e. car-sharing, ride-sharing, bicycle-sharing, and boat-sharing systems) or other areas (i.e. tool-sharing, office-sharing, and textile leasing).

RE mechanisms in the sufficiency-oriented PSS literature are described primarily based on four effects: (1) **"re-spending effect"** (freed up resources, such as time and income, are re-allocated towards less sustainable consumption behavior (e.g., air travel)); (2) **"modal shift effect"** (substitution of more sustainable 'active' forms of transportation, like walking or biking, for less sustainable transport modes, such as driving made available by transport sharing systems); (3) **"lifetime shift effect"** (the shorter lifespan of a product in a sharing system induced by, for example, increased usage or reckless treatment of the products); (4) **"moral licensing effect"** (consumers behave in less sustainable ways due to perceived 'moral credits' obtained by behaving 'sustainably' in another area).

A wide range of RE magnitude is observed in literature (e.g., 2-300% in car sharing systems), however, a 'backfiring effect' (that is, a RE magnitude above 100%) is found in each of the four sharing systems for which RE magnitude is calculated, eliminating all potential benefits of sufficiency-oriented PSS and even creating worse-off conditions.

Despite the recognition that RE triggered by sufficiency-oriented PSS limits the achievement of potential sustainability benefits, the analysis of the sample indicated that: (1) RE mechanisms are mostly related to consumption systems; (2) current RE research emphasizes estimating impact rather than understanding behavior; and (3) the investigation of RE associated with product- and result-oriented PSS is still limited. To achieve the full potential of sufficiency-oriented PSS, research must explore the underlying mechanisms of RE in the design of PSS within holistic consumption-production systems.

### Keywords

Sufficiency, Product/Service-Systems, Rebound effect, Sharing systems, Systematic Literature Review

## **89. EU project CIRCULAR FOAM “Transforming the Value Chain of Rigid Polyurethane Foams”**

Angee Fehling, Katja Wendler, Rita Schulze

DECHEMA e.V., Frankfurt am Main, Germany

### **Abstract**

In 2019, about 2100 kt of rigid Polyurethane (PU) foam was produced in the EU, mostly used as insulation material in refrigerating appliances and as thermal insulation in the construction industry. Although appliances are collected in Europe in significant quantities, their PU parts are mainly incinerated or landfilled, due to the lack of suitable recycling processes. In the construction industry, despite increasing use and demand for PU foams, there are no collection practices for end-of-life PU streams at all. Therefore, solutions for collection, dismantling, (fine) sorting and recycling of the material are urgently needed.

In the EU project CIRCULAR FOAM (2021-2025), these waste treatment steps and technologies are developed and adapted to the properties of PU and its applications and to the requirements of the chemical recycling processes. The latter will help to make waste a valuable source of alternative raw materials for the chemical industry and thus increase independence from fossil resources.

Recycling technologies alone cannot transform a value chain. Therefore, CIRCULAR FOAM will also address Design for Circularity and facilitate the interaction and collaboration between stakeholders necessary for future regional implementation of the technologies and potential investments. Rheinisches Revier in NRW/Germany, Katowice in Silesia/ Poland and Greater Amsterdam region/the Netherlands have been selected as pilot regions jointly developing a blueprint model of the circular value chain, which will address concepts for overcoming non-technological barriers and replicability to further regions.

### **Keywords**

Circular value chain, Regional transformation, chemical recycling, plastic recycling

## **91. Inception of India's *first-of-its-kind* Waste Recycling – Resource Recovery Park in Tholai village, Jaipur, Rajasthan.**

Dr. Rachna Arora, Mehar Kaur, [Dr.Reva Prakash](#), Katharina Paterok

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, New Delhi, India

### **Abstract**

India is one of the fastest growing economies with GDP ~3.5 trillion USD (IMF,2023). India's development is fuelled by resource consumption, increased waste generation, and environmental degradation with associated social displacement. To sustain current rate of growth and limit global warming to below 2°C, it is necessary to decouple economic growth from material consumption, environmental degradation, and exploitation of vulnerable, economically disadvantaged groups. Transitioning from the traditional linear 'take-make-dispose' economy to a resource efficient, circular economy is an important pathway. Such a systemic change requires implementation of a robust framework whereby stakeholders work in a collaborative, synergistic manner throughout the product's value chain and life cycle of materials to ensure resource security.

Waste generation and management are global issues expedited by disrupted supply chains, linear value chains, and use of virgin resources at unprecedented rates. In developing nations, waste management is primarily done by the informal sector, with leakages across the end-of-life management and downcycling of waste products into lesser value uses. This is a bigger issue for smaller enterprises (MSMEs), that unlike large industries, have limited technical capacities and resources for waste recovery/recycling and primarily work in illegal, unsafe working conditions with rudimentary extraction processes. To address these challenges, the Rajasthan government in its draft Electronic Waste Disposal Policy 2022 proposed the development of India's first-of-its-kind Waste Recycling/Resource Recovery Park for higher value resource recovery of plastics, e-waste, hazardous waste, ELV, and other waste streams, while providing waste collectors and recyclers safe working conditions by allocating ~44 hectares of land for this eco-industrial development.

To further the UN-SDG 12, the EU-Resource Efficiency Initiative is supporting the Rajasthan State Pollution Control Board with undertaking conceptual eco-industrial park planning and zoning, focusing on a sustainability framework, to serve as basis for the model park development. The proposed framework, rooted in circular design systems-thinking, includes urban, industrial symbiosis, climate and gender friendly infrastructure, and interaction and exchanges between waste types. It is based on economic; environmental; social; technological; and other key pillars – with monitoring parameters for each – to optimize economic and social benefits while minimizing environmental effects. The needs assessment through a technical-methodological approach conducted SWOT analysis, environmental/socio-economic impact assessments, site suitability to understand the risks and opportunities based on which, the conceptual site master plan proposed zoning of land-uses including allocation of industrial plots to maximize the potential of urban, industrial symbiosis.

### **Keywords**

recycling, critical value chains, secondary raw materials (SRM), reverse logistics, circular business models

## 92. An Integrated Framework for Sustainable Aquaculture to Ensure Food Security

Safa Mubeen<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Faculty of Architecture, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### Abstract

Food security is an essential prerequisite for promoting sustainable communities in developing societies such as India, Africa and Southeast Asia. A staggering 345 million people across 82 countries are currently grappling with acute food insecurity, an increase of 200 million since the outbreak of Covid-19. India has a high prevalence of child malnutrition with one-third of the world's malnourished children residing within its borders, while the country copes with a hunger index of 29.1. The population's transformation from producers to consumers due to rural-to-urban migration has further strained the country's food production. Furthermore, prolonged crop failures caused by erratic climate change resulted in the suicide of 5,563 agricultural labourers in 2021 accounting for 6.6% of the total suicides in the country, with Maharashtra and Karnataka registering the highest rates.

With a production rate of 178 million tonnes worth USD 151 billion in 2020, the aquaculture sector presents a promising solution to the global food and nutrition crisis. Fish provides essential micronutrients to enhance health quality and combat child malnutrition. For the sector to succeed and provide sustainable aquatic food in the future it is imperative for it to innovate, to foresee upcoming challenges and to help alleviate poverty while improving food security and income. However, the industry is still lacking in the rigorous action needed to achieve its full potential, with insufficient access to the resources required to improve its infrastructure. The adverse effects of overfishing and the sector's growth imbalance also necessitate attention. To evaluate the current situation, two case studies, namely of Rural Bangalore and Gokarna, are undertaken to examine the existing infrastructure and the potential impact the maturation of this sector will have in enhancing food security, income and employment. Additionally, surveys and interviews of the primary stakeholders are conducted to assess the present state.

An Integrated Framework for Sustainable Aquaculture (IFSA) has been proposed to target small-scale and subsistence-oriented farmers, amalgamating the people, planet, and economic components to recognize the sector's significance in the global food system. This framework has the potential to revolutionize the planet's food security. An app-based solution is proposed to deploy this framework, connecting producers, consumers, and other stakeholders through a common platform, aimed at achieving Sustainable Development Goals, specifically poverty reduction (SDG 1) and food security (SDG 2).

### Keywords

Food security, Aquaculture, Integrated framework, Malnutrition, Sustainable communities

## 93. Upskilling Workers in the Energy Transition: How Sector Meets Society Sustainably

Lindsay Moses

Mineral Law in Africa, Cape Town, South Africa

### **Abstract**

This poster hopes to engage readers on an energy transition's effects on the mining industry workforce. A truly just transition stands at the nexus of technological advancement, governmental capabilities, and civil society and industry concerns respectively. For resource-dependant states whose mining activity is closely linked to their GDP, industry resilience and adaptation are essential. The mining industry's labour force must be resilient to create a resilient industry and competitive state.

Governments can play a sustainable authoritative role in the energy transition by safeguarding their most valuable and accessible regenerative resource through law- human beings. The labour force is at the heart of an energy transition. the heart of the transition which is human beings.

The law which can embrace technology and protect human interest simultaneously will truly be a testament to our present and set a sustainable path for the future of human development. Practical measures such as a singular objective and coordinated policies within a nation's provinces and government departments can make all the difference across a global industry like mining. The law can create systems, skills, and objectives that can all be codified and transferred. Humans will always be necessary for all power projects, at some point in energy production, distribution, and transmission. (e.g., a programmer at a solar farm, remote operators and technicians for drilling or transport). It is thus up to governments to be proactive and determine at which level they would like their citizens and precisely their labour forces in the mining industry to be involved in mining activity through their local content policies. Going beyond mere requirements of a social obligation, governments can be specific and create an industry standard which accounts for the potential downfalls of mass-scale decarbonisation.

Social resilience policies including innovative lifelong learning local content policies (mainly via digitalisation) can simultaneously address intergenerational extractive justices and enable sustainability and sufficiency in minerals-based growth and development. Upskilling workers to have knowledge in machine learning eventually is a project of social resilience, and in countries where the mining of fossils has wreaked environmental damage, where mining has been responsible for longstanding land disputes and degradation, or where mining has been a harmful practice of displacement and echoes colonisation, resilient local content policies are a tool, to be used for good, to grow this industry sustainably and embrace technological advancements.

### **Keywords**

automation, mining, digitalisation, energy transition, local content policies



## 95. Insufficient supply of cross-cutting materials for batteries applications and rare earth permanent magnets – The neglected serious risk to the car

Anahita Jannesar Niri<sup>1</sup>, Steven E. Zhang<sup>2</sup>, Gregory A. Poelzer<sup>3</sup>, Jan Rosenkranz<sup>1</sup>, Maria Pettersson<sup>3</sup>, Yousef Ghorbani<sup>1</sup>

<sup>1</sup>Department of Civil, Environmental, and Natural Resource Engineering, Luleå University of Technology, Luleå, Sweden. <sup>2</sup>Geological Survey of Canada, Ottawa, Canada. <sup>3</sup>Department of Social Sciences, Technology and Arts, Luleå University of Technology, Luleå, Sweden

### Abstract

Electrification and power decarbonization are pivotal to the pursuit of the global carbon neutrality goal. The global deployment of associated technologies such as electric vehicles and renewable energy systems is escalating. Essential components of batteries and electric motors, referred to as green technologies, are highly material intensive. There are two different categories of raw materials known as battery materials (Li, Ni, Co, C, Mn, Sn, V, Mg) and cross-cutting materials (Cu, Al) used to manufacture batteries and current collectors respectively. Challenges related to the secure supply of battery materials such as lithium, graphite, and cobalt have attracted world's attention. It is undeniable that those critical materials play a key role in transport electrification and energy storage systems, but the fact that should not be neglected is the importance of sustaining the supply of cross-cutting materials, as well as metals that are key to permanent magnets. The lack or shortage of these metals makes it impossible for the world to implement green technologies in practice. Governments, economy experts, and scientists have recently started taking actions to deal with risks that have placed or will place constraints on the sustainable supply of all essential components of mass electrification.

The aim of this research is to highlight future and current factors threatening the steady supply of cross-cutting materials and rare earth magnets in a data-driven approach. First, we predict the future production of cross-cutting materials to assess the possibility of having a sustainable supply of copper and aluminum. To do prediction, we make use of several time series forecasting methods such as the Auto Regressive Integrated Moving Average (ARIMA) technique and Holt's method using the global production data on those metals from the last 4 decades. Although, secondary sources and recycling contribute to the supply of these elements, they cannot be the major resources, which highlights the need to forecast primary production. Production forecasting of key elements is important to plan for greater adoption of green energy. For rare earth magnets, different permanent magnet types and the required metals are discussed. Considering historic global production data, the impacts of current policy frameworks, geopolitical issues, geographical distribution, and environmental, social, and governance challenges on the sustainable supply of rare earth magnets are discussed. Consequently, different scenario baselines are provided and introduced to clarify and estimate the potential future bottlenecks to the supply sustainability of cross-cutting materials and metals for permanent magnets.

### Keywords

rare earth magnets, cross-cutting materials, supply sustainability, electrification, power decarbonization

## 98. Child Labour and E-waste Management: A Toxic Relationship.

Shreya Srihari<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Institute of Design, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### Abstract

Bangalore, India's information technology capital, is a big producer of Electronic Waste in the country. This city has limited resources to deal with e-waste and only 40% is managed. Bangalore(57,000MT) comes in third in e-waste production, after Mumbai(96,000MT) and Delhi-NCR(67,000MT). In addition to gross mismanagement of e-waste, Bangalore manifests a toxic relationship with child labour due to widespread poverty. This challenging situation has resulted in approximately 95,000 children in Bangalore being compelled to engage in the segregation of e-waste, highlighting the significant proportion of families who experience poverty and struggle to meet their basic needs. The parents frequently depend on their children's income to sustain their livelihood, and may choose to send them to work in e-waste segregation facilities. Some e-waste segregation businesses rely on middlemen to recruit child workers, who exploit vulnerable families by offering them the illusion of high wages or educational opportunities for their children. Due to unethical methods of segregation, multiple health issues are caused as e-waste contains toxic chemicals and heavy metals (Cd, Hg, As), particularly to children who are still developing and cause respiratory problems, prevalence of attention-deficit or hyperactivity disorders and higher DNA or chromosome damage, in addition to having a tremendous impact on the environment. Stigmatisation is also a huge problem, as these children face discrimination. Current solutions are limited to conducting educational workshops, organising collection drives and awareness campaigns. This paper proposes an integrated e-based management framework which comprises effective policies and technological solutions in the form of a smart phone app that the city can implement. The first approach, is a policy that will include an e-waste incentivisation scheme, resulting in a net-gain situation for the customer and the company. Companies will be required to establish an e-waste take-back program that motivates customers to return their e-waste to the company for a reasonable compensation. In the second approach, an app is developed which includes basic education, scheme implementation monitoring & stats, among others, that further encourages the customer to participate in proper e-waste management. In conclusion, the issue of e-waste mismanagement and child labour in Bangalore is a pressing problem that requires urgent attention. The combination of the proposed policy framework and technological solutions presented, provide effective ways to address the issue at hand and pave the way towards a more sustainable and ethical management of e-waste in the city.

### Keywords

Electronic waste, Child labour, Ethical management, Segregation facilities, Bangalore

## 101. Household wellbeing: the key to a sustainable and sufficient economy

Eleni Papathanasopoulou

American College of Greece, Athens, Greece

### **Abstract**

The transition to sustainable development continues to be elusive for a number of reasons including limited assurances economic systems will continue to provide opportunities for consumption and attainment of high living standards. Modelling economic systems to provide these guarantees is complex and challenging but invaluable in supporting decisions made by policy makers, consumers and producers.

This paper focuses on household well-being and how it can be supported through sufficiency while still support economic development. The research identifies explanatory variables which can be modelled to more comprehensively describe household consumption patterns. These patterns include not only spending on goods and services in the market economy, but also consumption of time spent with family and friends, time used to engage in the community and time spent in the environment. Data from the Living Cost and Food Survey, Understanding Society Survey, Quality of Life in the UK and Time Use surveys are combined to provide a varied and detailed data set of household well-being in the UK. Ordinary and generalized least square estimations and multivariate analysis are used to identify statistically significant explanatory variables of household consumption across different socio-economic and demographic groups.

The analysis shows that the consumption of goods and services only partly explains household well-being. Time spent with family, friends, enjoyment of the natural environment, financial security, health and access to basic services are also statistically significant in explaining well-being. The results allow functional forms of consumption across household groups to be developed that include both market and non-market activities.

The paper contributes to a number of efforts in moving towards sufficiency economies that provides high standards of living. Firstly, it begins to include market and non-market goods and services in modelling household well-being. This is important as it explicitly requires sectors often left out of macroeconomic modeling (for example the environment) to be included. These new sectors offer opportunities for job creation, capital investment and development that moves towards sustainable development. Secondly, it begins to provide composite household databases that are useful for microsimulations and agent-based models to test how different policies and societal structures can impact and influence household behaviour changes. These applications are useful in their own right, but further provide a level of detail for macroeconomic modelling that is often missing and therefore sometimes fail to convince policy makers, consumers and producers that transitioning to alternative and sustainable growth trajectories are less uncertain as often believed.

### **Keywords**

Household consumption, Well-being, Non-market sectors, Environment, Sufficiency

## **102. The transition from a linear facade to a facade as a service, The responsibility of the facade supplier in the planning phase**

Wael Soliman

Construction, Stuttgart, Germany

### **Abstract**

One of the most significant challenges facing the construction industry is the fragmentation of its supply chain. This issue has resulted in a linear "take-make-dispose" paradigm, which has led to a decline in the environmental, economic, and performance values of facades over time. The current price-driven facade industry treats each maintenance or refurbishment phase as a new project, with new players entering and exiting the supply chain at each stage.

The circular economy and 'product-as-a-service' paradigm have spawned the concept of 'facade-as-a-service' in order to address this issue. In this model, a single major player, the facade provider, owns and is responsible for the facade's tangible and intangible aspects throughout its entire lifecycle. With a single product owner, the manufacturer would be responsible for facade material, performance through integrated systems, performance monitoring, maintenance, and technological advancements. This strategy could increase the environmental, economic, and financial value of facades over the course of their lifetimes.

Between two extremes, a transition is possible: negative pressures, which originate from outside the organization or, in our case, the facade supplier, such as EU plans for carbon neutrality; and positive pressures, which are exerted as a result of recognizing the opportunities that lie ahead if this transition is made.

The opportunities include increased revenue streams for facade suppliers via long-term service contracts and the possibility of upselling additional services. The approach could also give the facade provider greater control over the entire lifecycle of the facade, resulting in improved quality and performance, and potentially reducing maintenance costs. Due to the facade provider's ongoing support, this strategy could also improve customer relationships and the likelihood of fostering greater customer loyalty. Additionally, the model may permit the incorporation of new technologies and materials into the facade, resulting in enhanced sustainability and performance. Lastly, the 'facade-as-a-service' model could enhance the environmental and economic sustainability of a facade over its lifecycle by reducing waste and potentially creating a closed-loop system.

In conclusion, the facade-as-a-service model offers a novel approach to the facade construction market. Considering organizational, technical, and financial responsibilities during the planning phase will provide us with a great deal of control over the facade's lifecycle and can result in a closed loop in facade industry.

### **Keywords**

Construction , Facade industry , Circular economy , Producer extended responsibility , closed loop

## **103. Rethinking due diligence: the need to incorporate bottom-up processes into responsible sourcing programs**

Andy Symington

KPMG Banarra, Sydney, Australia. UNSW Sydney, Sydney, Australia

### **Abstract**

In a climate of increased expectations from actors throughout mineral value chains, particularly in the context of renewable energy technologies, responsible sourcing has become a critical component of demonstrating corporate sustainability. Its importance is further emphasised by a rapidly evolving legislative landscape that is bringing in reporting and human rights due diligence obligations that require deep investigation of supply chains by procuring companies.

Human rights due diligence is a process outlined by the UN Guiding Principles on Business and Human Rights and has to a large extent become the core of most leading-practice responsible sourcing frameworks. However, the UNGPs can be criticised for taking inadequate account of community agency and viewing rights-holders as passive objects of company processes. This means that HRDD as currently employed could be considered inadequate to fulfil the beyond-compliance social expectations of communities, customers, investors, shareholders and consumers. At the same time, evolving traceability requirements impose a significant burden on downstream customers to gain visibility through multi-tiered supply chains to mine-site level.

This paper examines these trends and how they are acting on companies in the extractive sector. It argues that we need to take a more bottom-up view of the HRDD process, with community-level processes providing assurance through downstream supply chains and guaranteeing the traceability that top-down risk-based processes often fail to achieve. The type of collaborative initiatives that we are seeing in the critical minerals sector between communities, miners and downstream customers, facilitated by technology such as blockchain, appear to be key to achieving the outcomes increasingly expected by stakeholders in the value chain and by legislative requirements.

### **Keywords**

responsible sourcing, critical minerals, human rights due diligence, communities

## **104. Curbing illicit financial flow (IFFS) from resource rich developing countries: Improving resource governance to finance the SDGs (SDC and SNSF): Mapping of illicit financial flow in artisanal and small-scale mining sector (AGSM) in Ghana**

Abigail Tetteh Yankey

Fritz Brugger (Supervisor), Zurich, Switzerland. Fred Dzanku.(Supervisor), Accra, Ghana

### **Abstract**

Studies confirms that illegal mining hurts Ghana including lost of revenue due to tax evasion. These developments raise further concerns, given recent reports from the GHEITI that the share of gold production in the small-scale mining sector, which provides the economic livelihood of millions of Ghanaians, declined from 41 per cent in 2018 to 35 per cent in 2019 (GHEITI, 2021).

This paper is guided by four objectives (1) reviewing the strengths and limitations of existing methods for understanding the dynamics of IFFs in the ASGM sector, the extent to which the methods can be complemented to strengthen the methodological approaches for comprehending the dynamics of IFFs; (2) examining the major incentives, as well as the legal regulatory regime involved in IFFs in the ASGM trading sector; (3) assessing the roles, responsibilities and capacities of key stakeholders along the value chain of effectively curbing IFFs in the ASGM sector; (4) establishing the most promising policy responses and the kind of collaborative governance frameworks necessary for strengthening or establishing national, regional and international level-mechanisms to address the ASGM trade-related IFFs effectively.

The study deploys a qualitative research strategy and semi-structured interviews with legal and illegal miners, middlemen, politicians, regulators, gold buyers, and seller to indicate how gold flows from the mining site to smuggling and export using formal and informal means.

### **Keywords**

Artisanal small scale Gold Mining , Value Chain, Mining site, traders and Regulators, Risk, opportunities

## **105. Technical and economic proposal for the design of a photovoltaic panel recycling plant in Chile.**

Esteban Salfate<sup>1</sup>, Lorena Muñoz del Campo<sup>2</sup>, Héctor Silva<sup>3</sup>

<sup>1</sup>Viña del Mar University. Engineering and Business Faculty. <https://orcid.org/0009-0000-7726-1776>, Viña del Mar, Chile. <sup>2</sup>Universitat de Lleida, Escola de Doctorat, Pl. Victor 3 Siurana. <https://orcid.org/0000-0002-0986-1582>, Lleida, Spain. <sup>3</sup>Viña del Mar University. Engineering and Business Faculty. <https://orcid.org/0000-0002-2341-3954>, Viña del Mar, Chile

### **Abstract**

The progressive accumulation of solar panels as waste from the photovoltaic industry has been related as a highly polluting activity. Chile is currently recognized as the second best country in the world to invest at solar energy due to the radiation present in its territory. As a result of this activity, a peak of 120 thousand tons of photovoltaic panel waste is expected in 2043. Although Chile has the Extended Producer Responsibility Law as a legislative instrument that considers the recycling of solar modules, it does not establish collection and final disposal targets. The present study was carried out with the objective of structuring and evaluating a photovoltaic panel recycling plant in the country, covering a review of the state of the art, the types of existing panels in Chile, the potential to commercialize aluminum, copper, silver and silicon. as recovery products, a recycling pilot plant was projected and finally a financial evaluation was carried out to determine the profitability of the activity.

In the current scenario of waste present in the country, considering a 0.05% recovery of solar panels from industrial projects and 2% from residential projects, favorable financial indicators are obtained with Net Present Value (NPV) of CLP \$ 1,261,534, Rate Internal Return (IRR) of 11% and Return on Investment of 5%. Therefore, through the downcycling procedure, it was determined that recycling photovoltaic panels is economically profitable, creates jobs and contributes to reducing the carbon footprint of the solar panel industry.

### **Keywords**

Downcycling, Extended Producer Responsibility, Photovoltaic, Solar energy, Waste

## 107. UNEP Eco-innovation supplement for electronics – Business models, circularity and learnings from SMEs in developing countries

Robert Reinhardt<sup>1</sup>, Bettina Heller<sup>2</sup>, Sonia Valdivia<sup>3</sup>

<sup>1</sup>UNEP, Bonn, Germany. <sup>2</sup>UNEP, Paris, France. <sup>3</sup>WRF, St. Gallen, Switzerland

### Abstract

Background.

Electronics are among the fastest evolving, most innovative and highly competitive industries.

Demands for certain critical resources have increased with an ever-more complex mix of chemicals of concern (CoC) that are causing harmful impacts on human health and the environment. While chemical-related impacts often occur during a product's manufacturing and end-of-life, decisions influencing product ingredients are taken further upstream of the value chain. Thus, the entire value chain must be considered through impactful action and interventions at upstream stages to protect human health and the environment from chemical pollution. This is particularly relevant to SMEs operating in the electronics value chain, which are mostly found in developing countries. These SMEs often take part in the upstream value chain, namely the assembly processes (through imports of parts from manufacturers in e.g. Asia) while another majority of SMEs is situated at the downstream value chain in dealing with the sustainable management of end-of-first-life electronics, contained CoC and e-waste within emerging economies.

Aim and method.

UNEP's new Eco-innovation Electronics Supplement was created to respond to the electronics sector's need for more guidance in building resilient, competitive, and sustainable business models that reduce harmful (chemical) impacts in the products of SMEs. This supplement aims to build capacity and to reduce the risk of lack of resources. Designed together with the World Resources Forum and to be read alongside UNEP's Eco-innovation (Eco-i) Manual, the supplement provides electronics specific examples, learning case studies, and advice on applying the eco-innovation methodology and its opportunities in the electronics sector with a focus on SMEs in developing countries. The development and validation process of the UNEP Eco-innovation Supplement for Electronics was supported with findings of six pilots conducted in 4 Colombian companies and 2 Peruvian ones.

Results.

It has been found that companies that apply eco-innovation gain several benefits such as to increase their profitability along the electronics value chain, access to new and emerging markets while improving chemicals management through innovative business models for sustainability. For the six pilot companies, key sustainability approaches were identified such as 'circularity', 'energy efficiency', 'chemicals of concern management', 'packaging management', 'supply chain risk management', 'overall end-of-life management' and 'financial innovation'. As a result of the implementation of the eco-innovation methodology in the six companies, the following circular business models were chosen for implementation by the pilot companies: 'circular supplies', 'product life extension', 'product as a service' and 'circular recovery'.

### Keywords

eco-innovation, circularity, sustainable business models, life cycle thinking, chemicals of concern



## 109. The Sustainable Transformation of Healthcare: Challenges and Opportunities for Laparoscopic Devices

Tamara Hoveling, Jeremy Faludi, Conny Bakker

Industrial Design Engineering, Delft University of Technology, Delft, Netherlands

### Abstract

The World Health Organization (WHO) describes climate change as “the biggest health threat facing humanity”. Ironically, the healthcare sector itself is one of the biggest polluters worldwide. Healthcare’s increasing disposal of (e-)waste is partly responsible for this. To minimize the environmental impact of healthcare’s waste streams, a worldwide transformation is needed. An interesting starting point for this transformation may lie in the field of laparoscopic procedures. These are minimally invasive procedures, in which surgeons insert a thin shaft with an attached camera into abdominal or pelvic cavities through tiny incisions. Laparoscopies are performed over 13 million times per year. Especially due to recent technological developments and a large focus on infection prevention, many laparoscopic devices are currently single-use electronic devices. Although these devices save human lives, they make a large contribution to the globally expanding (e-)waste.

Fortunately, the healthcare sector is gaining interest in methods and tools to lessen their environmental burden. Existing practices that help loop waste back into the system (such as re sterilization, remanufacturing, and recycling) seem promising, but are facing challenges to fit within the currently linear supply chain of the healthcare system. To ease this transformation, it is vital that we gain an understanding of what exactly hampers the normalization of environmentally sustainable practices. Our research aimed to uncover just that. We synthesized data from literature and 11 expert interviews into an overview of the most important challenges to the sustainable transformation of the widely-used laparoscopic devices, and beyond. Additionally, we propose potential opportunities to overcome these challenges.

**Disclaimer** – This research falls under the Digital Health in a Circular Economy (DiCE) project, which is funded by the Horizon Europe program of the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

### Keywords

Health care, Medical design, Environmental sustainability, Laparoscopy

## **T10. Real-time, sensor-based assessment of environmental impacts in industrial production**

Charisios Achillas<sup>1</sup>, Christos Koidis<sup>2</sup>, Dimitrios Aidonis<sup>1</sup>

<sup>1</sup>International Hellenic University, Department of Supply Chain Management, Katerini, Greece. <sup>2</sup>Engineers For Business S.A., Thessaloniki, Greece

### **Abstract**

Life Cycle Assessment (LCA) is acknowledged as the most widely used methodology for the assessment of the environmental impacts of products and services. However, despite that the methodology is well defined and standardized, there is some criticism against it. One of the key issues raised is the fact that in most cases, LCA studies do not take into consideration real data related to the production, transportation and use of products, but those rely their results on data sourcing from Life Cycle Inventory (LCI) databases, available in the market (e.g. Ecoinvent). In this work, we focus on the development of an LCA Simulations Engine that is designed in a way to exploit sensors and IoT technologies in order to produce customized, real-time assessment of industrial production. With the tool, a critical number of different environmental impacts are quantified with the use of acknowledged/referenced LCA methodologies, especially those that are required for environmental certification (e.g. Environmental Product Declaration). The functional characteristics of the LCA Simulations Engine are presented, and a real-world case study is discussed to highlight key differentiations of the tool in comparison to other existing LCA software available in the market. The paper concludes with interesting managerial highlights.

This work has received funding from the European Union's Horizon 2020 research and innovation programme KYKLOS 4.0, under grant agreement No 872570.

### **Keywords**

Life Cycle Assessment, industrial production, sensors, environmental product declaration, Internet of Things

## 112. Europe is a major importer of deforestation embodied in metal products

Stefan Giljum, Sebastian Luckeneder, Victor Maus

Vienna University of Economics and Business (WU), Vienna, Austria

### **Abstract**

Mining of mineral resources is one of the most environmentally harmful human activities, causing a range of environmental impacts, including local pollution, land degradation and biodiversity loss. Global resource demand has rapidly increased in the past two decades, calling for measures by actors along the supply chain to reduce the negative consequences of mining activities. However, information on mining-related environmental impacts embodied in internationally traded products is almost entirely missing. Here we quantify deforestation related to mining of metal ores and coal across countries world-wide using various data sets based on satellite images. We then link this information to 'GLORIA', a global trade model with high sector detail developed for UNEPs International Resource Panel. For the first time, we can thereby trace deforestation induced by mining along international supply chains and determine the final product groups that drive mining-induced deforestation in tropical and other forest ecosystems. We find that deforestation caused by the expansion of global mining sites amounted to more than 9,700 km<sup>2</sup> in the past 20 years. Coal and gold together accounted for more than two thirds of global mining-induced forest loss. Tracing embodied deforestation to final consumer countries reveals that final demand of the EU-28 was linked to 14% of global deforestation, only second to China (18%). We also find that 85% of the mining related deforestation footprint of the EU occurs outside the EU borders, in particular in mining countries with tropical rainforests. Our results have important implications for increasing transparency along global supply chains, allowing to identify hot-spots for interventions by companies and policy makers.

### **Keywords**

mining, deforestation, global trade, multi-regional input-output model, responsible sourcing

## **T14. The African Mining Vision and the AfricaMaVal Programme: Views on policy alignment to encourage the recycling of mineral waste.**

Herman Cornelissen

DMT Kai Batla (Pty) Ltd, Randburg, South Africa

### **Abstract**

Although there are some goals and objectives that the African Mining Vision (AMV) and the EU Critical Raw Materials (CRM) program share, they are independent projects.

The African Union created the AMV as a framework for policy to support "transparent, egalitarian and optimal exploitation of natural resources to underpin broad-based sustainable growth and socioeconomic development" in Africa. By encouraging local value addition, expanding the role of mining in local economies, and encouraging regional and international cooperation, it seeks to ensure that African countries get the benefits from their natural resources.

The EU CRM programme, on the other hand, is an initiative launched by the European Commission to ensure the sustainable supply of critical raw materials (CRMs) that are essential for the EU's high-tech industries. The programme aims to reduce the EU's dependence on imports of CRMs and to promote responsible sourcing and extraction of these materials.

While the AMV and the EU CRM programme have different scopes and objectives, they share some common interests in promoting sustainable mining practices, responsible sourcing, and value addition. Therefore, it is theoretically possible for these initiatives to complement each other, and there may be opportunities for cooperation and collaboration between Africa and the EU on critical raw materials issues.

However, an Oxfam report (2017) on the state of the African Mining Vision records questions about the slow pace of implementation thereof, and of its ability to meet the purposes for which it was created. The report also notes a general lack of awareness of the African Mining Vision, particularly among key stakeholders in Africa's mineral sector.

This paper explores the state of the African Mining Vision and, more specifically, the tools created for its implementation, as well as reasons for the slow uptake. The question of whether these are systemic issues in the host countries that will also affect AfricaMaVal programme, are central to the discussion in this paper. The policy instruments and mechanisms of the African Mining Vision are examined and compared to the policy vision and project objectives of the AfricaMaVal programme to identify potential areas of deployment difficulty for uptake of the AfricaMaVal programme within the continents mining host countries. A specific technical focus is the AfricaMaVal programme's consideration of mineral resources in spoils or waste deposits and the enabling framework that the African Mining Vision provides to encourage optimal exploitation of these sources, or the lack thereof.

### **Keywords**

Governance, mineral, recycling, raw materials, Africa

## 115. Circular Economy Resource Information System (CE-RISE)

Golnoush Abbasi

NILU, Oslo, Norway

### **Abstract**

The rising demand and limited supply of critical raw materials (CRM) impair the resilience of EU industries affecting the achievement of Green Deal objectives for an equitable, zero-emission, and digitalized Europe. In response to these challenges, the European Commission aims to take action to minimize the loss of secondary raw materials (SRM) and optimize the reuse of SRM across value chains. The CE-RISE project proposes an integrated framework and an ensuing resource information system to identify optimal solutions for the effective reuse, recovery, or recycling of these materials by; (a) defining a set of RE criteria to evaluate the extent by which products and embedded components can be reused, repaired, refurbished and/or recycled, (b) incorporating information on RE criteria and material composition of products into the Digital product passport (DPP) to enable traceability of materials in the supply chain, (c) integrating DPP and information on the environmental footprint of products (PEF), socio-economic and environmental (SEE) impact of RE processes to enable confidential and anonymized information sharing among actors across value chains, (d) providing open-access software application to disseminate information regarding the assessment of RE criteria, PEF and SEE impacts of products to all stakeholders including consumers and policymakers.

CE-RISE will advance scientific methodologies to enhance the reusability and recyclability of products, and track products through their life cycles, and materials through the value chains. CE-RISE will also contribute to bridging the digital divide in society by supplying affordable ICT devices and supporting access to digital education and job opportunities. Finally, CE-RISE will foster a dynamic ecosystem geared towards prolonging the use of materials and stimulating circular business models.

### **Keywords**

Resrouce, Informaion system, Digital product passport (DPP), circular business model, Product footprint

## **116. 'Feminine Hygiene Product for Homeless Women'**

Archa Sunil

PES University, Banaglore, India

### **Abstract**

Even though a home is one of a person's most important possessions, statistics show that 1.8 million Indians are without a place to call home. Furthermore, due to the COVID-19 pandemic, when more people of the poorest strata of the population were affected, the true numbers increased. The homeless population lack access to basic necessities and face inhumane conditions.

One of the greatest types of urban poverty and social vulnerability is homelessness, which is also a stark sign of poor governance and the state's lack of commitment to a welfare state. One of the sectors most impacted by homelessness is women. While homelessness violates the most fundamental human rights for all groups, women who are homeless and live on the streets experience the most abuse, violence, pregnancy, menstrual disorders, and sanitation issues. Due to the lack of sanitation and menstrual hygiene, homeless women are more prone to UTI's, infections and other diseases. In developing and underdeveloped countries, the need for affordable design solutions is very high. Many existing solutions for the poor and the homeless, are not feasible in countries like India. The government lacks funds for large scale projects and even if such projects exist, many of it fail due to the illiteracy and the backward mindset of the lower strata of the society. This project attempts to solve the inadequate hygienic care for homeless women in Bangalore (and in India at large).

For the purpose of gathering research for this project, night shelters in Bangalore were visited. BBMP officials and NGO staff members were interviewed to gain insights on the city's resources and facilities for assisting the homeless. Homeless women were interviewed, and NGO's and Organizations that provide temporary shelters for the homeless in the city were identified and observed. Contextual inquiry was performed in this study.

This project attempted to create undergarments that are highly affordable, feasible and 100% biodegradable for underprivileged women. Following extensive research and analysis, a 3D model of the concept was developed on Autodesk Fusion 360 and a physical prototype was created using sustainable materials. This project resulted in a working prototype/appearance model of underwear for underprivileged women. The prototype demonstrated the idea of a set of inexpensive underwear for the underprivileged. The project did not solve homelessness or the harsh living conditions faced by them but merely proposed a solution to help reduce the effects of homelessness.

### **Keywords**

homeless women, hygiene, biodegradable, urban, affordable undergarments

## **123. Non-metallic mineral-based value creation in Mauritania and Senegal – impacts of local capacity building**

Omar Jatlaoui, [Wibke Crewett](#)

German Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany

### **Abstract**

The Mauritanian mining sector is mainly focused on iron, gold and copper production and hence, dependent on metal ore export and volatile international market prices for those commodities. Local value creation based on further processing of the raw materials into different products, is therefore largely absent. Non-metallic raw materials, in particular, have the potential to contribute to the sustainable diversification of the Mauritanian mining sector and reduce vulnerability to external price fluctuations of. Compared to metals, non-metallic raw materials offer great potential in terms of local value creation as requirements in terms of technology and staff qualification for processing is less.

In order to further develop the value creation in the mineral sector of Mauritania, the German Federal Institute for Geosciences and Natural Resources (BGR) has, commissioned by BMZ, carried out the technical cooperation project “Promoting the non-metallic resource sector in Mauritania – (PSENMM)”. In cooperation with the Mauritanian partner, the project supports the ANARPAM (“Agence National de Recherches des Géologique et du Patrimoine Minier”) on site in Nouakchott (Mauritania) (04/2020–03/2024). Project activities included, among other things, the creation of a non-metallic raw materials value chain. The approach of the BGR project is to support the partner in developing its technical capacity by supporting from exploration and laboratory analysis and the publication of reports in order to meet international standards. The project sought to increase both, production and processing of raw materials in the country in order to open up new markets and create local employment opportunities.

This project is a particularly successful example for value chain creation in the non-metallic raw materials value chain establishment. As a project result, the kaolin deposit investigated and published within the PSENMM project in southern Mauritania is now being mined by a domestic company SMB-Mining-Sarl and further processed and marketed by a Senegalese company (Twyford). Mauritania supplies the tile factory with 100 million t raw material per year.

Kaolin mining is the first private non-metallic raw material operation in Mauritania and the first Mauritanian-Senegalese cooperation product to be produced on an industrial scale that will be distributed internationally. The Senegalese buyer of the Mauritanian kaolin creates value not only in Mauritania, but also in Senegal itself and thus for the entire region as the projected tiles and construction material markets are located in entire Western and Northern Africa.

### **Keywords**

West Africa, Mauritania, Mineral Resources, Kaolin, Value Chain

## **124. Environmental risks and economic potential of mining legacies – Experiences of the German technical cooperation in the Andean region**

Jacob Mai, Achim Constantin, Wibke Crewett

Federal Institute for Geosciences and Natural Resources, Hannover, Germany

### **Abstract**

Many countries in the Andean region, including Peru, Chile and Bolivia, are home to substantial mineral resources and have a long mining history, which has led to the widespread presence of mining legacies in the form of abandoned mines without adequate closure. While the extractive industry is a vital contributor to their economies and to social development, the potential negative impacts are severe.

Particularly abandoned mines, without adequate closure, pose long-lasting risks to public health and safety, and the environment. Responsible management of these mining legacies is crucial in order to minimize the release of pollutants into the environment, but it is also relevant in order to obtain a social license to operate for mining projects. In addition, mining legacies can also be regarded as secondary resources as they often contain valuable minerals. Reprocessing the waste material not only has economic potential but also reduces the reliance on virgin materials, minimizes waste generation, and mitigates environmental impacts. In the Andean region, appropriate legislative frameworks are partly missing and supervisory authorities are partly not fully equipped to ensure sustainable management of such mine sites.

In order to support the development of a more sustainable and responsible mining sector, the MinSus project, implemented by the Federal Institute for Geoscience and Natural Resources (BGR) and commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) supports a comprehensive approach that includes adequate mine closure and the use of secondary resources. This approach can help to reduce the environmental impacts of mining activities, recover valuable materials, and create new business opportunities. Additionally, it can help to address the environmental and social risks associated with mining legacies while also promoting the long-term sustainability of mining operations. MinSus therefore strengthens technical capacities within national ministries, geological services, environmental assessment and control agencies, develops pilot projects and promotes regional knowledge exchange between the Andean countries,

The presentation will outline technical support and experiences from two case studies on mining legacies and their potential contribution to a circular economy. One being a comprehensive environmental and risk assessment, including geological, geochemical and metallurgical analysis with a final proposal for the rehabilitation of old tailings. The second case study shows the technical support for the mineral processing of a mining operator, who is reutilizing old tailings to extract valuable material while also conducting adequate mine closure.

### **Keywords**

Andean region, Mining legacies, Responsible Mining, Circular Economy



## 125. Energy use caps under scrutiny from an ecological economics perspective

Veronika Kiss

GreenFormation, Budapest, Hungary

### **Abstract**

To avoid climate catastrophe, biodiversity collapse and their seriously negative impacts on human wellbeing, systematic and radical approaches are needed to maximize environmental and social benefits as well as minimize trade-offs between social justice and environmental sustainability, for which ecological economics has been also calling for. Due to the fact that energy use is the biggest driving factor of carbon dioxide emission, developed energy capping schemes were analyzed from an ecological economics perspective. These schemes set an absolute set of energy use or carbon emission of a country/region in line with the national/regional carbon emissions targets, and then lower the set cap until it reaches sustainable scale. Since two goals of ecological economics: reaching sustainable scale and effective allocation are relatively easily reachable through implementing energy caps, just distribution was more deeply investigated. Considering justice theories as well as Hungarian household energy use patterns related data, different socio-economic variables were selected and their role in influencing household energy use patterns was revealed using cross tabulation, multinomial regression, discriminant analysis and expert interviews.

According to the results, households using mostly solid fuel live under the worst living and dwelling conditions and pay more on energy from the total housing costs than households in the other three identified clusters using primarily 1) piped gas, 2) central heating or 3) gas and electricity for heating. Solid fuel using households consume slightly more energy than the Hungarian average, meaning that if an energy capping scheme based on equal per capita quota distribution is implemented, it would not benefit them automatically. Results also show that the poor and marginalized are more often exposed to pollution and environmental problems, while left out from opportunities aiming to reduce household energy use. Their bad dwelling and equipment conditions cause higher burden to pay for sufficient energy related costs, enhanced energy poverty, hurt capabilities and thus energy injustice. The violations of capabilities are not recognized by society leading to recognitional injustice.

Via planning an energy capping scheme, social justice and other factors including dwelling conditions should be considered, instead of equal per capita quota distribution. Furthermore, procedural justice meaning the access to proper information on opportunities as well as education from childhood on energy use needs to be granted. Furthermore, mitigating illegal energy source use, and ensuring proper data collection revealing the underlying causes of energy use are necessary to reach sufficiency for all in energy use.

### **Keywords**

energy use caps, social justice, energy sufficiency

## **126. Sustainability and circularity in the textile value chain, A global roadmap – UNEP key priorities and recommendations for the sector**

Maelys Nizan, Bettina Heller

UN Environment Programme, Paris, France

### **Abstract**

#### **Background:**

The textile sector plays a key role in driving industrialization, trade, development, and social value. Yet, the sector is struggling to address its contributions to the triple planetary crisis on climate change, nature loss, and pollution. Every year, the textile sector emits 2-8% of the world's greenhouse gases while using 215 trillion litres of natural water resources. Additionally, the value chain has deep social impacts, with textile workers at risk of exploitation, underpayment, forced labour, health risks, and abuse, and with women particularly vulnerable as they represent the majority of the garment workforce. By transforming the textile value chain to one that is sustainable and circular, we can not only address these environmental and social impacts, but also support people, prosperity, and equity. To achieve this scale of sector transformation, all stakeholders along the textile value chain need to work together towards a common goal.

#### **Aim and method:**

UNEP's new report 'Sustainability and circularity in the textile value chain: a global roadmap' identifies key prioritised actions that different stakeholder groups should take to drive a just transition in the textile value chain by applying a systemic value chain approach. Building on research and consultations with over 140 textile value chain stakeholders, it defines a common agenda of transformation towards sustainability and circularity.

#### **Results:**

To deliver system change three priorities are identified: shifting consumption patterns, improved practices and infrastructure investment. These priorities are interconnected and require a coordinated approach by all value chain actors. Within these priorities, the roadmap proposes nine 'building blocks' that shape a sustainable and circular textile value chain. The building blocks address the key drivers of environmental and/or socio-economic impacts ('hotspots') within the value chain, support the delivery of the existing industry goals, and require multiple stakeholders to act together. The report further identifies the priority actions that each stakeholder group can take to deliver against the building blocks.

#### **Keywords**

textile , circularity, value chain, key priorities, sustainability

## **127. Developing and using an environmental hazard radar for minerals and metals supply chains – synopsis and review of the OekoRess project trilogy**

Jan Kosmol<sup>1</sup>, Christopher Demel<sup>2</sup>, Regine Vogt<sup>3</sup>, Günter Dehoust<sup>4</sup>, Aissa Rechlin<sup>5</sup>

<sup>1</sup>German Environment Agency (UBA), Dessau-Roßlau, Germany. <sup>2</sup>Projekt-Consult GmbH, Hamburg, Germany.

<sup>3</sup>ifeu – Institut für Energie- und Umweltforschung gGmbH, Heidelberg, Germany. <sup>4</sup>Öko-Institut e.V., Freiburg/Darmstadt/ Berlin, Germany. <sup>5</sup>Ecologic Institut gGmbH, Berlin, Germany

### **Abstract**

How do the environmental impacts and risks of mining affect the availability of minerals and the criticality of raw materials? This was the initial research question ten years ago at the beginning of a three-part series of research projects commissioned by the German Environment Agency called OekoRess. Main outcomes of the first part were two desktop research methodologies to assess environmental hazard potentials of mining sites (1) and raw materials (2) based on freely available data. The second part applied the material-related approach to more than 50 raw materials and proposed to use the results to identify environmentally critical raw materials that should receive special attention in resource efficiency and responsible sourcing policies and business practices. In late 2022, the results of the third part were published: 100 of the world's largest iron, copper and bauxite mining sites were screened for their environmental hazard potentials by further developing and applying the site-related assessment methodology. The main outputs are 100 hazard profiles of major mining sites presented in the form of an interactive map. They can be a powerful tool to help companies meet society's growing expectations of responsible business behaviour in global supply chains which are increasingly becoming legally binding in the EU and other jurisdictions. The methods and results of this project series can be used as a starting point for risk analysis in the context of due diligence processes in line with Step 2 of the Human Rights and Environmental Due Diligence process as defined by the OECD and the UN.

In this presentation, Jan Kosmol will summarize and review the main findings of the OekoRess project trilogy from his perspectives as initiator and supervisor of this project series and as a policy advisor for responsible and more sustainable mineral supply chains.

### **Keywords**

Mining, Mineral raw materials, Environmental hazard assessment, Supply chain, Due diligence

## 128. Circularity potentials for different lithium salts as electrolyte in Li-Ion batteries.

Martina Serra, Eleonora Crenna, Roland Hischer

Technology and Society Laboratory, Empa, St.Gallen, Switzerland

### Abstract

Today resource scarcity is a crucial issue, especially with regard to non-renewable natural resources. Increased demand for Lithium-Ion Batteries (LiBs), leads to an increase of environmental impacts, specifically the extraction of raw materials (e.g. lithium). Lithium is a key component inside the electrolyte, i.e. the liquid which enables the lithium ion transfer between the cathode and anode. Therefore, the recovery of this element would help alleviate the environmental impacts of LiBs production. Currently, lithium hexafluorophosphate ( $\text{LiPF}_6$ ) is the most used electrolyte salt inside commercially available LiBs. However, when the battery is open before going into the recycling path, the hexafluorophosphate anions ( $\text{PF}_6^-$ ) hydrolyze emitting hydrogen fluoride (HF), a toxic gas problematic from an environmental and handling point of view. Thus, safety concerns due to the ecotoxicity of fluorides are increasing in the recycling industry.

In the frame of the on-going (Empa-internal) project FluoriBat, we assessed the environmental sustainability of LiB when using an alternative Li-based salt which is more robust against hydrolysis e.g. Lithium bis(trifluoromethylsulfonyl)imide (i.e. LiTFSI). From a circular economy perspective, an easy recovery of the electrolyte salt from spent batteries allows to close the cycle of lithium and avoid toxic emissions. For the purpose of the study, Life-Cycle Assessment (LCA) methodology is used. The main steps involved are firstly the collection of data on the production of the two salts and recovery pathways. Secondly, life cycle inventory (LCI) modelling of the LiTFSI production and recovery process at the cell level, on a potential industrial scale (applying prospective LCA techniques based on in-house experiments). The LCI of the  $\text{LiPF}_6$  production was already available in the Ecoinvent database, therefore no additional modeling was performed. Finally, the calculation and interpretation of life cycle assessment results.

The LCA results show that the environmental impact across 16 impact categories analyzed for the production of a LiB cell with LiTFSI, is comparable to the production of the same cell with  $\text{LiPF}_6$ . Instead, impacts for producing cells with LiTFSI recovered are some orders of magnitudes higher than those of the cell production with primary salt, due to energy intensive recovery processes and high quantity of water solvent needed. Potential improvements in recovery techniques may focus on alternative recovery processes to reduce the high energy demand (e.g. passive evaporation of water instead of active) or on reducing the amount of water used through more efficient techniques at industrial level.

### Keywords

Life-Cycle Assessment, Environmental sustainability, Lithium-ion batteries, Recovery, Circularity

## **129. A Collaborative Approach to Sustainable Mining Governance in the Andes: Insights from BGR's MinSus Project**

Achim Constantin, Jacob Mai, Wibke Crewett

Federal Institute for Geosciences and Natural Resources, Hannover, Germany

### **Abstract**

The Andean region possess a wealth of mineral resources, such as copper and lithium, which are increasingly in demand by various industries and sectors, including renewable energy, electronics, and transportation. Many analysts therefore already predict a new boom of extractivism for the region. The mining industry is therefore one of the most important economic sectors of many Andean countries and has the potential to contribute significantly to its growth and social development, desirably in line with the Sustainable Development Goals (SDGs) of the UN Agenda 2030. At the same time, the sector also creates complex socio-economic and environmental challenges in the region.

Even though stricter environmental laws are in place today than a few decades ago, participation mechanisms are increasing, and monitoring and compliance with environmental protection standards has generally increased, many mining projects in the Andean countries face major challenges in obtaining the so-called social license to operate. It is therefore a predominant [Cr1] task for the companies and governments to ensure compliance with advanced sustainability standards in new and current mining operations, at the same time do we see ongoing ecological and health threats from abandoned mining sites.

In this context, the German Federal Ministry for Economic Cooperation and Development (BMZ) has commissioned the Federal Institute for Geoscience and Natural Resources (BGR) and the German Agency for International Cooperation (GIZ) to jointly carry out the MinSus project in cooperation with its regional counterpart, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC).

The presentation will showcase how the MinSus project has promoted responsible and sustainable mining in the Andean countries over the past seven years. We will outline how MinSus has supported responsible mining by creating sustainable and resilient critical mineral supply chains for future technologies by building capacity for sustainable mining practices, improving governance frameworks, and fostering partnerships between stakeholders.

The presentation will also feature concrete examples of dealing with abandoned mining sites. We will report on collaboration of development partners and governments in the Andean countries in order to manage those mining legacies. It will be illustrated how the investigation of these sites with regard to environmental and health hazards can be carried out, as well as how the potential for tailings reprocessing can be determined ("secondary mining"), demonstrating concrete approaches to managing mining legacies in a responsible and sustainable way.

### **Keywords**

Value Chains, Critical Minerals, Responsible Mining, Andean Region, Abandoned Mines

## 130. Achieving sustainability in buildings: an interdisciplinary approach to the selection and use of building materials

Eleonora Crenna<sup>1</sup>, Marcel Gauch<sup>1</sup>, Estefania Barros Bermeo<sup>2</sup>, Juan Sebastian Martines Tola<sup>2</sup>, Dolores Catalina Sucozhanay Calle<sup>2</sup>, Paul Fernando Vanegas Pena<sup>2</sup>

<sup>1</sup>Technology and Society Laboratory, Empa, St. Gallen, Switzerland. <sup>2</sup>Departamento Interdisciplinario de Espacio y Población, Universidad de Cuenca, Cuenca, Ecuador

### Abstract

Several countries in Latin America have experienced a rapid adoption of industrialization processes in the construction sector, with the predominant use of concrete. While this has made it possible to partially cover the housing deficit in these countries, concrete constructions do not entirely respond to the needs and the environmental and socio-cultural realities of the local communities. For instance, in Ecuador, the construction sector is responsible for the consumption of 48% of the materials extracted and 15% of the fossil fuels used. From a socio-economic perspective, workers in Ecuador face problems related to occupational health, security and social benefits; while consumers present concerns to aspects related to the cultural heritage of buildings.

The incorporation of criteria that provide the sector with elements of sustainability were therefore sought. The project CEELA –Strengthening Capacities for Energy Efficiency in buildings in Latin America (<https://proyectoceela.com/>)–, funded by the Swiss Development & Cooperation agency and led by EBP, defined 15 principles for the design and construction of Energy Efficient and Thermal Comfort Buildings (EECT) in Ecuador, Colombia, Mexico and Peru. This project aims to promoting energy-efficient, low-CO<sub>2</sub>-emission and adaptive comfort buildings, thus enabling resilience and sustainability of local communities. In this context, looking at local materials and vernacular techniques becomes relevant, considering the benefits they can bring from a systemic perspective.

In the first phase of CEELA (2020–2022), the focus was directed towards the third principle, referred to embodied energy in building materials. Through the joint efforts of Universidad de Cuenca and Empa, a methodology was developed, which accounts for both environmental and technical (e.g. availability and physical-properties of materials), and socio-cultural aspects (e.g. cultural heritage), thus allowing for a more holistic view of materials and production processes. The methodology was applied in the context of Ecuador. It includes (i) the selection of five local building materials used in traditional, modern and artisanal construction, and (ii) the use of lifecycle based tools for individual and comparative analyses of the selected materials.

The results showed that integrating the evaluation of environmental and socio-cultural impacts of the production of local building materials allowed finding critical points to understand the current situation of the construction sector. This methodology can be used for decision making at public and private level around the scope of environmentally and socially sustainable buildings and its application extended to other Latin American countries.

### Keywords

sustainable construction, local materials, lifecycle approach, environmental impacts, social LCA

## 133. Digital Product Passports for universal access to circularity and sustainability information

Deborah Leone<sup>1</sup>, Alessandro Fontana<sup>1</sup>, Rembrandt Koppelaar<sup>2</sup>, Enikő Hajósi<sup>3</sup>

<sup>1</sup>SUPSI DTI, Viganello, Switzerland. <sup>2</sup>EcoWise Ekodenge Ltd., London, United Kingdom. <sup>3</sup>WEEE Forum a.i.s.b.l., Brussels, Belgium

### Abstract

In the future product information can be made easily accessible using Digital product Passports to make products more circular and sustainable. Digital Product Passports are a new innovation combining a web portal where all kinds of product information can become centrally accessible by scanning QR codes on a product. The passport functionality will mean each product or product model will be universally identifiable, similar to a human passport, and evidence information can be accessed by regulators for enforcement purposes, for example, to radically reduce the possibilities for greenwashing. In this presentation we provide the design to realise two benefits of Digital Product Passport systems: sharing Critical Raw Materials information for reuse operators and recyclers, and disclosing Life Cycle Sustainability for consumers. Both use cases were developed as part of the 32 partner EU-funded CircThread project, [www.circthread.com](http://www.circthread.com). The Critical Raw Materials information use case is based on an assessment of existing critical raw materials information management approach and an information needs survey with 10 manufacturers, producer responsibility organisations, collectors and recyclers. The needs were used to generate key product information management processes and exchanges. Information to enhance Critical Raw Materials reuse and recycling accessible to recyclers via QR-codes in the Digital Product Passport would need to include product registrations, materials declarations, life cycle status updates, sorting of products based on critical raw material contents, and flagging of products for critical raw materials component extraction. The Life Cycle Sustainability information use case is based on an analysis of state-of-the-art practices and standards in product-level sustainability areas, together with the methodologies available for sustainability assessments integration, followed by phases of identification, classification, and selection of sustainability indicators. Those phases are carried out referring to circular use-cases, with the aim to identify information flows to be linked with the Digital Product Passport for the calculation process. Information to enhance Life Cycle Sustainability accessible to consumers via QR-codes in the Digital Product Passport would need to include environmental and social labels, indicators and scores, and environmental and social questionnaire results from the product supply chain. The options and requirements to implement these use cases in the market for manufacturers, as part of setting up Digital Product Passport system, will be discussed. Based on suppliers information requirements, the approach to disclose information, the IT requirements for Digital product Passports, and the possibilities to share sensitive data using DataSpaces for secure data contracts based information exchanges.

### Keywords

Digital Product Passport, Circular economy, Critical raw materials reuse & recycling, Sustainability assessment, DataSpaces

## 135. Rethink Rotor

Marcin Orawiec<sup>1</sup>, Saskia Schmidt<sup>2</sup>

<sup>1</sup>architect, Aachen, Germany. <sup>2</sup>student, Darmstadt, Germany

### Abstract

With around 21.7 % of gross electricity in Germany, wind energy is a rapidly growing market. The rotor blades of wind turbines have to be replaced after 20 years. Every year, about 7,500 are used as fuel, sand substitute neither residue-free, CO<sub>2</sub>-neutral, nor sustainably thermally disposed of. Ann the near future, a much larger number can be expected.

Therefore the aim of Rethink\*Rotor is to replace the current practice of recycling or final disposal with the reuse of the elements as building products and thus their remaining in the anthroposphere. For this purpose, the rotor blades are sorted according to shape and resilience and classified for usability in the construction sector.

The project Rethink\*Rotor focuses on a broad spectrum. Starting with 30 to 60 pieces for an industrial hall or 600 for a noise barrier up to 2000 or more for a pontoon construction as a floating support structure for a floating village. These are only three selected examples of the many topics that the Rethink\*Rotor project deals with. An important aspect is to find a secondary use near the original location of the wind turbine in order to minimise transport distances. To this end, work is also being done on processing concepts that make it possible to implement them on site. One of the prerequisites is that the joints for the components can be realised with low-tach methods.

Thanks to the prospects for subsequent use of the rotor blades, the acceptance of wind turbines in an urban context is also increased.

This is our way out of the recycling dilemma - with new applications; circular, "profitable" in the construction sector.

### Keywords

reuse, circularity, rotorblades, renewable energy, second life use



## **136. Move it: mobility in transition**

Christophe Roncato Tounsi, Hugo Le Boulzec

University Grenoble Alpes, Grenoble, France

### **Abstract**

Many scholars of the transportation sector have argued that research and public institutions should focus on four categories of possible policy modification: pricing, fuel-switching regulations, strengthening vehicle emissions standards and travel reduction. Countries and territories have massively adopted these categories and elaborated their transition scenarios along these lines.

Such is the case of California's sector-by-sector institutional roadmap for its ecological transition (California's 2022 Scoping Plan) which was designed to "lay out a path to achieve targets for carbon neutrality and reduce anthropogenic greenhouse gas (GHG) emissions by 85 percent below 1990 levels no later than 2045". In this regard, the ambition of the Scoping Plan is to further the long history of California's environmental reforms which has designed, tested and exported a wide number of regulations across the country and the world.

This presentation takes the cue from the Scoping Plan and, by focusing on the transportation sector, proposes to question some of the assumptions behind the Plan so as to further research the potential of transformation of this key sector of the transition. By relying on institutional data and on an environmental history approach, we question the position of the Plan on decoupling between economic growth and the consumption of natural resources of the Californian transport system, and investigate alternatives in the field of active mobility. All in all, this research tackles key questions that are central to a socially, environmentally just and realistic transition.

### **Keywords**

Transportation, Mobility, Dynamic stock and flow model (MATER) , Environmental history, Ecological transition within planetary boundaries

## **138. Science-based targets: a pathway to achieve the SDGs**

WLADMIR MOTTA

CEFET-RJ, RIO DE JANEIRO, Brazil

### **Abstract**

The Sustainable Development Goals (SDGs) remains a challenge for humanity and the lack of effective actions has made these goals increasingly challenging. In this sense, the Science Based Targets Network (SBTN), a proposal from the Global Commons Alliance (GCA), which is a network of organizations working together to ensure that societies and the global economy prosper, underpinned by the principles of sustainable development, SBTN has as its general objective that the establishment of science-based targets becomes standard business practice and was built on a understanding of the nature-related risks facing business. This study will focus on the Science Based Targets for nature, that by pointing out that the biggest risk business face today is inaction, brings, in these sense, a proposal for action, allowing business to align their efforts with global sustainability efforts related to nature, in this case the SDGs. Understanding that the SDGs represent a global consensus, where 193 countries have committed themselves to a comprehensive and ambitious sustainable development agenda by 2030 and that to achieve them, the private sector is an indispensable partner and has a critical role to play in advancing of this goals. Also considering that SDGs act as an important roadmap regarding future policy direction at international and national levels, being a major catalyst for innovation and new market opportunities for the private sector to embrace and drive economic and social growth. In these context, could the Science Based Targets for nature contribute to the challenges of the SDGs? How could the implementation of the SBTs by business change the current approach? Can SBTs contribute to National Action Plan on Business? The present study aims to answer these questions and shed light to this discussion through a literature review and a bibliometric study, clarifying this valuable and important correlation between SBTs and SDGs.

### **Keywords**

Science-based targets, Sustainable Development Goals - SDGs, National Action Plan, Policy, Business

## 139. The Meaning Construction of Sufficiency

Lena Leifeld, Simon Oertel

Paris Lodron University, Salzburg, Austria

### Abstract

Despite pressures to reduce their ecological impact, organizations often struggle to adopt and enforce a comprehensive sustainable strategy (Jungell-Michelsson & Heikkurinen, 2022) due to institutionalized structures and practices that are difficult to change (Hasenfratz, 2018). Traditionally, the strategy of firms predominantly focuses on growth and performance (Fiss & Zajac, 2004) including efficiency and consistency (Bocken & Short, 2016). Sufficiency as a strategic orientation goes a step further by aiming to decrease the production and consumption of goods (Spangenberg & Lorek, 2019).

Despite an increasing popularity of sufficiency for organization, research on how organizations understand and conceptualize sufficiency has received scant attention yet. Furthermore, there is a lack of studies to date on the question of influencing factors that can explain why the understanding of sufficiency differs between organizations (Beyeler & Jaeger-Erben, 2022) and how this understanding changed over time.

This is where our study starts focuses on the self-representation of 39 businesses in the German food industry, a sector that is of high relevance in the context of sustainability (Somlai, 2022).

Focusing on qualitative content analysis, preliminary findings indicate that only a few businesses have an explicit sufficient strategy but that the existence and content of such strategies are influenced to a large extent by organizational and institutional characteristics.

### References

- Beyeler, L., & Jaeger-Erben, M. (2022). How to make more of less: Characteristics of sufficiency in business practices. *Frontiers in Sustainability*, 3, Article 949710, 131. <https://doi.org/10.3389/frsus.2022.949710>
- Bocken, N., & Short, S. W. [S. W.] (2016). Towards a sufficiency-driven business model: Experiences and opportunities. *Environmental Innovation and Societal Transitions*, 18, 41–61. <https://doi.org/10.1016/j.eist.2015.07.010>
- Fiss, P. C., & Zajac, E. J. (2004). The diffusion of ideas over contested terrain: The (Non)adoption of a shareholder value Orientation among German Firms. *Administrative Science Quarterly*, 49(4), 501–534. <https://doi.org/10.2307/4131489>
- Hasenfratz, M. (2018). Die Nachhaltigkeit der Dinge. In S. Neckel, N. Besedovsky, M. Boddenberg, & M. Hasenfratz (Eds.), *Sozialtheorie. Die Gesellschaft der Nachhaltigkeit: Umriss eines Forschungsprogramms* (1st ed., pp. 101–122). transcript Verlag. <https://doi.org/10.14361/9783839441947-007>
- Jungell-Michelsson, J., & Heikkurinen, P. (2022). Sufficiency: A systematic literature review. *Ecological Economics*, 195, 107380. <https://doi.org/10.1016/j.ecolecon.2022.107380>
- Somlai, R. (2022). Insights into business strategies for reducing food waste in the Australian food industry. *Business Strategy and the Environment*, Article bse.3292. Advance online publication. <https://doi.org/10.1002/bse.3292>
- Spangenberg, J. H., & Lorek, S. (2019). Sufficiency and consumer behaviour: From theory to policy. *Energy Policy*, 129, 1070–1079. <https://doi.org/10.1016/j.enpol.2019.03.013>

### Keywords

Sufficiency, Family Businesses, Change Management

## 140. Just Transition” under the Plastics Treaty Agenda

Alexandra Harrington<sup>1</sup>, Karine Siegwart<sup>2</sup>

<sup>1</sup>Law School, Lancaster University, Lancaster, United Kingdom. <sup>2</sup>International Union for Conservation of Nature IUCN, Gland, Switzerland

### Abstract

Pollution is one of the five major drivers of biodiversity and ecosystem devastating change, and has many adverse impacts on natural resources, ecosystems and biodiversity, on land, in water and in the marine environment. It reduces the ability of ecosystems to provide services such as carbon sequestration and decontamination and threatens many species at risk through environmental and health harms. Pollution from the unsafe use of plastic materials, chemicals, pesticides and waste also a direct impact on the health of humanity and natural resources.

Sufficiency and justice concerns relating to natural resources converge around the area of just transition, especially when efforts to conserve natural resources require the reorientation of aspects of global and national economies. Just transition as a theoretical argument and a legal requirement has become synonymous with the carbon and energy sectors. However, just transition can be carried through to a number of other natural resource conservation efforts. This has become apparent in the efforts to negotiate a new Plastics Treaty, where attempts to protect natural resources from the threats of plastic pollution have been combined with arguments regarding the need for a just transition in accomplishing this.

The Plastic Treaty’s intended scope, as articulated by UNEA resolution 5/14, includes the circular economy and elements of the plastic life-cycle. In the plastics context, the transition away from plastic production as well as plastic-intensive industries and the informal sector can be seen as essential yet also carries with it the potential to cause unemployment and poverty. Just transition could offer a bridge through which to address the immediate issues of job loss as well as underlying socio-economic barriers and achieve synergies with other treaty systems, including trade rules.

A just transition in the context of the plastics life-cycle and circular economy will depend on the national or sub-national setting in which it occurs but also will require international law to guide and oversee full implementation. IUCN, the International Union for Conservation of Nature, vision is: a just world that values and conserves nature (Nature 2030 | IUCN). Our presentation, which links to the IUCN submissions for the Intergovernmental Negotiating Committee (INC) on Plastic Pollution, will discuss how just transition as a theory and legal framework can be used to address plastic pollution impacts on natural resources. The presentation will also include practical results from different projects and support countries in their engagement in the negotiation process.

### Keywords

Just Transition, Plastics Treaty, Informal sector, Circularity of Plastics, Pollution and Biodiversity

## **141. Eco-Industrial Parks as route to a circular economy**

Bernd Oellermann

NCPC-SA, Pretoria, South Africa

### **Abstract**

The Eco-Industrial Park (EIP) concept is not new. However, it has undergone a transition into a more comprehensive model for approaching industrial spaces through the work of UNIDO, the World Bank and GIZ by way of the international Eco-Industrial Park Framework. The application of the EIP Framework in the South African context can contribute significantly in the Just Transition (JT) for industry to a circular economy as part of the broader JT agenda.

The EIP approach requires a holistic and systems-based approach that integrates various aspects of the industrial space. These aspects include economic, social, environmental, operational, technological and other areas that need to be addressed in coordinated fashion in order to achieve the potential of the EIP approach in this transformation to a circular economy. In doing so, it also contributes to fundamental questions about how we function as society and how value chains, industry and economics work, such as whether one can or should (and how to) still think of the concept of economic growth in its current form or consumer-driven approaches.

In South Africa the EIP approach has been applied at national level through work of the Department of Trade, Industry and Competition (the dtic), National Treasury (NT), the National Cleaner Production Centre (NCPC-SA) and others. This has led to extensive collaboration and partnerships, which have proven to be crucial in the successful implementation of an EIP approach. Coordination and integrated approaches have similarly been highlighted as being of high importance.

This paper intends to share learning and insights from the national EIP work, as well as from the country-level intervention for South Africa on the Global Eco-Industrial Parks Programme (GEIPP) implemented by UNIDO in seven participating countries worldwide with the intention to identify commonalities with other initiatives in the Circular Economy regarding mechanisms of transition for industry and society as a whole.

### **Keywords**

Eco-Industrial Parks, Circular Economy, Just Transition, industrial development, systems

### **143. Life Cycle Assessment and Costs of Biochar Production from Palm Oil and Rice Wastes for Soil Amendment**

Djasmine Mastisya Saharudin, Harish Jeswani, Adisa Azapagic

The University of Manchester, Manchester, United Kingdom

#### **Abstract**

Biomass wastes have various utilisation potentials, from being the source of renewable energy to the production of furniture, building materials, enzymes, animal feeds, specialty chemicals and much more. In Malaysia, however, these wastes are largely underutilised with significant amount being sent to landfills each year. Around 20 Mt of palm oil wastes, such as fronds, mesocarp fibres, empty fruit bunches (EFBs) and kernel shells are discarded annually, either landfilled or left to decompose in fields. On the other hand, approximately 1.7 Mt of rice straws are burned each year as a fast and cheap waste management option to prepare for the next cropping season. To avoid the environmental, health and waste management problems associated with disposal of biowastes, they can be converted into biochar to provide agricultural benefits (e.g. fertiliser reduction, soil N<sub>2</sub>O emissions reduction, increased crop yield) when used for soil amendment. Due to the stable carbon in biochar, it is also considered as one of the negative emissions technologies (NETs), rapid and large-scale deployments of which is vital to mitigate climate change. However, the environmental and economic implications of biochar production from these wastes are not fully known. Therefore, this research presents the first life cycle sustainability assessment of large-scale biochar production in Malaysia using palm oil and rice waste. Slow pyrolysis is assumed for biochar production and process simulation is used to model the process at different temperature (300–600°C). These data are used to estimate the life cycle environmental impacts and costs of biochar production. The cradle-to-grave system boundary includes biomass acquisition, its transport and pre-treatment, biochar production, transport and spreading to agricultural soil. The benefits of soil application are also included, including carbon sequestration and reductions in the use of chemical fertilisers and soil N<sub>2</sub>O emissions. Two units of analysis are considered: 1 t of biochar produced and 1 t of CO<sub>2</sub> removed for both the impacts and costs. The results of this assessment can be used to identify more sustainable feedstocks and process conditions for biochar production.

#### **Keywords**

life cycle, negative emissions technologies, carbon dioxide removal, waste management, sustainability assessment

## 144. Environmental impact of API synthesis: focus on final API purification and tuning

Amelie Verlinden<sup>1,2</sup>, Lieselot Boone<sup>1</sup>, Alain Collas<sup>2</sup>, Bruno De Witte<sup>2</sup>, Jo Dewulf<sup>1</sup>

<sup>1</sup>Ghent University, Ghent, Belgium. <sup>2</sup>Janssen Pharmaceutica NV, Beerse, Belgium

### Abstract

The production of synthetic Active Pharmaceutical Ingredients (API's) may be carbon intensive due to the number of complicated reaction steps, all of which require solvents, energy and chemicals. The final steps of API synthesis may entail a purification step, followed by a tuning step to optimize the physical properties of the API crystals. These physical properties are important if the next step of drug product involves the manufacturing of solid tablets. An example of such a property is the flowability of the API, which becomes even more relevant when continuous DP manufacturing is considered.

From a process intensification point of view, the purification and tuning steps may be integrated in one crystallization but this often limits the degree of tuning that can be achieved. However, splitting of process steps implies extra resource consumption and more risks to loose high-value API. In this case study, the resource footprint of different scenarios (purification and tuning integrated or separate) was calculated and the biggest contributors to the environmental impact were identified.

The resource footprint of the integrated approach was found to be 25% lower than this of the separate steps. The highest contributor in both approaches is the solvent use. Different options were explored to reduce the footprint of the separate steps. A sensitivity analysis was performed looking at the impact of the resource footprint of the raw API in the entire analysis.

This study was performed with the financial support of Vlaams Agentschap Innoveren & Ondernemen.

### Keywords

Pharmacy, Life Cycle Assessment, Sustainability , Active Pharmaceutical Ingredient (API), Crystallization

## **145. Addressing informal e-waste management in India: the Ecowork project and its challenges and successes in establishing a co-working facility in Delhi**

Dea Wehrli<sup>1,2</sup>, Deepali Sinha Khetriwal<sup>2</sup>, Michael Gasser<sup>2</sup>

<sup>1</sup>Empa, St.Gallen, Switzerland. <sup>2</sup>Ecowork, Delhi, India

### **Abstract**

Ecowork is a pioneering project that tackles the challenge of informal e-waste management in India, focusing on Delhi as an e-waste hub of the country. The project proposes a business-oriented solution through the establishment of a co-working facility, providing informal dismantlers with a secure and legitimate work environment. By leveraging existing efficient collection systems and promoting social inclusion, the project aims to reduce pollution and enhance the recovery of valuable materials through their channelization to formal downstream recyclers. Key objectives include shifting dismantling activities to the Ecowork facility, redirecting dismantled e-waste to formal processing, and providing training and business skills to create opportunities for micro-entrepreneurs. Ecowork's main goal is to avoid pollution and reduce health risks associated with informal e-waste recycling, while promoting the circular economy and resource efficiency. Through its efforts, the project aims to demonstrate that sustainable and socially responsible e-waste management is feasible, contributing to economic development and environmental sustainability.

During the establishment of the first Ecowork facility in 2023, various challenges are being faced, including legal, social, and economic barriers. These challenges included navigating the formal and informal sectors, gaining the trust of the informal sector, extensive paperwork for applying to be a licensed facility, and managing financial planning. Despite these challenges, the project has achieved significant results and valuable learnings, which will be shared and highlighted. Overcoming these challenges is critical to scaling the project in other Indian cities and emerging and developing countries. The project's success in navigating these challenges can serve as a blueprint for future initiatives aimed at promoting sustainable and socially responsible e-waste management in similar contexts.

### **Keywords**

Informal sector, India, closure of materials value chains, Social inclusion



## **146. Inclusive recycling in Costa Rica: The case of organics in the municipality of Turrialba**

Susy Lobo Ugalde<sup>1</sup>, Victoria Rudin Vega<sup>1</sup>, Ana Lorena Vallejo Chaverri<sup>2</sup>, [Sandra Mendez Fajardo](#)<sup>3</sup>

<sup>1</sup>ACEPESA, San José, Costa Rica. <sup>2</sup>Municipal Solid Waste Management, Turrialba, Costa Rica. <sup>3</sup>Skat Foundation, St. Gallen, Switzerland

### **Abstract**

In the implementation of decarbonisation, circular economy and climate change adaptation plans, Costa Rica has been strengthening the sustainable management of solid waste through the promotion of a circular economy in the municipalities of Golfito, San Carlos, Liberia and Turrialba. Thus, the closure of open dumps was initiated, impacting the people who work in the first link of the recycling chain. Some of these groups organized themselves to continue their work, while others are still working at the closed sites, without their contribution to the conservation of natural resources being valued. In this context, with funding from Latitud R Platform, the project "Inclusive Recycling: Towards a Circular Economy" is being developed, seeking the recognition of this population by national and local authorities and society in general. To this end, organizational work is promoted based on the formation of formal associations, influencing public policies that aim to protect their human rights, while enabling the continuation of waste recovery and recovery activities with the necessary working conditions.

A national movement of grassroots waste pickers emerged, a process that the Central American Association for the Economy, Health, and Environment ACEPESA has accompanied, facilitating exchanges with peers such as the Latin American and Caribbean Network of Waste Pickers (Red Lacre), to reinforce the lessons learned by groups from different countries in the region, especially Colombia and Chile. In this learning journey, their capacities and skills have been strengthened to cope with changes in their work environment and economic activities, improving the quality of life of their families. At the national level, in the municipality of Turrialba, noted for its commitment to implementing circular economy and sustainability strategies, the Association of Grassroots Recyclers of Turrialba (ASORET) was formed, and linked to recycling municipal activities. Currently, with funding and technical support from the Skat Foundation of Switzerland, and as a pilot experience, this group is being trained to be integrated into the integrated management of organic waste from restaurants and greengrocers. Within this framework of inclusion, a selective collection service is being implemented for small businesses in the center of the municipality, incorporating ASORET members as field staff. A pilot aerobic composting plant will also be implemented, in whose operation and management members of the association will also be involved, together with the municipal government, a model that will be documented and promoted as an example of multi-sectorial collaboration for inclusion and organics circular economy.

### **Keywords**

Informal sector, Inclusion, Organic waste, Circular Economy, multi-sectorial collaboration

## **147. Empowering sustainable buildings: Data-Driven Solutions for Estimating Energy Needs & CO2 Emissions.**

Volodymyr Getmanskyi

ELEKS, Lviv, Ukraine

### **Abstract**

Nowadays the role of greenhouse gas problems in the light of economic development can't be underestimated. There are many classical CO2 emission calculations supported by different frameworks (LCA, GLEC) and which typically can be simplified to a multiplicative model with the norm of emission, distance/time/power and emission factors as an auxiliary variable. But with the obvious pros (precision, direct factors) there are several cons, - the standard norms in the calculations are nominal (average emission per kWh/1 km (and what if the temperature will be -10°C or capacity will be overloaded)), the environment and production conditions are dynamic (seasons, quality), there are many exogenous factors (can't be included into the calculations as is (weather)) and deeper horizon factors (scope 2-3).

We propose to use a modern probabilistic approach to resolve the above limitations and to extrapolate exact emission metering, known equipment and materials specification, and conditions, in time, in scale, and even partially to a new production structure. The model is the ML/DL ensemble that covers geospatial extrapolation, scale and elasticity estimation based on the empirical data. The results can be proven based on the ex-post validation and against the direct calculation baseline.

### **Keywords**

GHG emissions, Machine learning, Models, Validation of GHG emissions data

## **148. Challenges of evaluating environmental sustainability of digital health devices: a systematic review**

Naomi Muindi, Erasmo Cadena, Lieselot Boone, Jo Dewulf

Research Group STEN, Ghent University, Coupure Links 653, B-9000, Ghent, Belgium

### **Abstract**

Health care causes substantial environmental impacts, and medical devices (e.g. single use surgical instruments, wearables and imaging equipment, etc.) are among the most resource-intensive components of the health care system. For a thorough evaluation of the environmental impacts of these devices, life cycle assessment (LCA) methodology is often used. Besides the direct impacts due to the devices' life cycle, the indirect impacts associated with the use of a medical device can, in some cases, present larger environmental impacts than the direct ones. Therefore, a systems perspective is needed to comprehensively evaluate the environmental sustainability of medical devices by including impacts of service delivery associated with such equipment. For instance, when assessing the environmental impacts of an electronic surgical device, it is important to also consider the underlying benefits and drawbacks of the device in the surgical value chain (i.e. length of hospital stay, HVAC requirements, etc.) in addition to the product's life cycle.

This systematic review is part of the Horizon Europe DiCE project (grant agreement number: 101060184). DiCE aims at developing new circular integrated solutions that tackle the problem of health e-waste. This study focuses on two objectives: i) to investigate the current state of knowledge on the use of LCA to evaluate the environmental sustainability of digital devices; ii) formulate recommendations for improvement based on the gaps identified. Relevant publications were identified through literature research conducted in the electronic databases such as PubMed, Scopus, Embase, and Web of Science. The searched phrase was built as a combination of keywords linked to medical health devices and environmental sustainability. The results of this systematic review highlight the limitations of the current environmental sustainability assessment in the literature. To the authors' knowledge, results show that the impacts of digital health devices are only considered at the product level and overlook potential indirect impacts associated with the service delivery linked to such devices. Therefore, a holistic sustainability assessment of digital devices should consider the direct life-cycle impacts of the device, as well as the positive and negative effects induced by the use of the device and the broader structural changes to the healthcare infrastructure. Future steps consist of applying these recommendations in relevant use cases such as the ones included in the DiCE project.

### **Keywords**

Sustainability, LCA, Digital health devices, Healthcare sector, e-waste

## **149. The Green Game: “Using Gamification to Promote Tree Planting and Environmental Conservation in Urban Areas”**

Riddhi Kasar<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Institute of Design, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### **Abstract**

Urbanisation is a groundbreaking process that brings about growth, but it comes at a cost. The swift urbanisation occurring in developing nations has exerted significant pressure on green spaces. Over the last three decades, the world has lost 10.3% of its total forested area. In India, the forest cover constitutes only 21.7% of the country's total geographical area. Without further action, it is estimated that about 289 million hectares of forests in tropical regions alone will be deforested between 2016 and 2050, leading to the emission of 169 giga tonnes of CO<sub>2</sub>. Furthermore, if the global temperature increase is not maintained below 1.5°C, the risk of future pandemics, lack of food security, increased poverty, increase in diseases and a decrease in the planet's biodiversity is prominently high. Not only are the tangible byproducts affected, but deforestation will have a drastic and direct effect on the mindsets of young people, hindering them from believing that there is hope for a better world and a better future for all.

Many awareness programs and initiatives have been developed to promote environmental well being. However, this paper focuses on not just spreading awareness, but promoting implementation as well; encouraging people to directly go out and plant more trees. A case study is conducted in Bangalore, India. With a population of approximately 18 million, an existing history of declining forest cover, and immense urbanisation, the impact of the proposed solution is tested.

The proposition utilises an application that incorporates a gamified rewards system. Functioning as a normal map, this application not only aims to help the users plant more trees, but also helps them find the right location where planting a tree will make a significant difference. To ease the users' process of planting trees, it shows them nearby nurseries as well. The same process can be applied en route when the user is travelling, to encourage them to make a quick stop along their route to help the environment. To further fuel this encouragement, the app embodies a treasure map like UI that enables the users to bring out the adventurer in them by making them complete “quests” by planting trees for points and benefits. Efficient, and showcasing significant potential, this system can bring about prominent change since it directly involves all the stakeholders related to environmental conservation, thus proving to be the much needed, possibly impactful solution.

### **Keywords**

Environmental Conservation, Gamification, Planting Trees, Rewards, Urban Areas

## **150. Linking mismanaged plastic waste flows to critical ecosystems in the Western Indian Ocean**

Janaka deSilva<sup>1</sup>, Leander Raes<sup>2</sup>, Lynn Sorrentino<sup>1</sup>

<sup>1</sup>IUCN, Gland, Switzerland. <sup>2</sup>IUCN, Washington D.C., USA

### **Abstract**

Pollution is one of five major drivers of biodiversity and ecosystem change. Plastic pollution has many adverse impacts on ecosystems and biodiversity, reducing ecosystems services such as carbon sequestration and decontamination. Pollution from the unsafe use of materials, chemicals, pesticides and waste has also a direct impact on health, and damage to social systems.

The impacts of plastic pollution on the marine environment are well documented. Identifying actions to reduce plastic pollution that minimise impacts on important ecosystems and species requires coupling of available information from biodiversity and ecosystem data with plastic material flow information. This case study explores coupling available information from the Western Indian Ocean to identify nature positive solutions. IUCN, the International Union for Conservation of Nature, developed the Red List of Ecosystems which has been applied by CORDIO for coral reefs in the Western Indian Ocean from Somalia to South Africa. The IUCN Red List of Threatened species provides data on conservation status, species geographical range, main threats and use and trade when available. In addition, through the IUCN Marine Plastics and Coastal Communities project, a profile of Plastic Waste and leakage into the environment in Kenya, Tanzania, Mozambique and South Africa has been conducted. Combining the spatial information generated by the Red List of Ecosystems, the Red list of Species with the plastic leakage hotspot maps provides a mechanism to assess where marine plastic leakage hotspots overlap. The combination of these results are key to identifying actions to reduce mismanaged plastic waste flows that potentially have the highest positive impact on biodiversity.

We highlight why actions to address plastic pollution need to account for biodiversity and ecosystems in planning. Such information could support countries in their engagement with the Intergovernmental Negotiating Committee on Plastic Pollution and concurrently address their commitments to the Global Biodiversity Framework Target 2.

### **Keywords**

Biodiversity, Ecosystems, Plastic Pollution, Plastic Inventory, Western Indian Ocean

## 153. Having enough versus wanting more: a case for sufficiency experienced in society?

Damaris Castro, Brent Bleys

Ghent University, Ghent, Belgium

### Abstract

In the quest for sustainability, an ever more important strategy which targets the affluence factor is sufficiency. As the success of the sufficiency strategy depends on people's willingness to lower consumption levels and alter behavioural patterns, analysing to what degree people are receptive to this strategy is crucial. An indispensable first step before implementing sufficiency-related policies is therefore estimating the level of sufficiency experienced in society.

In this paper we aim to investigate the level of sufficiency experienced in society by means of 2 dimensions and 2 domains. The concept is broken down along 2 counterpart dimensions: measuring the level of "having enough" (sufficiency dimension) is supplemented with measuring the level of "wanting more" (insatiability dimension). Furthermore, instead of using a general phrasing, sufficiency is evaluated with respect to 2 specific domains: materialism and leisure time. This leads to a total of 4 different metrics, each measured with a statement ("I have enough on a material level"; "I want more on a material level"; "I have enough leisure time"; "I want more leisure time") rated on an 11-point scale from 0 (totally disagree) to 10 (totally agree). These questions were added to the 2020 edition of the LEVO survey (N=1633), a large-scale survey which is weighted to be representative for the population in Flanders.

We found that on average, people significantly experience sufficiency above the midpoint according to the sufficiency dimension (average scores 7.86 and 7.24 for material and leisure respectively). However, the average scores for the insatiability dimension (4.65 and 4.72 for material and leisure respectively) are not significantly different from the midpoint, and scores for this dimension show significantly more variability than for the sufficiency dimension. As expected, the sufficiency and insatiability dimensions are inversely correlated with each other ( $\rho = -.604$  and  $\rho = -.731$  for material and leisure respectively). However, a significant fraction of respondents (36.3% and 27.6% for material and leisure respectively) answers inconsistently to both dimensions, that is: either a high or a low score for both the sufficiency and insatiability dimension. Furthermore, we investigated whether these metrics correlate with openness towards sufficiency-related policies. Towards this end we made use of a question asking employees about their relative preference for either additional income or additional leave days. Finally, in the paper we analysed and compared what determinants explain each of the 4 metrics, as well as what determinants explain the difference between consistent and inconsistent respondents.

### Keywords

experienced sufficiency, sufficiency strategy, sufficiency metrics

## 155. Tire-rific Tech: Digitalizing resource recovery for circular economy

Dr. Lyubomyr Matsekh<sup>1,2</sup>, Roksolana Khyzhak<sup>3</sup>, Anastasiya Palko<sup>4</sup>

<sup>1</sup>ELEKS, Reutlingen, Germany. <sup>2</sup>Reutlingen University, Reutlingen, Germany. <sup>3</sup>ELEKS, Lviv, Ukraine. <sup>4</sup>ELEKS, Chicago, USA

### Abstract

In the last 150 years, global average temperature has increased by more than 1°C[i]. This increase is due to greater atmospheric concentrations of greenhouse gases (GHG), such as carbon dioxide, methane and nitrous oxide. GHG emissions are at their highest point ever over the last 800,000 years. The average for the last 800,000 years was between 150 and 300ppm[ii]; in the last 100 years it is above 400 ppm[iii]. The consequences for the environment and humans – already dramatic – will be potentially catastrophic. To avoid this, global warming has to be limited to not more than 2°C by 2100. To achieve this, by 2030 anthropogenic GHG emissions need to be lowered to 55% of those in 2010; by 2050 they must reach the state of net zero. Research[iv] shows that achieving the goals mapped out in the Paris Agreement requires urgent and rapid change. The longer we delay the reduction of GHG emissions, the greater will be the need for ever more drastic measures. Digital technologies can play a major role in achieving the net zero goals.

eTracks approached ELEKS with an initiative to re-engineer the existing platform, eSRP in order to digitise the end-to-end tire management process. The goal of the project was to improve traceability, remove manual transactions and reporting, increase compliance with regulations (e.g., Resource Recovery and Circular Economy Act, 2016, S.O. 2016, c. 12, Sched. 1). Additionally, eTracks wanted to enable the easy addition of new features to support expansion into other regions and material classes.

ELEKS helped eTracks to achieve these goals by creating a product scope and vision, developing an interactive web application that could work both on desktop and mobile devices, and adding new transactions to help identify any inconsistencies during the recycling process to meet the core requirements of traceability and flexibility. Computer vision and AI capabilities were also added to help with optical character recognition, signature validation, photo validation and more. Finally, user testing was done before releasing the application for use. In January 2022, eTracks launched its Sustainable Recovery Platform to help manage recyclable materials, organisations' compliance with regulations, and resource recovery data accuracy. This project showcases how digital technologies can contribute to circular economy.

References:

[i] <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions>

[ii] <https://dictionary.cambridge.org/dictionary/english/ppm>

[iii] <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions>

[iv] [https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15\\_Chapter2\\_Low\\_Res.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf),  
[https://folk.universitetetioslo.no/roberan/t/global\\_mitigation\\_curves.shtml](https://folk.universitetetioslo.no/roberan/t/global_mitigation_curves.shtml), <https://www.cicero.oslo.no/en>

### Keywords

circular economy, waste management, digitalisation, GHG emissions, Net zero

## 156. Catalyzing Sustainability Innovation in the Construction Industry Ecosystem through Intrinsic Self-Motivational Targets

Mateusz Wielopolski<sup>1</sup>, [Willem Bulthuis](#)<sup>2</sup>, Luma Vasconcelos<sup>3</sup>

<sup>1</sup>ÆVOLUTION® Circular Materials Innovation, Bayreuth, Germany. <sup>2</sup>Corporate Ventures Advisory, Munich, Germany. <sup>3</sup>Universidad Politécnica de Madrid, Madrid, Spain

### Abstract

The importance of sustainability innovation in the construction sector has never been greater. While there is an ever-growing global demand for buildings and infrastructures, there also is an unprecedented pressure to substantially reduce Green House Gas and waste generation, as well as energy and raw material use in the construction sector. Substantial innovation is needed to address these challenges effectively, which requires collaborative action across the full construction value chain. By deploying the plethora of emerging sustainability innovations effectively, the construction sector can accelerate in the global transition to a far more sustainable and circular economy, complying with the increasing regulatory and societal pressures.

However, the construction ecosystem is complex, high-cost, risk-sensitive, and considerably fragmented. Effective innovation and transitioning from linear to circular systems require synergetic actions. Often new business models involve several actors (e.g. investors, contractors, installers, architects and suppliers of material, equipment and energy) that may present conflicting interests. External pressure from regulations and absolute quantitative targets such as Science-Based Targets are helpful. On the other hand, they are hard to translate into concrete actions aiming at systemic change and aligned between stakeholders along the value chain. Above all, they are not very suitable to motivate all the staff in the participating companies.

Therefore, the **Better Building Initiative (BBI)** has developed the **BBI Manifesto**, a collaborative framework and an alternative target-setting model that fosters intrinsic self-motivation of companies and their staff, easy progress measuring and systemic change support. The key aspects of this target-setting approach are:

1. Relative i.s.o. absolute targets, the goal is on incremental progress rather than abstract long-term ambitions,
2. Selectivity, focus on only a few company-specific topics for gradual improvements while avoiding maladaptation, and
3. Openness, facilitating collaborative, open innovation with ecosystem partners through transparency on the company-specific targets

The BBI is designed as an industry platform to inspire, inform, build trust, scout, match, collaborate and transform. It takes a holistic approach to promote a practical transition, for such intent several theoretical concepts are combined, including:

**Dynamic Capabilities:** the resilience potential of companies to reconfigure their internal and external resources (from material to know-how) to adapt to rapidly changing business environments,

**Relational View:** strategic management focused on the company network, rather than on its own resources and individual achievement,

**Open Innovation:** broad mindset considering that innovation should embrace varied individuals and organizations to succeed

### Keywords

Circularity, Sustainable Construction, Innovation Ecosystems, Built Environment, Collaboration



## **157. Resource Efficiency to Resource Sufficiency: Role of Innovations in a Circular Economy Framework vis-à-vis Sustainable Lifestyle for Environment (LiFE)**

Rachna Arora, Vivek Jaisree Mohandas

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Delhi, India

### **Abstract**

The notion of sustainable development is embedded in the fundamental belief that the externalities associated with the current production and consumption patterns are to be internalized by slowly shifting to sustainable lifestyle practices. The present work seeks to address the role of innovations across the upstream and downstream, dispersed across the current production and consumption patterns aiming at Sustainable Lifestyle for Environment (LiFE). At the 2021 UN Climate Change Conference (UNFCCC COP26), India had put forward the concept of LiFE to accelerate the transition to a circular economy which would nudge companies, governments, individuals and various other institutions to create an ecosystem that will rethink priorities, redesign systems and reinforce environmentally friendly behaviours to be self-sustainable.

The enhanced thought of resource efficiency to resource sufficiency, accelerates the absolute reduction of resource consumption. While moving towards sufficiency, approaches of material and energy efficiency transcends into the concept that centrally focuses on “doing with what is needed” and “consuming what is necessary”, eventually addressing the consumption behaviour (‘absolute reductions in energy and material use’). Globally, it has been observed that commitments like the climate treaty or the ongoing discussions on global plastic treaty, sufficiency-based approaches supported by innovations seek to reduce or moderate the current practices (Innovative approaches - e.g. responsible marketing discrediting fast fashion trends or providing consumers to opt-in for plastic cutlery free food delivery services or adopting 'reuse-refill' models). It is important to assess the role of diverse set of stakeholders as needed to follow a sufficiency-based consumption approach. Hence, broadening the perspectives to a resource sufficient economy is critical and radical which will ensure an absolute reduction of resource usage (quantity, quality and equity) but will also address the social inclusiveness that was not clearly addressed in the current functioning of goods and services.

### **Keywords**

Resource Efficiency, Resource Sufficiency , Lifestyle for Environment (LiFE) , Innovation, Circular Economy

## **159. How could energy service demand develop? Quantitative analysis of different sufficiency scenarios**

Frauke Wiese<sup>1</sup>, Carina Zell-Ziegler<sup>2</sup>

<sup>1</sup>Europa-Universität Flensburg, Flensburg, Germany. <sup>2</sup>Öko-Institut, Freiburg, Germany

### **Abstract**

Sufficiency is a key strategy to reach climate and other sustainability goals. However, so far, this strategy is underrepresented in energy and climate scenarios. This is partly because sufficiency is often misunderstood as an individual lifestyle choice that cannot be counted on and partly because of lacking knowledge on existing quantified sufficiency potentials. Recent research has shown that there is a broad instrument mix to promote sufficiency and that it can be politically implemented like for example efficiency policy. Also in the latest IPCC report, aggregated potentials of demand-side mitigation options has been published, including sufficiency options. However, for in-depth modelling, detailed data on the potentials of different energy service demand reduction in different sectors and data on quantified effect of different sufficiency policy measures is required.

In our work, we first analyse existing sufficiency scenarios and compare assumptions on energy service levels in all sectors to make the inclusion of sufficiency options and their ambition transparent. To address the question of how the reductions in energy service levels can be achieved, we next consider sufficiency policies and measures. In a systematic review of peer-reviewed and grey literature, we build up a sufficiency potential database from studies that quantify the effects empirically or theoretically. The results of this database are on the one hand detailed entries for modellers as well as aggregated sectoral potentials for the case study Germany to be used by policy makers or other stakeholders. Summarised, the aim of this work is to make sufficiency applicable as a political strategy by providing knowledge for its practical implementation as well as for its consideration in scenarios.

### **Keywords**

energy service demand reduction, climate neutrality scenarios, sufficiency potential, sufficiency policy, case study Germany

## **160. Sufficiency & the Just Transition: Toward an ethic of enough in resource custodianship and governance**

Julie Hassman

University of Cape Town, Cape Town, South Africa

### **Abstract**

The World Bank projects that more than 3 billion tonnes of minerals and metals will be needed to develop sufficient wind, solar and geothermal power and the necessary energy storage, to achieve 2050 net-zero climate targets. This reflects massive increases over current production volumes for many minerals and metals. Yet, mining remains an industry rife with social and environmental risks and harms at both the local and global levels. Mining operations also require vast amounts of water and energy (much of which is currently generated via fossil fuel-intensive modes of production). Moreover, once higher-grade mineral ores are depleted, energy requirements and mining waste volumes will further increase as lower-grade ores are pursued, widening impacts on the land. Numerous questions are often raised from a justice-oriented perspective in this context: Who will benefit from the energy transition to a low-carbon economy? Who will bear the burdens? How can these disparate impacts be balanced? Upon closer examination, however, few of these questions challenge underlying principles of growth, utilitarianism, and efficiency that drive standard narratives of the energy transition.

The concept of sufficiency pushes us to think more deeply about the normative principles that underpin our resource laws and policies. Yet, while a growing body of literature addresses energy justice and the 'just transition', sufficiency remains an underexamined concept in this context. From a legal-theoretical perspective, the proposed paper explores what the principle of sufficiency might contribute to the broader project of rethinking resource governance in light of climate change and the just transition. The paper offers a novel contribution by moving beyond the energy justice literature to draw upon the rich body of thinking around the ethical principles of care and repair. Examples to ground the theoretical discussion are drawn from the South African context.

### **Keywords**

Resource custodianship, Sufficiency, Just Transition, Ethics of Care, Energy Justice

## 162. Circular Economy, Critical Minerals and Deep Seabed Mining

Moana Simas<sup>1</sup>, Fabian Aponte<sup>1</sup>, Kirsten Wiebe<sup>1</sup>, [Jessica Battle](#)<sup>2</sup>

<sup>1</sup>Sintef, Trondheim, Norway. <sup>2</sup>WWF, Geneva, Switzerland

### Abstract

Demand for minerals required to support the transition from fossil fuels to renewable energy sources and battery storage can be cut by as much as 58% through innovation in renewable technology and circular economy measures, according to a new analysis commissioned by WWF (The Future Is Circular: Circular Economy and Critical Minerals for the Green Transition, Sintef, 2022).

The report explores the different pathways that can influence the demand for critical minerals for a net-zero scenario. The authors analyze these through four different technology scenarios, from a current through to an advanced technology scenario, where new technologies low in critical minerals take off and become a larger market share of annual installed capacity by 2050. In addition to technology choices and increased diffusion of these, circular economy strategies play a significant role for avoiding a mineral shortage during the transition. Here, it is not only enhanced recycling capacities that make the difference but especially strategies such as lifetime expansion and demand reduction, both through a more efficient use of the technologies as well as through reducing the demand for energy.

30% reduction in all critical minerals studied – nickel, manganese, cobalt, copper, platinum, lithium and rare earth elements – can be achieved by implementing new renewable technologies. Reductions are particularly notable for cobalt, nickel and manganese, where 40-50% percent of mineral demand can be reduced by switching to technologies such as solid state or lithium-iron-phosphate batteries (LFP).

WWF will elaborate on these findings and further explore some of these innovative technologies and enhanced recycling of battery materials to demonstrate that we do not need to open the deep sea to minerals' extraction. Ultimately, the choices made in the next few years by governments through policy interventions, investments and regulations, and by businesses through investments and specific business decisions, will shape and define the needed volumes of these minerals over the next decades and into 2050.

### Keywords

circular economy, critical minerals, green transition, deep seabed mining , low-carbon technologies

## **164. The Introduction of a New Ecologically Conscious Form of Public Transportation in India's Cities**

Pranav Bharadwaj

Institute of Design, PES University, Bangalore, India

### **Abstract**

This paper examines the potential effect of using electric cars as a mode of public transportation in urban areas, focusing on commuters seeking sustainable and efficient transportation and also assessing the downsides of the existing public transportation systems. According to the Central Pollution Control Board, public transportation vehicles account for approximately 40% of all vehicular pollution in India. There were roughly 1.52 million registered buses in India in 2020. Despite the fact that the Indian government has adopted Bharat Stage emission standards to control vehicle pollution, challenges remain in densely populated urban areas. The average particulate matter emissions from a diesel bus in Delhi were 7 times higher than the BS-IV standards. In India, the average occupancy of public buses is 66%, which is greater than the global average of 50%. During peak hours, bus occupancy on Delhi lines reached 200%. Delhi metro trains frequently overflow during rush hours. According to a DMRC survey, 60% of commuters said they were overcrowded on the way to work everyday. Overcrowding is not only unpleasant, but it also presents a safety risk, and it has become a challenge to manage during the COVID-19 pandemic. Valuable data related to this study, on infrastructure requirements, cost-effectiveness, and user acceptance is obtained using user surveys, interviews and focus group discussions.

The proposed system intends to use electric cars as a mode of public transportation with a set route and specified stations. An app will count the number of persons in each vehicle and use GPS to locate entry and exit points. The payment will be taken from a preloaded wallet. This system attempts to handle issues like hygiene and overcrowding, along with pollution and other factors that discourage people from using public transportation. The research, planning and implementation of this system is divided into three subsystems: a) Product development, b) Strategic car station placement, c) Optimal route determination. The first subsystem deals with the development of the app, algorithms, GPS location sensing etc. The second subsystem strategically places car stations and charging stations based on the battery lives of the cars being used. The third subsystem is concerned with determining best routes to ensure the most efficient use of batteries while maximizing station and passenger coverage. Overall, the implementation of this system has potential to address several challenges that existing public transportation systems encounter in India's densely populated urban areas, leading to a sustainable transportation system.

### **Keywords**

Public transport, Electric cars, Transportation, Sustainable, Pollution

## 165. From FineFuture to FINEST towards a more sustainable circular economy

Stefan Dirlich<sup>1</sup>, Axel Renno<sup>1</sup>, Jonathan Engelhardt<sup>1</sup>, Peter Stemmermann<sup>2</sup>, Hermann Heipieper<sup>3</sup>

<sup>1</sup>Helmholtz-Institute Freiberg for Resource Technology at Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany. <sup>2</sup>Karlsruhe Institute of Technology, Karlsruhe, Germany. <sup>3</sup>Helmholtz Centre for Environmental Research, Leipzig, Germany

### Abstract

The EU-funded H2020 project FineFuture successfully tackled the recovery of fine particles for an increased resource efficiency, and an improved pneumatic flotation technology was one of the key outcomes with the very realistic option of bringing it to industry. Though being potentially suitable for secondary material as well, the focus was on primary ores such as manganese, magnesite or iron. Nevertheless, feeding the pneumatic flotation cell with tailings material was also conducted in some experiments, and resulted in satisfactory recovery rates of the target elements.

However, due to resource depletion and the paradigm of climate-neutrality economy needs to be transformed into a more circular one, making use of sustainable value chains and keeping resources longer in the loop. Therefore, the research goes further with the project FINEST, and tackles finest particulate matter of anthropogenic origin such as shredder waste from WEEE or cars, fine ashes, etc. The target elements considered from these waste materials are microplastics, mineral additives and disperse metals. The idea is to combine different waste streams by blending them in order to stimulate improved process behavior, and an increase of the recovery rate of valuable elements such as copper, iron etc. Most of the waste streams considered in FINEST are currently not utilized, resulting in a great benefit for circularity and simultaneously reducing environmental harm through the reduction of the amount of material that needs to be disposed of. The unavoidable residuals are treated in a way that all compounds are inert, and allow for a safe disposal.

The project is largely oriented towards transdisciplinarity, and the FINEST Research School is additionally embedded into the research project. The school aims to train postgraduate students in a structured way to allow them to become transfer experts in resource management. While offering training at industry during the PhD phase, the school follows the concept of “transfer via brains”, which means to aim for an excellent education of the PhD's, who will enter industry afterwards with the goal to manage a transformation from inside into more circular thinking.

### Keywords

finest particles, resource recovery, microplastics, mineral additives, disperse metals

## 169. Lithium from geothermal brines – More sustainable than from conventional sources?

Vanessa Schenker<sup>1</sup>, Peter Bayer<sup>2</sup>, Christopher Oberschelp<sup>1</sup>, Stephan Pfister<sup>1</sup>, Stefanie Hellweg<sup>1</sup>

<sup>1</sup>Swiss Federal Institute of Technology Zurich, Zürich, Switzerland. <sup>2</sup>Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

### Abstract

Lithium, a key metal for the electrification of the mobility sector, is mainly mined from pegmatites in Australia and salars in South America. However, to overcome a potential supply risk and to become independent of international supply chains, economic hubs (e.g., Europe or U.S) have started to investigate other domestic deposit types (e.g., geothermal brines). In the future, these brines might not only be used for energy provision but also for lithium supply. However, the co-production of lithium and geothermal power in Europe and U.S. is still under development and the data availability regarding life cycle assessment is lacking. Hence, it remains unclear what the environmental impacts of lithium from geothermal brines are and if they have lower environmental impacts compared to global lithium production from conventional sources.

To close this research gap, a parametrized tool was developed to model life cycle inventories for lithium extraction from geothermal brines in Europe and US. The life cycle inventory modeling was based on patents, scientific literature, and company reports. We developed scenarios including changes in energy provision on-site. Additionally, parameters, such as chemical composition of the brine and overall efficiency, were varied. These inventories were utilized to quantify environmental impacts (i.e., climate change impacts based on IPCC (2021) and water scarcity impacts based on the AWARE method) of 1 kg lithium carbonate with battery grade. Ecoinvent v3.9.1 was chosen as an inventory data source for the background system.

Our results show that the co-production of lithium and power in the US has higher environmental impacts than the one in Europe. The geothermal brine in the US tends to have higher concentrations of iron, zinc, manganese, silica, and zinc than in Europe. These impurities determine the input energy and chemical demand for purification steps and hence, influence the environmental impacts. The results are benchmarked against current lithium supply from salt lakes. Finally, we discuss the implications for future lithium supply in Europe and US.

### Keywords

Life cycle assessment, Geothermal brines, Batteries, Lithium, Low-carbon technology

## **170. The challenges of value chain dynamics to meet the ideals of a circular economy by recovering material from households in Lower and Middle-Income countries. A case study from Accra, Ghana.**

Kwabena Poku<sup>1</sup>, Karl Williams<sup>1</sup>, Matt Stables<sup>1</sup>, Terry Tudor<sup>2</sup>

<sup>1</sup>University of Central Lancashire, Preston, United Kingdom. <sup>2</sup>Connected Places Catapult, Milton Keynes, United Kingdom

### **Abstract**

The waste sector is an area where the valorization of material is critical in order to meet the aims and aspirations of the circular economy. Within developed nations there exists legislation and policies which supports the recovery and recycling of material from different waste streams; as highlighted by the European Circular Economy Action Plan. However, this is not the case within Lower and Middle-Income countries (LMIC), where the value chains are less clearly defined. Household solid waste is seen as unwanted by-product with little interest from the populous who do not see its potential value as a resource. This has led to the leakage of material such as plastic, metals and organics into the environment, posing health and environmental risks. To support the development of value chains in these regions it is important to enable recovery from municipal solid waste. Full exploitation of resources from households calls for a value chain transformation towards proactive recovery. Fundamental to this is the engagement of all stakeholders through the entire recovery chain from generation, collection, sorting and reprocessing and finally to use in new products. Key to this is the participation of households in the waste value chain development starting at the separation at source. An empirical study to investigate household's participation role and engagement within non-government scheme for the creation of formal waste segregation programs. This paper uses a case study from Ghana where a value chain for plastic material is being created by Jekora Waste Segregation Scheme in Accra. The research combined questionnaire surveys from households and semi-structured interviews with stakeholders in the waste sector. The results highlighted the barriers to the introduction of a successful valorization of plastic materials. These were: (i) irregular collections, (ii) lack of storage, (iii) time, (iv) inadequate infrastructure and (v) low compliance of legislation. The research showed that many households were willing to participate in source separation and therefore enable the valorization of plastic. However, the lack of both financial incentives and unresolved issues around waste collection are inhibiting the uptake. Improving collection efficiency supports household participation, however, this is reliant on the next stage of the value chain- in this case Jekora. The findings indicated that multi-dimension interventions were required and stakeholders need to work together. This is a challenge within Ghana where funding for waste collection is allocated across the different parts of the value chain leading to breaks in the links.

### **Keywords**

Circular Economy, Valorization, Waste Separation, Plastic Waste



## 172. Sufficiency as a dwelling practice – the role of the architect vs the role of the occupant

Griet Verbeeck<sup>1</sup>, Ann Bosserez<sup>2</sup>, Nick Van Loy<sup>1,3</sup>, Elke Knapen<sup>1</sup>

<sup>1</sup>UHasselt, Diepenbeek, Belgium. <sup>2</sup>Thomas More University College, Mechelen, Belgium. <sup>3</sup>Thomas More University College, Geel, Belgium

### Abstract

Since 2006 the Energy Performance of Buildings Directive and its recasts have made EU Member states introduce energy policy to improve the energy efficiency of their housing stock. This energy efficiency policy is highly object-oriented, as houses are considered objects or products to be optimized for their energy performance, with the performance expressed in relative terms (kWh/m<sup>2</sup>) and evaluated for standard climate conditions and standard occupant behaviour. Energy sufficiency on the contrary focuses much more on practices rather than on products. In old, energy-devouring houses, sufficiency-oriented practices are often intuitively adopted by the occupants to avoid high energy bills. However current design trends for new houses and deep renovations often unconsciously disable existing sufficiency-oriented practices through the evolution towards larger homes, open floor plans and highly glazed facades.

In contrast to energy efficiency that considers the occupant as a passive user who uses the house and its systems as intended, energy sufficiency aims at reducing energy consumption by supporting occupants to make places and people –instead of rooms and buildings– comfortable in a dynamic way. But this requires an engagement from both the architect and the occupant. Nevertheless, sufficiency as a concept and its potential for new and renovated houses is unfamiliar to almost all stakeholders, being it policy makers, architects or home owners.

The presentation will present two methodologies that support sufficiency-oriented dwelling practices: 1) a spatial design methodology that has been used to analyse multiple dwelling typologies for their potential for and degree of sufficiency-oriented living practice and that can be used to create sufficiency-supporting designs for new houses and renovations, and 2) a methodology to develop sufficiency-oriented heating practices that can accompany the spatial design. These methodologies can be used by architects to create home designs that can enable and support sufficiency-oriented living. For this reason, they are also included in the curriculum of students in architecture.

However, since sufficiency is more a practice than a product, the role of the occupant to effectively adopt sufficient behaviour is crucial. Therefore also a test has been developed to determine occupant profiles for heating practice based on set point temperature, clothing level and thermal sensation, that allow to evaluate the compatibility of the occupant's current heating practice with a more sufficiency-oriented heating practice. Preliminary results of this test will be shared.

### Keywords

housing, heating practice, design methodology, architects, occupants

## **173. Model-based LCSA: Assessing circular economy solutions for currently underutilized or unused plastic waste, end-of-life electric vehicle batteries, and bio-based side and waste streams.**

Alexander Koch, Andreas Ciroth

GreenDelta, Berlin, Germany

### **Abstract**

Life Cycle Sustainability Assessment (LCSA) has seen an increasing uptake in the past years, promising a comprehensive assessment of sustainability over the life cycle, with a consideration of environmental, economic, and social impacts. Higher data demands and a mix of qualitative and quantitative data from various sources make LCSA more complicated than Life Cycle Assessment alone. And yet, a basically linear life cycle model as used in LCSA struggles to reflect some key concepts of sustainability, including thresholds and possible non-linear system behaviour and system transitions.

In model-based LCSA, basically, a system dynamics model is combined with an LCSA model, addressing all or selected sustainability dimensions. Model-based LCSA was developed to overcome limitations of LCSA, while at the same time offering a practically feasible modelling and assessment approach.

The approach was recently developed and tested in a series of Horizon research projects, including TREASoURce. The TREASoURce project aims to initiate systemic change by developing technologies and circular economy (CE) solutions in cities and regions for currently underutilized or unused plastic waste, end-of-life electric vehicle batteries, and bio-based side and waste streams.

Due to the systemic nature of the solutions as well as the focus on replicability for various local conditions, the sustainability assessment takes on the novel, model-based LCSA approach. It thereby considers impact indicators for sustainability, in a social, environmental, and economic dimension, but also performance indicators for circularity, context indicators as well as market indicators.

Integrating a generic system dynamics model into sustainability assessments and applying it to the key value chains showed that, for one, given the urgency of sustainability issues, the relatively simple qualitative assessment method allows for a quick identification of hotspots and critical success factors. Second, a focus on local conditions and markets further allowed to identify consumer preferences and further gain insight into the feasibility of the CE solutions.

In the presentation, we will introduce and demonstrate the approach, and then show its application in the cases from the project.

All in all, this new approach to sustainability assessment overcomes many limitations of existing frameworks, essentially allowing for all-inclusive and well-timed decision-making, thereby accelerating the transition to a more sustainable and regenerative economy.

### **Keywords**

circular economy, LCA, system dynamics, regional , value chains

## **174. Learnings from building up a national virtual circular economy observatory to fast-track cross-stakeholder adoption of more circular value chain configurations at scale**

Markus Zils, Peter Hopkinson

University of Exeter, Exeter, United Kingdom

### **Abstract**

The UK National Interdisciplinary Circular Economy Research (NICER) programme is a four year £30M evidence and data driven programme to accelerate the adoption and implementation of CE across 5 major resource flows (metals, CRMs, textiles, chemicals and Building minerals) and their sectoral applications. The programme is co-ordinated by a CE-hub, which is also responsible for the design and delivery of a UK CE data observatory and knowledge hub. In this presentation we will describe some of the many data challenges in building a consistent, joined up and outcome focussed CE data model for the UK, that combines public data assets with relevant industry data to model, quantify and evaluate the economic, social and environmental benefits from diverse and complex linear to circular value chain transformations. The building blocks for the CE-observatory is based around an agnostic value chain taxonomy to represent and visualise baseline linear and future circular value creation pathways. For any given resource flow, component, product or sectoral application, we then build up a knowledge, stakeholder and data map, to identify gaps, value hypotheses and potential collaborations. A stock-flow model is then constructed to identify current value leakage and potential interventions to quantify future CE value creation opportunity. The presentation will provide a worked example based on rare-earth permanent magnets which forms a use-case in the UK government's Integrated Data Service Programme. This use case is working across UK government departments with an interest in critical materials, notable REE and specially REE PMs which are fundamental to UK ambitions for electrification of the economy and energy security. Using a novel, systemic and transparent approach to data pooling provides data inputs into a business dynamics model to generate financial and biophysical outputs aligned to diverse policy requests and KPIs. The same data pool and model is flexible and updateable allowing rapid responses to further policy requests without the need to start again or commission new data collection. The DPN has already saved one government department from commissioning new data collection and an immediate response to 5 policy questions, which it otherwise would have been unable to answer. We will present this use case. The presentation will highlight how DPN can be operationalised across different product-material/sectoral applications, highlight key pain points and blockages in creating full end to end system visibility and next steps in scaling our approach through the CE observatory.

### **Keywords**

value chains , circular economy , taxonomy, value creation, data

## **175. Urban Mine ReWIR – Deconstruction–Reconstruction–Construction of Resources and Competences as metabolic relationship for transforming value chains**

Elisabeth Clausen<sup>1</sup>, Kathrin Greiff<sup>1</sup>, Ina- Marie Orawiec<sup>2</sup>, Meike Jungbluth<sup>3</sup>, Stefan Bösch<sup>1</sup>

<sup>1</sup>RWTH Aachen University, Aachen, Germany. <sup>2</sup>OX2architekten GmbH, Aachen, Germany. <sup>3</sup>Roskopf Gruppe, Aachen, Germany

### **Abstract**

The goals of Sustainable Development and the European Green Deal can only be achieved if sustainable resource extraction, production, use and recirculation as required in a circular economy is created and established for this purpose. The transition to a Circular Economy should enable efficient and circular use of natural resources in order to keep resource consumption within planetary boundaries. A holistic system change is required, such as structural changes in consumption patterns and a transition from linear to circular resource flows. This technological, economic, social and cultural transformation will undoubtedly become one of the greatest achievements of mankind.

In addition to the dematerialization and rematerialization, there is a high demand for raw materials, particularly with regard to the transformation into a low-carbon economy, which can only be met by mining primary raw materials being indispensable for welfare. The construction industry is responsible for the largest resource extraction and waste generation. It is therefore important to focus on this sector for a sustainable transformation in which the extraction of primary raw materials and the circular economy are thought, developed and designed together.

In Germany, currently the Rhenish lignite mining area (RLMA) is facing the major challenge of phasing out of lignite production by 2030 and the need of actively shaping a comprehensive structural change and transformation from fossils to regenerative energy as well as from extractive to regenerative value chains. It is about the deconstruction, reconstruction and construction of materials, resources and competences: Urban MineReWIR. With Urban MineReWIR an alliance is specifically focusing on transforming the construction sector from extractive to regenerative materials flows and value chains with the help of the knowledge, skills, resources and processes from the traditional supplier companies of regional mining.

The MineReWIR alliance founded in 2019 aims to build a sustainable and long-term innovation ecosystem together with the mining suppliers and service providers in and around the RLMA. The aim is not only to preserve the existing industrial backbone, but also to strengthen existing competencies with new innovation and business fields in the construction industry and urban development. The danger of de-industrialisation is thus deliberately turned into an opportunity for sustainable industrial diversity by proactively and sustainably creating a wise balance between ex-novation and innovation in the cooperation between business, science and society. The presentation will give an insight into the concept and the development of the last years as well as a future outlook.

### **Keywords**

Circular Economy, Regenerative material flows and value chains, Balance of Exnovation and Innovation, Primary and secondary resources, Sustainable construction industry and urban development

## **177. Development of a Methodology for a BIM-Based Decision Support Tool in Early Planning Phases in the Framework of a Material Passport for Buildings**

Fenja Kamps<sup>1,2</sup>, Pascal Keppler<sup>1</sup>, Johannes Hamhaber<sup>2</sup>

<sup>1</sup>EPEA – Part of Drees & Sommer, Stuttgart, Germany. <sup>2</sup>Institute for Technology and Resources Management in the Tropics and Subtropics – TH Köln, Cologne, Germany

### **Abstract**

Due to its resource intensity, the building sector is particularly important in the transition to a decarbonized and circular economy, as its upstream and downstream processes account for a large share of raw material extraction, greenhouse gas emissions, and waste generation in Europe and worldwide. Great effort is already being made to improve the energy efficiency of buildings in their use phase. However, resource consumption for manufacturing of buildings and embodied carbon are often not the focus of building optimization, although with improving energy efficiency in the use phase, these account for an increasingly large part of the environmental impact during the entire life cycle of a building. Also, the recycling potential of building materials is not yet sufficiently exploited, due to the large number of stakeholders involved, a comparatively long life cycle, and slow digitization compared to other industrial sectors, resulting in information loss throughout the different stages of a building's life cycle. An important lever for transforming the construction sector towards more circular and sustainable practices is material passports for buildings, which precisely document the materials used and their environmental impact as well as possible subsequent use scenarios. However, material passports offer more potential than just documentation: In the early planning phases of construction projects, the influence of planners on the subsequent environmental impact and the circularity of a building is greatest. A digital material passport, which serves as an optimization tool and provides decision support early in the design process, facilitates planners to design more circular and environmentally friendly buildings.

The aim of this study is to develop a methodology for a BIM-based decision support tool that enables variant studies in the early design phases at the building and building component level with regard to global warming potential, material sourcing, and material recovery. First, process and data requirements for a comparison of variants at the building and building component levels were analyzed. As a first approximation to provide decision support, benchmarks were determined by analyzing data from a pool of electronic building component catalogs collected in the context of life cycle assessments of buildings and circular engineering consulting in several European countries, mainly Germany. In addition, the requirements for data collection were analyzed for updating and improving the benchmarks on an ongoing basis in order to identify the optimization potential of buildings and building components more precisely in the future.

### **Keywords**

Circular construction, Embodied Carbon, Resource Efficiency, Material Passport, BIM

## 180. The role of e-waste repurposing business models

Kwaku Addai

Electro Recycling Ghana, Accra, Ghana

### **Abstract**

*Why do we recycle:* If e-waste is properly disposed of and recycled, this can not only help create jobs, but also reduce the burden on the environment and build a sustainable industry.

*Knowledge as the key function of sustainable recycling:* In times of sustainability and how this can be maintained, we have made it our mission to further carry on our many years of experience in the recycling business. It is important to us to pass on our experience and know-how and thus to be a pioneer in building sustainable work and sustainable recycling in Ghana.

*Our Goals:* The goals are to create jobs while protecting the environment and to provide education and a better future through innovation and research.

*Establish recycling:* Developing recycling and sharing information - our initiatives to promote a formal sector involving informal

*Build a network:* Responsible for efficient networking between business, politics and education, we support the strengthening of an environmentally aware society.

*Create Jobs:* We create jobs through core competence and social commitment. Best practice in the industry.

*Save resources:* Environmental protection is not an option for us, but a necessity through the extraction of additional resources.

*Innovation:* We develop innovative recycling for the production of our own B2C products as well as environmentally friendly processing methods for the extraction of raw materials.

How does it work?

- Reliable waste logistics through transport permit, appointment and load securing for maximum protection
- Sorting of the accepted e-waste into categories, as well as separating wired and wireless devices
- Examination of waste electrical equipment for possible reuse and spare parts recovery
- Dismantling and removal of pollutants based on defined treatment concept and recycling of individual components

How does it work?

- Creating awareness and education: To raise awareness among the population in Ghana, we work with regulators to develop campaigns and education programs aimed at educating the public about the risks of end-of-life batteries.
- Building infrastructure: Another challenge is to help build appropriate infrastructure for the collection, transportation and disposal of end-of-life batteries.
- Improve regulation: In order to improve regulation for the disposal of batteries in Ghana, we adhere to current regulations and share our experiences and findings with the relevant authorities. This will allow new structures and policies to be developed to ensure safer and more effective disposal of batteries.

### **Keywords**

E-waste, Repurposing, Recycling, Circular, Environment

## **181. How effective is product stewardship in supporting a circular economy in Australia?**

Nick Florin<sup>1,2</sup>, Rose Read<sup>2</sup>, Simran Talwar<sup>1</sup>

<sup>1</sup>Institute for Sustainable Futures, University of Technology Sydney, Sydney, Australia. <sup>2</sup>Product Stewardship Centre of Excellence, Sydney, Australia

### **Abstract**

The presentation will share findings from a recent research project that assessed the effectiveness of product stewardship and extended producer responsibility activities in Australia in driving circular economy outcomes. The research was led by UTS Institute for Sustainable Futures and the Product Stewardship Centre of Excellence.

Product stewardship aims to manage and reduce the environmental and human health impacts of products and materials throughout their lifecycle and is a major part of the Australian Government's policy agenda supporting a shift to more circular economy. The aims of product stewardship align with the three principles of a circular economy – to eliminate waste and pollution, keep products and materials in use, and regenerate natural systems. Thus, the broad adoption of product stewardship by businesses as participants in the value chain is important for driving the circular economy transition.

The research examined more than 100 product stewardship activities, compiling, and analysing publicly reported environmental, social, and economic annual performance data available on the Product Stewardship Gateway (a major output of the project). The project also surveyed Australian businesses and the public to understand how and why businesses are engaging in product stewardship action, and how consumers are engaging as consumers and users of reuse and recycling services.

The research shows how product stewardship action is effective in reducing the environmental and human health impacts of products and materials. Most of the product stewardship activity is focused on reducing impacts at the end of life of products by offering collection services and material recovery. Only one-third is focused across all stages of the product lifecycle including design, production, and consumption. Individual business initiatives are active at the design and production and consumption stages, focusing on better material choices, eliminating hazardous materials, and innovation in product and packaging design. However, there is an opportunity for more collaborative action focused on preventing waste generation at the production and consumption lifecycle stages.

Among businesses and the general population there is limited awareness and understanding of the concepts, and sub-optimal adoption in the absence of regulatory levers. The research highlights a need for increased efforts to explain concepts and demonstrate how product stewardship action creates positive environmental, social, and economic benefits across the whole value chain. Coupled with the right policy and regulatory settings and financial incentives, there is an opportunity to drive broader adoption of product stewardship to deliver a safe and sustainable circular economy.

### **Keywords**

product stewardship, EPR, circular economy

## 183. Implementation strategy and results of Santa Marta pilot project for local prevention of Marine Litter

Jan Janssen<sup>1</sup>, [Alejandra Gámez](#)<sup>2</sup>, Carlos Fernando Cadavid<sup>2</sup>

<sup>1</sup>Co-autor, Santo Domingo, Dominican Republic. <sup>2</sup>Co-autor, Medellín, Colombia

### Abstract

This abstract relates to the Value Chains thematic area. The case study points out strategies and results of improved plastic waste recycling and stakeholder integration in order to reduce marine pollution while increasing social and economic benefits for local communities.

Marine pollution is ubiquitous in Caribbean region and poses a serious threat to Blue Economy and tourism. An average of 2,014 litter items per kilometer can be found on beaches and coastal areas, being plastic the predominant material.[1]

PROMAR (Prevention of Marine Litter in The Caribbean Sea)[2] is a project funded by the German government through BMUV[3], implemented in Dominican Republic, Costa Rica and Colombia.

Santa Marta, Colombia, generates 116.435 tons of solid waste per year[4]. Despite of having a public cleaning service provider as well as formal and informal waste management and recycling companies, 413 tons of waste leaked into the sea in 2022, as estimated by a Waste Flow Diagram (WFD).[5]

A pilot project was initiated in the communities around the Manzanares river with the following components:

- technical support and training to different actors associated with separation, collection and recycling of waste, e.g. recycler associations and the public waste management service
- integration of informal recycling activities with the Colombian system of Extended Producer Responsibility (EPR) for packaging materials
- valorization of collected materials

The pilot project pretends to reduce the waste leakages in the intervention area based on an integrated, participative “source to sea” approach and by strengthening the value chain through a circular economy approach. The pilot project has raised awareness on Marine Litter in more than 16.000 households, transformed (recycled) around 1.000 tons of packaging materials, and strengthened formal and informal actors of the recycling chain and EPR.

As one of the main lessons learnt was that - to assure financial sustainability and high quantities of separated recyclables - recyclers associations, the municipal waste collection and EPR schemes should be integrated. Based on this and other pilot experiences, PROMAR has developed a toolbox (PROMAR Blue Box) that allows local actors to design and implement effective and sustainable action to reduce plastic flows into the sea.

[1] World Bank Group, Marine Pollution in the Caribbean not a minute to waste  
<https://documents1.worldbank.org/curated/en/482391554225185720/pdf/Marine-Pollution-in-the-Caribbean-Not-a-Minute-to-Waste.pdf>

[2] <https://promar.org/es>

[3] <https://www.bmuv.de/en/>

[4] ESSMAR E.S.P (public service company of Santa Marta), 2018: Informe de Caracterización de Residuos Sólidos

[5] Fundación Socya, 2022, Waste Flow Diagram for Santa Marta

### Keywords

Circular Economy , Marine pollution , Solid Waste Management , Value Chains , EPR



## 184. Soaring of global copper demand urges cohesive emission mitigation strategies from both demand and supply sides

Shuangmei Li<sup>1,2</sup>, Xuehong Zhu<sup>1</sup>, Shauhrat S. Chopra<sup>2</sup>

<sup>1</sup>Central South University, Changsha, China. <sup>2</sup>City University of Hong Kong, Hong Kong, China

### Abstract

Copper demand is projected to grow considerably over the coming decades given the mushroom deployment of clean energy technologies. It raises a concern that the carbon footprint of copper supply would intensify attributed to its emission-intensive production process. Prior studies are limited to either the low-carbon supply of copper based on its traditional-energy-dissipation property or copper demand forecasting due to its pillar role in renewable energy transition with a low technological resolution. Here we evaluate the historical (2000–2021) global greenhouse gas emissions from the copper value chain and simulate the future (2022–2060) reduction potential of joint supply- and demand-side mitigation techniques by combining a component-by-component and stock-driven material flow analysis and dynamic life cycle assessment with multidimensional parametric scenario analysis. We find that the end-use and metallurgical technology iterations as well as material efficiency strategies with the consideration of material rebound effect are the fundamental pathways to decarbonize the copper value chain in consideration of regional heterogeneity. Such a model framework that integrates high-precision demand scenarios with supply scenarios could be applied to other critical metals and reveal how to decarbonize the value chain while ensuring cleantech expansion toward a 1.5 °C future.

### Keywords

copper value chain, greenhouse gas emission, stock-driven material flow model, dynamic life cycle assessment, integration of demand and supply scenarios

## **185. Supply chain justice considerations for new energy vehicles**

Benjamin McLellan

Kyoto University, Kyoto, Japan

### **Abstract**

Climate change solutions - particularly those that involve the trans-sectoral integration of new technology systems such as electric (EV) and hydrogen fuel cell (FCV) vehicles - are of significant interest for their potential benefits for mitigation, but also due to the impacts and risks across their supply chains. Notably, the resource supply concerns over critical minerals for these technologies has been highlighted. However, the concept of justice in these supply chains has been only partially considered. This paper will examine some of the key social and environmental justice concerns across the full supply chain of EV and FCV, with alternative case studies. The Just Transition and its implications for the distributional justice impacts in upstream countries (notably impacts of expanding metal mining and reducing fossil fuel extraction) and downstream countries (differential impacts on consumer groups) will be quantitatively examined using tools including lifecycle assessment (LCA).

### **Keywords**

LCA, critical minerals, just transition, energy, transportation

## **187. Life Cycle Approaches for Biodiversity Impacts of Mining and Resource Extraction: Combining Remote Sensing and Life Cycle Assessment**

Michael Götz<sup>1</sup>, René Itten<sup>1</sup>, Tomasz Orpiszewski<sup>2</sup>, Leon Hauser<sup>3</sup>, Patrick Laube<sup>1</sup>

<sup>1</sup>Zurich University of Applied Sciences, Institute of Natural Resource Sciences, Wädenswil, Switzerland. <sup>2</sup>Zürich University of Applied Sciences, Institute for Wealth & Asset Management, Winterthur, Switzerland. <sup>3</sup>University of Zurich, Institute of Earth System Science, Zürich, Switzerland

### **Abstract**

The inclusion of indirect lifecycle-based environmental impacts (Scope 3) of products and their associated resource consumption is becoming increasingly important for companies as well as for investors, consumers and other stakeholders in value chains. Life Cycle Assessment can provide valuable decision support for companies, investors and consumers. However, the availability of representative, consistent and reliable regionalised Life Cycle Inventory models that enable the quantification of biodiversity impacts for resource extraction is still lacking.

The aim of this project was to identify possible approaches to reduce the effort for data collection for life cycle approaches and at the same time the dependency on data collected by the companies themselves. To achieve this, we as group of geoinformation systems, remote sensing and LCI database experts identified remote sensing-based data sources, which enable the linking of remote sensing data from satellite imagery to LCI models with focus on the mining and resource extraction sector. In the last ten years the availability of satellite imagery has increased significantly, and data providers have developed advanced remote sensing-based data products.

Satellite images cannot be used directly for LCA studies but have to be processed and evaluated in order to derive information which can be used within LCA inventories, such as land use changes or transportation distances. There are several commercial providers which offer already processed remote sensing-based data products. The range of application of offered data sets is rather wide.

We performed a comprehensive literature research to identify remote sensing-based data products that could be integrated into Life Cycle approaches and categorised the data products according to their Scientific Readiness Levels (SRL), Technology Readiness Level (TRL) and Application Service Readiness Level (ASRL) as well as their relevance for quantification of biodiversity impacts with Life Cycle approaches.

Remote sensing-based data products can contribute to more refined and spatially detailed life cycle inventory models, especially for land use and land use changes, as well as biodiversity impacts related to mining and resource extraction activities. Remote sensing-based data products have the potential to facilitate the data collection for large-scale LCI modelling of mining and resource extraction covering both longer time periods and larger spaces with more regionalised parameters, enable a more detailed and refined analysis of the biodiversity impacts related to mining and resource extraction activities.

### **Keywords**

LCA, Readiness level, Life Cycle, Remote sensing, Biodiversity

## **189. Financing e-waste collection and recycling in low- and middle-income countries – suggestions for operational principles for the concept of ‘e-waste compensation’**

Oluwatobi Adegun<sup>1</sup>, Leslie Adogame<sup>2</sup>, Alexander Batteiger<sup>3,4</sup>, Hannah Jung<sup>5</sup>, Jana Mandel<sup>3,4</sup>, Andreas Manhart<sup>6</sup>, Israel Olagunju<sup>7</sup>, Tobias Schleicher<sup>6</sup>, Reinhardt Smit<sup>5</sup>, Adrian Clews<sup>7</sup>

<sup>1</sup>Verde Impacto Nigeria, Lagos, Nigeria. <sup>2</sup>SRADev, Lagos, Nigeria. <sup>3</sup>GIZ, Eschborn, Germany. <sup>4</sup>PREVENT Waste Alliance, Eschborn, Germany. <sup>5</sup>Closing the Loop, Amsterdam, Netherlands. <sup>6</sup>Öko-Institut e.V., Freiburg, Germany. <sup>7</sup>Hinckley Recycling Ltd., Lagos, Nigeria

### **Abstract**

The concept of e-waste compensation allows international brands and users of electronic equipment to contribute to a sound management of equivalent e-waste volumes in low- and middle-income countries by providing finances to an organization that organizes collection and environmentally sound management of e-waste on behalf of the brands and users. While comparable compensation concepts are already established for greenhouse gas emissions and plastic waste, it is rather new for e-waste management.

While the concept has the aim of improving e-waste management in countries with deficits in this field, there are no defined minimum criteria or benchmarks for this type of compensation market yet. In general, most stakeholders agree that the approach should contribute to an implicit set of objectives, including a better control of hazardous substances, support of local collection and management systems, and a focus on local value addition and job creation. In addition, there is a wide consent that related approaches should be in-line with national and international regulations and effectively rule-out unintended side effects such as sub-standard working conditions and illegal waste trade.

This contribution proposes a set of principles to guide future e-waste compensation attempts in-line with the objectives above. The principles were developed within project E-waste Compensation as an international financing mechanism in Nigeria (ECoN), which was funded under the PREVENT Waste Alliance in 2021 and 2022. The principles summarize multiple inputs from key stakeholders, as well as various existing discussion lines around e-waste management and international financing mechanisms. The principles are aimed to advance the debate around e-waste compensation and to support the definition of eligible compensation claims in this field.

### **Keywords**

E-waste recycling, E-waste compensation, Nigeria, international financing mechanism

## 190. Sufficiency and sustainable peace in a viable world

Jürgen Scheffran<sup>1</sup>, Roland Weber<sup>2</sup>

<sup>1</sup>University of Hamburg, Hamburg, Germany. <sup>2</sup>POPs Environmental Consulting, Schwäbisch Gmünd, Germany

### Abstract

To find a balance between human needs and planetary boundaries, possible strategies include the preservation of ecosystems within viable limits; improving the efficiency of resource use; risk reduction and security for resource infrastructures; fair distribution and justice in resource management; sufficient production and consumption to satisfy human needs. Combining these strategies, sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs." Today's main challenge is humanity's ability to sustain ability to preserve environmental space against multiple crises, disasters and violent conflicts that threaten nature and needs of present and future generations. The destructive and ecocidal impact of war have been inherent in many wars in the last century, from the World Wars and the Cold War to the US-Vietnam war and most recently the Russian-Ukrainian war which is disastrous to societies and the environment, increases military resource demand and resource loss.

Sufficiency asks for necessary human needs, values and goals and how they can be adapted to growth limits. Harmonizing human society and natural environment can: 1) accept available natural services as "sufficient" (what is enough?), without further efforts to satisfy needs; 2) "substitute" insufficient services by new values achieved with less natural resources and impacts. Avoiding the violation of minimum existential needs and bridging external and internal constraints, the freedom to pursue happiness through satisfaction and sufficiency are key synergies between sustainable development and peacebuilding.

While negative peace is about preserving existence against physical violence and positive peace about unfolding development against structural violence, preservation and unfolding of nature and society are also essential for sustainable development. Thus, socio-ecological transformation towards sufficiency is also a peace project, reducing and including lower ecological footprints of consumption societies and lower demand of resources, which together with possible elimination of wars for resources, conflict management and peace policy can promote a sustainability transitions. To avoid "war against nature" a "peace with nature" has been proposed by UN Secretary-General Antonio Guterres. The double transformation to a viable world in the common house of planet earth requires a variety of concrete measures for sustainable peacebuilding, including cooperation, disarmament and common security as well as a resilient, low-carbon and low-conflict energy supply. A viable world of coexistence and cohabitation of different world orders can address common problems and avoid geopolitical conflicts.

### Keywords

Sufficiency, Sustainable Peace, Viable World, Multiple Crises, Synergies

## **193. Greenhouse gas emissions from residential building and circular economy mitigation strategies**

Naomi Keena<sup>1</sup>, [Daniel Rondine!](#), Alejandra Acevedo<sup>2</sup>

<sup>1</sup>McGill University, Montreal, Canada. <sup>2</sup>Universidad de Lima, Lima, Peru

### **Abstract**

The production of materials for buildings, accounts for 11% of global greenhouse gas (GHG) emissions. Circular-economy (CE) strategies and life cycle design approaches promise emission reductions through rethinking material use. However, detailed assessments outlining the potential of such strategies to reduce GHG emissions are lacking. In this paper a life cycle assessment of typical residential units in Montreal and Lima are presented. The models presented are representative of typical North American and South American residential construction. The results outline the potential for GHG emissions reductions if CE strategies of design for disassembly, extended service life, reuse, and recycling are considered. The study takes a deep dive on the state-of-the-art recycling of construction materials and highlights areas where more research is needed to foster CE end-of-use strategies, such as in the case of structural wood. Building material dichotomies are highlighted where the use of perceived 'low carbon' materials in a primary life cycle fail to achieve GHG reductions when considered over multiple cycles due to energy and carbon intensive recycling processes. Our results indicate that in the case of housing, circular end-of-use strategies can reduce building materials life cycle GHG emissions by up to 76%. This is primarily due to 1) avoiding non-renewable material extraction in secondary life cycles, and 2) diverting building materials from landfill. With more residential buildings meeting net zero energy targets with deep energy retrofits, energy efficient design as well as the decarbonization of electricity supply, a greater awareness is shifting to the mitigation of GHG emissions associated with materials and construction. CE strategies offer one path forward.

### **Keywords**

housing, LCA , circular economy, built environment, material production

## 194. Reducing chemical exposure and staying within global boundaries by sustainable and reduced consumption – A win-win argument for sufficiency

Roland Weber<sup>1</sup>, Martin Scheringer<sup>2</sup>

<sup>1</sup>POPs Environmental Consulting, Schwäbisch Gmünd, Germany. <sup>2</sup>ETH Zürich, Zürich, Switzerland

### Abstract

The global boundaries which define the safe operating space for humanity have been crossed for new entities such as plastic pollution and persistent organic pollutants like per- and polyfluoroalkyl substances (PFAS).<sup>1</sup> A main driver for this pollution are consumption societies with high ecological footprints as well as externalizing production and pollution to developing countries. Pollution is responsible for 9 million premature death a year (one in six deaths worldwide) including 1.8 million deaths from toxic chemicals.<sup>2</sup> 10'000s of chemicals with hazardous properties are used in consumer products such as PFAS in surface-treated consumer products (e.g. textiles, carpets, fast food packaging, cosmetics), flame retardants in e.g. electronics, vehicles, textiles as well as more than 3000 chemicals with hazardous properties in plastic. This results in human exposure and contamination of human blood and breast milk where hundreds of industrial chemicals can be detected. Health effects alone from endocrine disrupting chemicals are estimated to cause costs of 157 billion € in Europe (1.3% of GDP) and 340 billion € in the US (2.3% of GDP).<sup>3,4</sup> While chemical legislation can restrict individual hazardous chemicals, no chemical legislation currently can control the health effects of chemical mixtures. Therefore, reduction and minimization of exposure also needs awareness and knowledge on consumer level to protect health.

Reduction of consumption and the shift to consumption of sustainable products is one important approach to reducing exposure to chemicals of concern and reducing environmental pollution at production sites (of consumer products and food). This win-win situation of reduction of consumption (sufficiency) and personal health benefits as well as reduction of the pollution footprint can be a good impulse and education tool for promoting more sustainable consumption and production patterns. The One Health Joint Plan of Action of FAO, WHO, WOA and UNEP includes activities that aim to strengthen collaboration, communication, capacity building, and coordination across all sectors responsible for addressing health concerns at the human-animal-plant-environment interface. Similarly, the Stockholm Convention on persistent organic pollutants has awareness raising components in its implementation. Such frames could be utilized for global education on sustainable consumption including the positive effects of sufficiency for consumers and the environment.

1) Cousins et al. (2022) *Environ Sci Technol.* 56, 11172–11179.

2) Fuller et al. (2022) *The Lancet Planetary Health.* 6 (6), e535–e547.

3) Attina et al. (2016). *The Lancet Diabetes & endocrinology,* 4(12), 996–1003.

4) Trasande et al. (2015) *The Journal of Clinical Endocrinology & Metabolism* 100, 1245–1255.

### Keywords

Chemicals in products, Exposure, Sustainable consumption, Sufficiency, Health protection

## 196. Material flow analysis of the recycling of lithium-ion batteries in South Africa: collection, processing, and product distribution

Dominic Vooght<sup>1</sup>, Christie Dorfling<sup>1</sup>, Louis Louw<sup>2</sup>, Frans Van Schalkwyk<sup>1</sup>, Guven Akdogan<sup>1</sup>

<sup>1</sup>Department of Chemical Engineering, Stellenbosch University, Cape Town, South Africa. <sup>2</sup>Department of Industrial Engineering, Stellenbosch University, Cape Town, South Africa

### Abstract

The increasing demand for lithium-ion batteries (LIBs) in South Africa (SA) raises concerns over their disposal and recycling once they reach end-of-life (EOL). There are currently no LIB waste processing facilities in SA or on the African continent, and no legislation to mandate their collection and recycling. There is thus limited comprehensive data available on the volumes of EOL LIBs available for recycling. Given this, the aim of this study is to determine the volumes of EOL LIBs available for recycling, and to perform a Material Flow Analysis (MFA) to track the flows and fates of materials resulting from their recycling to provide recommendations for the future of EOL LIBs recycling in SA. A Reverse Logistic Network (RLN), or recycling network, for LIB waste in SA was modelled. Using this RLN, MFAs were performed in both e!Sankey<sup>®</sup> and STAN<sup>®</sup> software packages for the period of 2021 to 2033. The MFA tracks the flows of material through the LIB recycling stages of collection, pre-processing (dismantling and mechanical pre-treatment), inorganic and organic acid-based hydrometallurgical processing, and end-product distribution. Three primary MFAs were performed: an MFA over the entire RLN boundary, an MFA over the processing boundary, and an Elemental Flow Analysis (EFA) over the processing boundary. It was concluded that the viability of the RLN is heavily dependent on the EOL LIBs collection rate: an optimistic collection rate strategy (2021: 10%; 2033: 65%) yields a feasible EOL LIBs process plant in 2023. This increases to 2027 at a pessimistic approach (2021: 1%; 2033: 45%) and is infeasible at the current collection rate (1%), conveying the urgent need for regulatory action. The majority of the EOL LIBs are expected to result from consumer electronics (> 90%). Inorganic acid-based processes are preferred to organic processes from a waste treatment and saleable product perspective. Organic acid-based processes are preferred to inorganic processes from a raw material consumption perspective, with average flows of 14.45 vs. 26.77 ton raw material/(ton EOL LIBs) for 2023 for the respective processes. Inorganic acid-based processes show a higher recovery of cobalt, lithium, nickel, and manganese than organic processes with an average recovery of 0.93 vs. 0.89, respectively. End-products from inorganic acid-based processes are recommended for distribution as they remain in the SA market from 2028 to 2033, promoting a circular economy between the LIBs recycling and manufacturing industries.

### Keywords

Material flow analysis, Circular and regenerative economy, Material lifecycle approaches, Transforming value chains, Spent lithium-ion batteries and e-waste recycling



## 197. Reverse logistic network optimisation for the recycling of end-of-life lithium-ion batteries in South Africa

Dominic Vooght<sup>1</sup>, Christie Dorfling<sup>1</sup>, Louis Louw<sup>2</sup>, Frans Van Schalkwyk<sup>1</sup>, Guven Akdogan<sup>1</sup>

<sup>1</sup>Department of Chemical Engineering, Stellenbosch University, Cape Town, South Africa. <sup>2</sup>Department of Industrial Engineering, Stellenbosch University, Cape Town, South Africa

### Abstract

There is an increasing demand for lithium-ion batteries (LIBs) in South Africa (SA) due to the increased demand for consumer electronics, growth of the renewable energy sector, and the emergence of the electric vehicle (EV) industry. There is currently no specific legislation in place to mandate the collection and recycling activities of these LIBs once they reach end-of-life (EOL). Additionally, there are no EOL LIBs processing facilities in SA or on the African continent and there is thus an urgent need for sustainable recycling routes for EOL LIBs in SA. Given this, the aim of this study is to develop and optimise an environmentally sustainable and economically viable Reverse Logistic Network (RLN) for the recycling of EOL LIBs in SA. RLNs for integrated EOL LIBs and e-waste recycling were modelled using anyLogistix® supply chain software, which considered the following stages: waste material collection, pre-processing (dismantling and mechanical pre-treatment), hydrometallurgical processing, and end-product distribution. RLNs were modelled and simulated for the period of 2023 to 2033 and considered scenario variations in the hydrometallurgical processing route (mineral vs. organic acid), product types, and process facility configurations (centralised vs. decentralised facility approaches). The optimal RLN configuration was determined via a combined Greenfield Analysis (GFA) and Network Optimisation (NO) experiment approach, as well as objective function optimisation to consider both economic and environmental performance indicators. It was found that a RLN consisting of 212 decentralised EOL LIB waste collection centres, 8 decentralised dismantling facilities and a single, centralised scaled-up hydrometallurgical process plant utilising a mineral acid-based approach was found to be the optimal RLN configuration. This optimal configuration yielded a RLN Net Present Value (NPV) of 450 million South African Rand (ZAR) over the network lifetime. To account for environmental performance, a carbon cost optimisation yielded a net NPV after equivalent cost of carbon emission of 429 million ZAR. A mineral acid-based process producing a Lithium-Nickel-Manganese-Cobalt-Hydroxide (NMC) precipitate product was found to be the optimal process route as NMC, a LIB cathode precursor, is commercially used to produce LIBs. Thus, this RLN promotes a circular economy between the LIBs recycling and manufacturing industries. A sensitivity and break-even analysis concluded that the recycling network is viable at current conditions but is sensitive to fluctuations in material transport cost and the operating cost of processing the waste EOL LIBs.

### Keywords

Reverse Logistic Network, Recycling Value chain, Spent lithium-ion batteries and e-waste recycling, Circular and regenerative economy, Recycling chain development and optimisation

## **198. Evaluation of the suitability of the Buipe Cement Kiln of Savanna Diamond Ltd. (Ghana) for co-processing of TDF and WEEE-plastics waste**

Tobias Schleicher<sup>1</sup>, Ed Verhamme<sup>2</sup>, Sampson Atiemo<sup>3</sup>, Letitia Nyaaba<sup>4</sup>, Chandrasekhar Babu<sup>5</sup>

<sup>1</sup>Öko-Institut e.V., Freiburg, Germany. <sup>2</sup>Alternate Resource Partners, Zeevenbergen, Netherlands. <sup>3</sup>Mountain Research Institute, Koforidua, Ghana. <sup>4</sup>Ghana National Cleaner Production Centre, Tema, Ghana. <sup>5</sup>Savannah Diamond Ltd., Buipe, Ghana

### **Abstract**

The Ghana component of the Swiss Sustainable Recycling Industries (SRI) Program identified sound treatment pathways and final disposal solutions for various hazardous fractions, including waste car tires and WEEE-plastics. Accordingly, one solution could be co-processing in cement kilns. Applying co-processing as a solution would also be the introduction of co-processing in Ghana.

However, to allow a safe and environmentally sound introduction of co-processing in Ghana, it should follow current technical guidelines for environmentally sound co-processing of hazardous waste as alternative fuels and raw materials for use in cement kilns conform to decisions VIII/17, IX/17 and BC-10/8 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal and decision OEWG-VII/9 of the open-ended Working Group of the Basel Convention, as ratified in 2003 by the Ghana authorities. These guidelines are recorded in the UNEP Basel Convention Technical Guidelines on Environmentally Sound Co-processing of Hazardous Waste in Cement Kilns (UNEP BC TG).

An assessment of the Buipe cement plant, located in the Northern Region of Ghana and owned by M/S Savanna Diamond Company Limited showed that this cement plant could potentially be capable of co-processing (hazardous) waste and Refuse Derived Fuel (RDF)/ Solid Recovered Fuel (SRF) in an environmental sound manner, although adjustments (such as AFR feeding systems) will be required to enable co-processing according to international guidelines and standards (UNEP Basel Convention Technical Guidelines on Environmentally Sound Co-processing of Hazardous Waste in Cement Kilns, Directives on the European Parliament on Industrial Emissions).

To identify required adjustments and changes and their potential investments a detailed co-processing suitability assessment (full assessment) has been executed for Tire Derived Fuel (TDF, being tire shreds size 50x50 mm), and WEEE-plastics waste.

Additionally, field visit has been executed. The gathered data and field visit results followed by a kiln process evaluation were used to do an overall evaluation of the state of the cement plant organization and operation and its TDF and WEEE-plastics waste co-processing capability. Three issues required further elaboration: (1) source/stack emission limits, (2) a performance test and (3) the AFR feeding system. All above mentioned actions have led to the setup of an overall list of conclusions and recommendations to be presented at the conference.

### **Keywords**

Sustainable Recycling Industries, Ghana BUIPE cement plant, full assessment, Co-processing AFR (TDF and WEEE-plastics waste

## **200. An Integrated Framework for Vertical Farming to Ensure Food Security in Developing Countries**

Arohee Sinha<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Institute of Design, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### **Abstract**

This paper analyses the benefits of indoor vertical farming for urban residents, exploring the various ways in which this innovation can improve food access and security, reduce environmental impacts, and enhance the overall well-being of the urban population. Food security is an emerging issue for low-income households of the global south, which necessitates sustainable and locally-produced food, contributing to their socio-economic development. The scarcity of land in urban areas, high transportation costs, and long supply chains, prevents crop production through conventional agricultural practices.

According to WHO, 8.9% of the world's population is undernourished, and around 9%, which is almost 697 million people, are suffering from severe food insecurity. Moreover, women, infants, children, and adolescents are more likely to be at the risk of malnutrition. This paper employs case analysis to identify potential pitfalls, literature review to provide a comprehensive overview of previous studies and analyses the data collected from surveys and interviews.

This study proposes an integrated framework for vertical farming which is practical, modular and scalable. This framework comprises of three sub-systems, the first sub system involves a controlled environment for plant growth which includes precise regulation of temperature, lighting, humidity, CO2 levels, nutrient solutions, and air circulation. The second sub-system introduces a smartphone application for educating users by providing three-dimensional visualizations. This app also aids in connecting users with a community of like-minded individuals interested in sustainable urban agriculture. The third sub-system elaborates on policy guidelines for the proposed framework, comprising of zoning regulations, building codes, environmental standards, energy efficiency requirements, water conservation guidelines, food safety regulations, and incentives for sustainable agriculture. These guidelines aim to promote sustainable urban agriculture and ensure safe, efficient, and equitable use of resources. The proposed framework creates job opportunities and promotes sustainable food systems in densely populated areas of developing countries, thereby ensuring food security for the marginalised sections, especially for women and children.

### **Keywords**

Urban Residents, Food Security, Malnutrition, Marginalised Section, Vertical Farming

## 201. Enhancing Water Security: A Community-centred Water Management Approach

Safa Mubeen<sup>1</sup>, Tarun Kumar<sup>2</sup>

<sup>1</sup>Faculty of Architecture, PES University, Bangalore, India. <sup>2</sup>CPDM, Indian Institute of Science, Bangalore, India

### Abstract

Water is an indispensable resource for the sustainable development of our planet. However, the pressing issue of water scarcity is a stark reality that confronts us. Roughly 66% of the world's population endures acute water scarcity for a minimum of one month per annum, with an estimated 700 million individuals at risk of being displaced due to water scarcity by 2030. The absence of access to clean and adequate drinking water accounts for approximately 829,000 fatalities annually. India holds 17.7% of the world's population within its borders, but only accounts for 4% of its water resources, making it one of the most water-stressed countries globally. The glaring disparity between these numbers vividly illustrates the gravity of the water crisis that confronts this nation. The confluence of factors, such as inadequate regulation, excessive privatisation, pervasive neglect, and indifference towards policies, have resulted in successive generations grappling with a persistent thirst for uncontaminated drinking water. Additionally, the scarcity of water has led to regional disputes over access to the country's inland rivers. Furthermore, the protracted history of caste discrimination in India has significantly aggravated the predicament of inadequate water accessibility among a substantial segment of the population. The scarcity of water, in proximity, disproportionately impacts women and children, as they are frequently tasked with its collection.

This necessitates the development of a community-centred water management approach in both urban and rural areas, which can effectively enable the transportation, identification, and utilisation of this vital resource. A comprehensive water strategy demands a systematic, holistic approach that accounts for factors such as population growth, economic development, climate change, and environmental sustainability. In this paper, an integrated framework that aims to address the challenge of water scarcity, in urban and rural areas, has been proposed. This puts forward a multifaceted and interdisciplinary approach, incorporating aspects such as resource optimisation, sustainable development, and equitable distribution; integrating technology for more efficient means of water storage, recharge, and filtration. This framework employs an app-based approach that incorporates a sensor module, capable of detecting key water parameters, such as water level, pH level, and total dissolved solids. Moreover, the app utilises GPS tracking to precisely map the boundaries of the monitored lakes, bolstering its effectiveness. The proposed solution fosters stakeholder collaboration by detecting, deferring, and transferring water within existing water bodies, thereby ensuring equal and sustainable water access to all.

### Keywords

Water security, Framework, Sustainable access, Equitable development, Technology

## **204. A Conceptual Interdisciplinary Multilevel System Perspective on Sufficiency: Product User Implications from Living With Less and Goals for the Transition**

Sahra Svensson-Hoglund<sup>1</sup>, Jessika Luth Richter<sup>2</sup>, Jennifer D. Russell<sup>1</sup>

<sup>1</sup>Virginia Polytechnic Institute and State University, Blacksburg, USA. <sup>2</sup>IEEE, Lund University, Lund, Sweden

### **Abstract**

To stay within planetary boundaries, the need for a sufficiency economy is widely discussed from societal (Lorek & Spangenberg 2014), business (Bocken et al., 2022), and lifestyle perspectives (Vita et al., 2019). The concept of sufficiency is defined as the minimum and maximum bounds of a “consumption corridor” within various social and ecological limits (Spengler, 2016; Fuchs et al., 2021). At the individual level, this entails a reduction in the number of objects an individual possesses (Fuchs et al., 2021). While it is known that in a realized sufficiency economy, socio-cultural values are more focused on time affluence and social connection over material accumulation and businesses are offering solutions to “real” consumer problems, rather than inventing new needs, a comprehensive understanding is missing – particularly from the perspective of individual consumers, or product users. This gap hinders the transition to a sufficiency economy as it prevents the generation of public buy-in.

In this presentation, I share a conceptual interdisciplinary Multilevel System Model that provides a tool for systematically discerning the implications that a sufficiency economy has upon the product user’s experience of acquiring, using, and disposing of goods. The product user’s experience of consumption is conceptualized as interconnecting objective and subjective transactional costs, risks, and gains – weighted against each other – and influenced by techno-economic and socio-cultural mediating and moderating factors (Svensson-Hoglund et al., 2022). The overall model centers on the identification of, and connection between: (1) the system structures and mechanisms, such as the economic system principles and actor incentives, and; (2) how this larger system is experienced by individuals, such as influencing their decision-making and perception about their belongings. As such, the proposed model captures the combined and interconnected impact of higher system-level mechanisms.

Following the model’s presentation, I share how it can be used by policymakers and other stakeholders to identify the key aspects of a sufficiency economy necessary for ensuring a positive consumer experience and quality of life. This is followed by a discussion of the main challenges and opportunities for individual happiness – focused on the varying characteristics of a sufficiency economy and how it impacts product users.

### **Keywords**

consumption , sufficiency , Multilevel Model , Conceptual Model , Consumer well-being

## **205. An integrated methodology to assess environmental, social and economic impacts in textiles**

Sanjeevan Bajaj

CRPG, New Delhi, India. FSLCI, Berlin, Germany

### **Abstract**

A key tenet of circular economy is to increase useful life of products as longer use increases their economic value. Theoretically, this also benefits the environment because increasing useful life leads to reduced demand for new products, thereby reducing supply and hence production, which in turn leads to lower emissions and lower consumption of virgin natural resources. Critics argue that such initiatives impede growth of manufacturing, a major driver of economic growth and employment. This criticism has sparked whole new discourses that question current economic theories around fuelling economic growth through increased demand while ignoring planetary boundaries. A related discourse, largely among the prosperous, questions if unbridled consumption should at all be considered as an indicator of human well-being. Also how much consumption (and by implication, economic growth fuelled by consumption) is sufficient to maintain well-being and yet stay within planetary boundaries.

Life cycle approaches enable scientific assessment of a product's impact on natural and social environments and expose trade-offs from one type of impact to another. This can be extended to also assess potential environmental benefits vis-a-vis potential economic gains or losses, both at the micro as well as macro economic levels.

We will present LCA based methodology to assess the impact of circular economy actions on the environment as well as the economy in an integrated manner. It will show which stages in the product's life cycle (and by implication, which parts in its value chain) need addressing in order to reduce environmental impacts without impacting macro-economic activity levels. Using the example of a specific action, i.e. increase in the useful life of garments through reuse, we will visualize scenarios on how environmental benefits may be increased while income and employment is redistributed within and beyond current value chains. Taking one specific case of garment reuse, we will also demonstrate quantification of macro-economic changes as a result of such redistributive action for circularity in textiles. Findings from this analysis will provide insight into how the action is likely to change environmental and social impacts. Thereby it will also help determine modalities of implementing the action in a way that the redistribution yields benefits for the natural as well as the social environments. The methodology will also enrich S-LCAs by showing how such redistributions across value chains are likely to change social impacts.

### **Keywords**

Circularity in textiles, Economic impacts, Garment reuse, Integrated LCA, Value chain

## **206. The limits of small sustainable fashion brands and a proposal to overcome them**

Anatolia Hinojosa<sup>1</sup>, Giulio Focardi<sup>2</sup>, Lorenza Salati<sup>2</sup>

<sup>1</sup>Universidad Nacional de San Agustín, Arequipa, Peru. <sup>2</sup>Osun WES srl (Biassono), Milán, Italy

### **Abstract**

The goal is to reduce the limitations of small sustainable fashion brands following the Multifactory Model, developed in Italy. We seek to experiment with the Multifactory Model to integrate rural women artisans and city professionals in a collaborative and egalitarian environment that is promoted by universities, government, business and civil society. To deal with artisans, the Multifactory project is integrated with ANDESSUR's sustainable fashion project, which is focused on the province of La Unión, district of Pampamarca, due to its importance in the textile history of the province, of the region of Arequipa and the whole of Peru. There is evidence that the textile artisans have preserved the textile art since pre-Hispanic times, and that Hiram Bingham himself in 1911 was amazed by the textile richness of the district of Pampamarca and took some samples to the United States where he demanded more carpets. As an example of the quality of the textile art until 1992, one of the largest and most beautiful carpets, which was made by men and women artisans of this district, was found in the Peruvian Government Palace in Lima. Nowadays, this carpet is a relic that is waiting to be restored. The methodology used in the applied research project is the participatory observation. The Multifactory Model is a model to start and manage shared workspaces based on aspects such as: horizontal governance, professional heterogeneity, circular aid and participation. The conditions for the application of the Multifactory model in the rural area of Arequipa were verified and there is a collaboration between researchers of the Multifactory and the NGO Andessur, to apply the Model for the benefit of 250 women artisans expert in the Peruvian textile art that is disappearing due to lack of innovation were identified.

### **Keywords**

Sustainable fashion, Multifactory, qualitative growth, small enterprises.

## 207. Considering the role of responsible sourcing certifications in battery mineral value chains

Damien Giurco<sup>1</sup>, Rusty Langdon<sup>1</sup>, Stephen Northey<sup>1</sup>, Helen Barreto Lara<sup>1</sup>, Bernardo Mendonca<sup>1</sup>, Wen Li<sup>2</sup>, Prok Vasilyev<sup>3</sup>

<sup>1</sup>University of Technology Sydney, Sydney, Australia. <sup>2</sup>The University of Melbourne, Melbourne, Australia. <sup>3</sup>Curtin University, Perth, Australia

### Abstract

Given the imperative for a fast and fair global transition to decarbonised energy and transport, batteries are increasingly going to feature in energy storage for homes, businesses, in energy grids and particularly electric vehicles. The origin of minerals used in batteries, including lithium, nickel and cobalt, are being closely examined for their social and environmental impacts by a range of stakeholders from consumers to electric vehicle manufacturers and financial investors.

This research compares the drivers for certification of responsibly sourced minerals in the battery mineral value chains. A broad review was undertaken of both certification and other sustainability assessments. The result maps data requirements across environmental, social and governance dimensions for prevailing approaches to sustainability assessment which span formal certification schemes (Initiative for Responsible Mining Assurance; Certification of Raw Materials) through to reporting and assurance standards (Battery Passport, Towards Sustainable Mining; Global Reporting Initiative; Carbon Disclosure Project; Dow Jones Sustainability Index; Responsible Mining Index; OECD Due Diligence Guidance for stakeholder engagement in the extractives sector).

Building on identified areas of commonality and divergence in data reporting requirements, barriers and opportunities for the broader uptake of certification by industry can be more clearly understood.

The paper concludes by explicitly considering the tensions between higher standards for responsible sourcing of primary materials as a mechanism for improving social and environmental performance; interactions with what responsibly sourced means for the growing role of secondary materials in a circular economy and finally the influence of geopolitical and industry dynamics in shaping an effective pathway for scaling a fast and fair transition to a decarbonised future.

### Keywords

battery, responsible sourcing, lithium, ESG, certification



## 208. Sustainable raw material supply for radiopharmaceutical cancer treatment by extraction of Ra-226 from phosphogypsum

Michael Haschke<sup>1</sup>, Charlotte Bornhöft<sup>1</sup>, Ed Yochum<sup>2</sup>, John Zehner<sup>2</sup>, Micha Zauner<sup>3</sup>, Horst Märten<sup>3</sup>, Ryno Botha<sup>4</sup>

<sup>1</sup>DMT, Essen, Germany. <sup>2</sup>SpectronRx, Indianapolis, USA. <sup>3</sup>UIT, Dresden, Germany. <sup>4</sup>ThorTech, Cape Town, South Africa

### Abstract

Radium-226 (Ra-226) is among the most sought-after naturally occurring radioactive raw materials to produce radiopharmaceuticals utilized for medical diagnostic and therapeutic applications. Yet there is no conclusive raw material supply for Ra-226, resulting in about 50,000 current cancer patients going untreated in the USA alone.

The main challenge of the Ra-226 supply chain is the lack of suitable raw materials for radiopharmaceutical suppliers. Possible sources include electronic instruments, recovered bearing coatings, lightning rods, uranium mining tailings, and phosphogypsum (PG) tailings as waste material from phosphate fertilizer production. The known U.S. demand is currently about 10 Ci per annum. However, it is expected to multiply when including patients from outside the USA. Recent research (e.g. EIT RawMaterials-funded project raPHOSafe) showed that PG tailings in Bulgaria, Morocco, and Spain are potential sustainable raw material sources, with typical activities of  $\geq 1\text{Bq/g}$  depending on the source region. Preliminary estimates yielded that a recovery of 50 Ci would require the processing of a 100x100x100m PG volume, which at first glance may not seem cost-effective. However, the business and ESG-compliance case changes rapidly when considering the significant added value from gypsum recycling (in light of rising gypsum demand in the EU), potential extraction of REE and P (critical raw materials) from PG, and also accounting for environmental benefits from rehabilitation of NORM-charged areas. A plausible and cost-effective solution would be facilitated by a coherent, independent third-party audited and ESG-compliant supply chain driven by increasing medical alpha therapy demand, and facilitated by a technical framework of automated sorting and processing facilities for effective recovery of Ra-226, and efficient radiopharmaceutical production facilities, which are now commercially readily available.

### Keywords

Circular Business Models, Radiopharmaceuticals, Phosphogypsum, Gypsum Recycling, Cancer Therapy

## **209. Sustainable Circular Economy Assessment Framework for E-waste Treatment Plant in developing countries – Case Study of Cuenca, Ecuador**

Gabriela Sucozhañay<sup>1</sup>, Melanie Haupt<sup>2</sup>, Dolores Sucozhañay<sup>1</sup>, Paul Vanegas<sup>1</sup>

<sup>1</sup>University of Cuenca, Cuenca, Ecuador. <sup>2</sup>Chair for Ecological Systems Design, Institute of Environmental Engineering, Zurich, Switzerland

### **Abstract**

E-waste has become a valuable but complex stream to manage. In developing countries such as Ecuador, where technological capacities are limited, E-waste is considered mainly as a source of primary material, so most of the existing treatment plants are limited to disassembly and export activities, neglecting its circularity potential. Today, although Ecuador is one of the few countries in the region with specific regulations on E-waste management and circular economy, E-waste treatment plants face significant challenges associated with a lack of information, incentives, knowledge, and skills to incorporating circularity practices, which limit their potential for value retention and reduction of environmental, social, and economic impacts. In this sense, evaluation frameworks offer an effective solution, as they are key tools for promoting continuous improvement, facilitating the replicability of practices, and supporting informed decision-making. In this work, we present a framework for the evaluation of the sustainable circular economy for e-waste treatment plants, using as a case study Cuenca city in Ecuador, where a pilot e-waste treatment plant combining repair, renovation, and recycling activities is planned to be located, fostering the retention of local financial value and the social inclusion of the informal sector. The evaluation framework was developed based on an exhaustive literature review on circularity and sustainability indicators, which was contrasted with the established environmental, social, and economic requirements of the local regulatory framework and categorized based on its scope. Then the processes and stakeholders associated with the evaluation were identified. The study put special attention on the social aspects since the informal sector, represented by scrap dealers and base recyclers who face harsh working conditions and vulnerability, has a crucial role in the management of e-waste

### **Keywords**

e-waste, Sustainable Circular Economy Framework, E-waste Treatment Plant , Developing countries

## 211. Circular Business Model for Digital Health Solutions: A Scoping Review

Camille Rønn<sup>1</sup>, Adrien Specker<sup>2</sup>, Andreas Wieland<sup>3</sup>, Christiane Lehrer<sup>3</sup>, Pascal Leroy<sup>4</sup>, Attila Márton<sup>3</sup>, Daniel Fürstenau<sup>1</sup>

<sup>1</sup>Copenhagen IT University, Copenhagen, Denmark. <sup>2</sup>World Resource Forum, St. Gallen, Switzerland.

<sup>3</sup>Copenhagen Business School, Copenhagen, Denmark. <sup>4</sup>waste electrical and electronic equipment, Brussels, Belgium

### Abstract

Digital health devices pervade the healthcare industry. With the increase in their usage, a growing focus and concern have been raised on the industry's continuing waste and negative environmental impact. This study seeks to analyze how a circular economy business model can be incorporated into a value-based healthcare framework with digital health devices as the unit of analysis. In considering the different stages of product life cycle and end-of-life management practices it will be researched how circular economy business models can follow criteria of value-based healthcare to ultimately increase sustainability in digital health while enhancing patient outcomes. The study will pursue a scoping literature review methodology and will be built on two theoretical pillars, the 4 R's in circularity and the value-based healthcare model. The literature review will implement a holistic approach and will aim at both finding research gaps and exploring potential concepts to lay the fundament for a future empirical study.

### Keywords

Circular Economy, Value-based Health Care, Digital Health, Life Cycle, Business Model

## **212. Conceptual and Methodological Framework on the Availability and Recoverability of Secondary Raw Materials (SRMs) focusing on Critical Raw Materials (CRMs)**

Kirsten Remmen<sup>1</sup>, Manuele Capelli<sup>1</sup>, Matthias Rösslein<sup>1</sup>, Antoine Beylot<sup>2</sup>, Daniel Monfort Climent<sup>2</sup>, Nathalie Korf<sup>3</sup>, Vera Susanne Rotter<sup>3</sup>, Patrick Wäger<sup>1</sup>

<sup>1</sup>Technology and Society Laboratory at Empa, St. Gallen, Switzerland. <sup>2</sup>BRGM, Orléans, France. <sup>3</sup>Chair of Circular Economy and Recycling Technology at Technische Universität Berlin, Berlin, Germany

### **Abstract**

The effective management of raw material supply and demand requires reliable and complete information and foresight on Secondary Raw Materials (SRMs) stocks and flows throughout their life cycles. Therefore, having knowledge about the availability and recoverability of SRMs, especially Critical Raw Materials (CRMs), is crucial. Existing knowledge platforms, such as the Urban Mine Platform ([www.urbanmineplatform.eu](http://www.urbanmineplatform.eu)) do not include the recoverability of SRMs or CRMs. During the Horizon Europe project FutuRaM, a conceptual framework is developed, extending existing frameworks to include recycling pathways showing both the availability and recoverability of SRMs. The FutuRaM framework includes four post-consumer waste streams (vehicles, batteries, electronic and electrical equipment, construction and demolition) as well as tailings from mining activities and slags and ashes.

In the first step, the concepts of "availability" and "recoverability" need to be defined by integrating all necessary requirements and boundary conditions of the six FutuRaM waste streams. This includes addressing aspects such as the quality of recycling or the fast development of innovative recycling technologies to ensure a comprehensive definition and subsequent assessment of recoverability. A conducted literature study further highlighted the need to build the FutuRaM framework on existing concepts and frameworks, e.g., the System of Environmental-Economic Accounting (SEEA) framework. To increase functionality of the developed framework, it is crucial to integrate available data, such as the European Waste Statistics data sets. In a further step, this available but widely scattered data needs to be harmonized to be fit for use in a SRMs availability and recoverability assessment. The harmonization and consolidation of data sets include the integration of an uncertainty assessment, which builds the basis for providing reliable information.

In our contribution, we will present the FutuRaM conceptual and methodological framework that aims to effectively support informed decision-making on the recoverability of SRMs and CRMs. This framework will be exemplified through case studies showing the crucial steps during the development in order to successfully contribute to advancing resource management for industry, policymakers, and researchers.

### **Keywords**

Secondary Resources & Waste, Resource Management , Raw Material Supply and Demand , Materials Life Cycle , Recoverability Assessment

## 213. Materials-as-a-Service (Maas) – Resource Leasing in the Context of Global North/South Circular Economy Transitions

Patrick Schroeder<sup>1</sup>, [Susanne Karcher](#)<sup>2</sup>, Sabine Oberhuber<sup>3</sup>, Iva Pesa<sup>4</sup>, Roos Janssen<sup>5</sup>

<sup>1</sup>Chatham House, London, United Kingdom. <sup>2</sup>ACEN, Cape Town, South Africa. <sup>3</sup>Turntoo, Amsterdam, Netherlands. <sup>4</sup>Rug, Amsterdam, Netherlands. <sup>5</sup>Het Groene Brein, Den Haag, Netherlands

### Abstract

While leasing business models such as product-as-a-service (PaaS) models and product service systems (PSS) already feature strongly in the circular economy, the agenda of primary mining derived "resource leasing" has not yet been explicitly explored or linked to the international circular economy transition debate. Resource leasing is an innovative business model that has the potential to facilitate the CE transition in Europe while at the same time provide long-term benefits to (mainly Global South located) resource extracting "producer" countries. It has the potential to facilitate the transition to a circular economy in key economic sectors such as electronics, automotive, aerospace, semiconductors, renewable energy and energy storage which heavily rely on resources such as platinum, copper, nickel, cobalt, silicon, lithium and many CRMs.

In an advanced circular economy, a range of mined minerals and resulting manufactured metals could be leased, rather than sold, to companies by producer countries, with the country of origin retaining ownership. That way the resource, in whichever form, is leased for a certain period of time and then 'returned'. The country would receive revenue from leasing the materials. A failure to return would lead to purchase at a premium price.[1].

This paper will provide a systematic analysis of the potential role of resource leasing in the context of circular economy transitions and global trade, with a focus on potential EU-Africa cooperation and trade arrangements. It provides insights on issues such as viable leasing models, governance arrangements relating to mining operations, transparency of royalty fee usage, traceability protocols, international procurement and current policy barriers. Furthermore, it aims to provide insights into how a international resource leasing model would support key policy development.

Circular resource leasing also seeks to address the phenomena of the Africa typical "resource curse" in which countries with abundant natural resources tend to have slower economic growth, higher levels of corruption, and weaker institutions, compared to countries without such resources by offering an alternative trading model.

Instead of limiting and concentrating control of resources to a few large corporations, the lease fee or royalty payments as part of a resource leasing arrangement can be used to fund social and circular economic development programmes within African communities and deliver just transition mechanisms benefitting all Africans. Key research objectives for resource leasing schemes under discussion are therefore covering :

- Transparent and fair allocation of resources
- Appropriate regulatory and governance framework
- Revenues management
- International cooperation on traceability

### Keywords

Resource Leasing , Just Transition, Materials as a Service, Traceability, Fair Trade

## 214. Critical Raw Materials and Value Chain Risks: Implications for Sustainable Development

Harikrishnan Tulsidas, Maria Teresa Pisani, Charlotte Griffiths

UNECE, Geneva, Switzerland

### Abstract

Mapping the risks for Critical Raw Materials (CRMs) to the Sustainable Development Goals (SDGs) is crucial for the energy, industry, mobility and digital transitions and combating climate change. Risks to CRM operations include social, environmental, regulatory, market, business, political, and financial. Social risks include local attitudes and expectations towards mining, such as land access and water management, and environmental risks involve waste management and political risks from policy changes. Regulatory risks come from changing regulations and compliance. Market risks are related to commodity price fluctuations and demand for minerals. Business risks come from operational and technological disruptions, and financial risks include capital and debt financing access.

The mining industry's top risk is social acceptance, which is linked to environmental, climate, and biodiversity risks. Increased awareness of mining and processing's impact on local communities, ecosystems, and habitats has made it difficult for mining firms to obtain social acceptance. Mineral processing and recycling's energy-intensive nature significantly impacts the environment, including freshwater use and hazardous chemical disposal. A circular economy approach prioritizes resource efficiency, waste reduction, and environmental protection, addressing environmental, social, and governance (ESG) issues in mining. Resource servitization models establish closed-loop systems, which is crucial in tackling mining's sustainability challenges. However, many companies have yet to adopt this approach, limiting their ability to gain social acceptance.

Mining risks have a significant impact on sustainable development. This paper explores how mining risks affect the SDGs, including poverty eradication, gender equality, access to clean energy, sustainable economic growth, resilient infrastructure, responsible production and consumption, and climate action. To achieve the SDGs, effective strategies to manage mining risks are needed. The United Nations Resource Management System (UNRMS) developed by the United Nations Economic Commission for Europe (UNECE) provides a comprehensive framework to address these risks. UNECE has also been developing a traceability and transparency approach and standard to verify compliance with ESG requirements along complex, opaque, and high risks value chains. A CRM value chain SDG risk index could help companies identify and manage risks and align with the SDGs, promoting sustainable mining practices. Considering ESG risks in mining operations is crucial for regulatory approval and combating climate change. These frameworks can be verified and trusted by regulators, investors, and consumers. Their implementation, supported by a sound and credible system for verifying compliance against ESG credentials, will help to mitigate negative impacts and contribute to sustainable mining practices and global sustainable development efforts.

### Keywords

Critical Raw Materials, Value Chain Risks, Sustainable Development Goals, Mining Risks, Circular Economy Approach

## **218. Development of a smartphone app for sustainable waste management in the manufacturing sector.**

Vishal Gadgihalli

Assistant Professor, PES University, Bangalore, India

### **Abstract**

Industry 4.0, the fourth industrial revolution, comprises automation, robotics, Artificial Intelligence, and virtual reality technologies, which have the potential to revolutionise the manufacturing industry. However, waste management, especially from electronic and consumer goods, has received very little attention in the industry 4.0 realm. Manufacturing waste is expected to be worth USD 8 trillion annually and is anticipated to grow by more than 7% between 2021 and 2027. India will produce almost 2 billion tonnes of manufacturing waste yearly by 2020, making it the third-largest source in the world.

In order to adopt industry 4.0, it is advised that smart manufacturing processes be implemented, and that waste generated in each phase be monitored and supervised. Sustainable materials or the use of intelligent immersive technologies must be used in place of synthetic materials used in the prototyping stage of manufacturing, such as polyurethane foam, synthetic clay, and EPS. Only these improvements can have a significant positive impact on the environment and human health. Based on the observation, it is obvious that regulations have to be framed before the manufacturing sector poses a serious environmental problem. The waste management guidelines established by governmental agencies are still not being followed by industries.

Industrial waste has emerged as a major issue with direct and indirect consequences for both the environment and human health. It has been discovered that the air in the arctic and antarctic regions of the world contains a variety of harmful compounds that are produced during manufacturing. This demonstrates very clearly the extent of environmental degradation that exists today. Governments from different nations must take a firm stance to establish rules for these acts in the industry 4.0 framework.

The recommended principles would provide sociolegal and policy directions to manage and control global manufacturing waste. These policies even contribute to raising awareness of the 3Rs and other sustainable environmental practices. These policies aim to make the polluters pay higher taxes. In order to achieve sustainable development, numerous frameworks, rules, and audit procedures must be created and executed. A smartphone app is proposed to facilitate auditing, waste management, raise awareness on policies, maintain transparency and generate feedback. The current study focuses on developing a smartphone app that relies on feedback. The app rewards and punishes organisations based on their adherence to these policies.

### **Keywords**

Manufacturing waste, Industry 4.0, Immersive Technologies, Smartphone App, Waste Management

## **221. Life Cycle Assessment for selected Blue Lagoon skincare products**

Silvana Loayza

Reykjavik University, Reykjavik, Iceland

### **Abstract**

The Blue Lagoon Ltd produces variety of skincare product by using natural ingredients appearing as by-products of geothermal energy harvesting in Svartsengi, Iceland. The goal of the hotspot analysis was to identify opportunities for reducing environmental impacts of two selected skincare by applying Life Cycle Assessment (LCA) of the products for two distinct scenarios; 1) produced outside Iceland, and 2) produced in Iceland. A cradle-to-grave LCA based on the ReCiPe2016 method was executed. Results indicates that overall impacts are lower by producing in Iceland rather than abroad. Future studies focused on packaging materials, and a complete sustainability life cycle assessment regarding the economic and social areas from the same product system are recommended to optimise processes.

### **Keywords**

Life Cycle Assessment, green products, Blue Lagoon skincare, circular economy, geothermal



## **225. Enhancing Capacities of Local Authorities for Sound E-waste Management in Ghana**

Lydia Essuah<sup>1</sup>, Berthy Kpiebaya<sup>1</sup>, Cornelia Stolzenberg<sup>2</sup>, Joseph Sikanartey<sup>2</sup>, Markus Spitzbart<sup>2</sup>, Sampson Atiemo<sup>3</sup>, Vincent Kyere<sup>3</sup>, Inga Hilbert<sup>4</sup>, Andreas Manhart<sup>4</sup>

<sup>1</sup>Ministry of Environment, Science, Technology & Innovation, Ghana <sup>1</sup>Mountain Research Institute, Obosomase, Ghana. <sup>2</sup>GIZ, Accra, Ghana. <sup>3</sup>Mountain Research Institute, Obosomase, Ghana. <sup>4</sup>Oeko Institute, Freiburg, Germany

### **Abstract**

Ghana generates large amounts of e-waste each year, but it also has an efficient collection system that is largely driven by informal and private sector participation. Managing and regulating e-waste pollution are the main challenges that the country is facing. The Ghanaian Government has begun setting up a legal framework to regulate the collection and management of e-waste in the country and over the last few years, the role of local Government in implementing these legal instruments in the respective Metropolitan, Municipal and District Assemblies (MMDA) has gained more emphasis. As a response, implemented by GIZ Ghana in cooperation with Mountain Research Institute, the E-Waste Programme has established a Human Capacity Development (HCD) programme aimed specifically at Environment and Health Officers at the local level. The goal of the HCD programme is to equip the MMDAs with the technical capacity required to exercise their roles in the National E-Waste Management Scheme. So far, over 140 c officers from 42 MMDAs in 10 regions of Ghana have been (i) trained in environmentally sound e-waste management and, (ii) assisted in developing technical guidelines for the management of e-waste and other scraps at the assemblies.

There are five Workshop Types for five different levels of authority and responsibility, to ensure an inclusive approach. The Ministry of Environment, Science, Technology, and Innovation (MESTI) and its partner agency, the Environmental Protection Agency (EPA), the Ministry of Sanitation and Water Resource (MSWR), the National Association of Local Authorities of Ghana (NALAG), the Ministry of Local Government Decentralization and Rural Development (MLGDRD), the Office of the Head of Local Government Service (OHLGS), and the Regional Environmental Health Directorate (REHD) were among those who attended the Type I workshop. Because of the Type I activities, a Technical Committee (TC) was formed, with the primary responsibility of overseeing the project's activities. The Types II and III workshops were designed for the political heads and specific officers from environmental health, planning, waste management, and other departments with a direct link to waste management in the selected MMDA assemblies. The Type IV workshop was organised for selected Type III workshop participants to review the compiled guidelines. Finally, a Type V workshop was held to publicise the project's successes. The MMDAs' adoption of this guideline will have a significant impact on the environmentally sound management of e-waste at the grassroots.

### **Keywords**

e-waste management, human capacity development, informal sector

## 226. Sustainable Recycling Industries Impact on Egypt

Ghada Moghny, Hossam Allam

CEDARE, Cairo, Egypt

### **Abstract**

Egypt's has started to focus on enhancing its e-waste management since 2009, which was reflected in the first international e-Waste Management Forum that was held in Cairo under the auspices of the Minister of Communication & Information Technology. Egypt, as one of the developing countries lacking policies & regulations on e-waste, was missing out on the economic potential & job creation opportunities associated with developing the e-waste sector & facing major environmental & health challenges due to the improper handling of the e-waste quantities generated.

The Sustainable Recycling Industries (SRI) project launched by the State Secretariat of Economic Affairs (SECO) in 2013 targeted the e-waste management in Egypt by conducting the first e-waste assessment in 2011 to identify the country's needs. The project started its activities in 2016 and is still ongoing. The SRI project supported the establishment of an e-waste recycling industry in Egypt by setting up rules for certifying formal recyclers and establishing an auditing system that continues inspection & regulation of their operations. SRI identified the need to establish policies & regulations to govern the industry which led to a new law and its executive regulations, in which, for the first time, e-waste is mentioned & defined as a hazardous waste with special conditions. SRI took a further step by establishing the corresponding legal guidelines, which set out the rules & policies for managing e-waste, supported by technical guidelines that specified the handling of e-waste throughout its life cycle, from collection to recycling.

Additionally, on the job creation front, SRI helped formalize the informal sector by incubating creative ideas from entrepreneurs & supporting them to establish their SMEs in the e-waste field. In parallel, the SRI project provided technical assistance to existing recyclers to develop & improve their operations resulting in increasing the number of e-waste recyclers in the country from 2 to 19. Capacity building & awareness programs didn't fall short through the implementation of the project & have covered all stakeholders, whether they're entrepreneurs, recyclers, auditors, governmental officials or private sector players in the industry. The SRI project has also developed a full curriculum for both technical & managerial personnel on e-waste management that will be introduced to technical vocational schools to enhance education in the industry.

Through all these activities, the SRI project in Egypt has not only had an impact on e-waste management but has also established a platform for cooperation between four Ministries as well as international organizations and projects in Egypt.

### **Keywords**

E-waste, Recycling, Circular business models, Egypt Policy, CEDARE

## 227. Sustainable e-waste manual dismantling, through the operation of the Technical Training Centre (TTC) in Ghana

Cornelia Stolzenberg<sup>1</sup>, Sampson Atiemo<sup>2</sup>, Prosper Dorfi<sup>2</sup>, Asiedu Raldwin<sup>1</sup>, Andreas Manhart<sup>3</sup>, Inga Hilbert<sup>3</sup>

<sup>1</sup>GIZ, Accra, Ghana. <sup>2</sup>Mountain Research Institute, Obosomase, Ghana. <sup>3</sup>Oeko Instit, Freiburg, Germany

### Abstract

In Ghana, over 90% of electronic waste (e-waste) that is generated in the country gets collected by the informal sector. From informal collection, the material is usually brought to currently informal scrap yards and scrap clusters, where it is dismantled, separated and resold as raw material. Although the efficiency of the informal sector in collection and dismantling presents a key ingredient in the success of Ghana's e-waste management, some of their procedures pose a threat to the environment and human health.

The objective of the "technical trainings for basic dismantling of e-waste in Ghana", a concept developed by the German Cooperation in 2019, is to build on the existing knowledge of the scrap dealers and expand their understanding of environmentally sound recycling practices to sustainably improve informal processing. The Technical Cooperation, implemented by the "Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH" in collaboration with the Ghana Ministry of Environment, Science, Technology, and Innovation (MESTI) renovated an old warehouse on the Old Fadama scrap yard and re-purposed it into a Technical Training Center for sustainable e-waste dismantling (TTC), which is operated in collaboration with the German Oeko Institut Freiburg and Mountain Research Institute. Overall, trainings on theoretical and practical manual dismantling and business formalisation were provided to over 2000 scrap workers and shop owners.

The demolition of the Old Fadama scrap yard led to an unexpected shift in the landscape of collection and manual dismantling in the Greater Accra Region. Around 6000 scrap workers were evicted and along with that, their economic activities were decentralized and spread out across the region. As a response, the GIZ E-Waste Programme, together with MRI and their pool of trainers, recalibrated the technical training concept to suit the new reality of the informal sector into remote mobile trainings. This training module entails deploying instructors and training materials to participants at designated hotspots, where scrap workers are stationed, or wherever training is required. The activity also helped to map micro and mini scrap locations all over the Accra metropolis and the region, hence plays a key role in the formalization process. A pilot phase gave recommendations on improvements, which were integrated into the concept. Because this is a novel module, participants' satisfaction, on-the-job performance, and the mobile training team's performance and impact were evaluated during every training activity to improve training materials and methods to ensure that participants get the most out of the program.

### Keywords

Informal sector, Circular business models, MOUNTAIN RESERACH INSTITUTE, MOUNTAIN RESERACH INSTITUTE, MOUNTAIN RESERACH INSTITUTE

## **229. Ghana and Senegal's Residential Boom: Opportunities for Scaling Local Biogenic and Geogenic Building Material Resources**

Mae-ling Lokko<sup>1,2</sup>, Frederick Wireko Manu<sup>3</sup>, Nzinga Mboup<sup>4</sup>, Ibrahim Niang<sup>5</sup>

<sup>1</sup>Yale University, New Haven, USA. <sup>2</sup>Willow Technologies, Accra, Ghana. <sup>3</sup>Building and Road Research Institute, Council for Scientific and Industrial Research, Accra, Ghana. <sup>4</sup>Worofila, Dakar, Senegal. <sup>5</sup>AARMBN, Dakar, Senegal

### **Abstract**

While the Sub-Saharan African region is home to 17% of the world's population today, it is projected to house over 75% of the world's population over the remainder of the 21st century (Roser & Rodés-Guirao, 2013). Given rising demands to provide housing for three times its current population and pressures to convert land-use for housing, current patterns of greenhouse gas (GHG) emissions from the built environment threaten to invert this region's role from being a carbon sink to a carbon emitter. Using Ghana and Senegal's residential sectors as case studies within the region, this presentation will focus on key opportunities for integrating biogenic and geogenic material resources into the rapidly growing domestic concrete masonry and timber products across prevailing housing typologies. For cement producing countries like Senegal that supplies the West African region, the presentation explores transition pathways for concrete masonry production which shift to low-carbon production fuels and integration in the value chain of earth-based masonry products. For cement importing countries like Ghana and most countries in the sub-Saharan region, opportunities to reduce import concrete masonry dependency is explored through scaling substitution with earth based, locally available biogenic cementitious substitutes and additives. Secondly, focusing on Ghana and Senegal's forestry sectors where historical and current deforestation rates outpace afforestation, the presentation explores concurrent opportunities to reduce GHG emissions associated with existing timber management practices and accelerate the development of market opportunities through the substitution of timber products through the use of non-timber biomass resources like bamboo, coconut, invasive typha composites and other agricultural by-product resources. While such value-added building materials today represent a small share of the sub-Saharan building materials sector, a whole life cycle analysis approach and integrated stakeholder framework is used to explore "supply push" and "market pull" strategies for scaling widespread adoption and normalisation locally.

### **Keywords**

biogenic materials, earth masonry, built environment, LCA, timber

## 231. Linear versus circular: differentiation factors in customer value propositions of reusable packaging

Päivi Petänen

VTT Technical Research Centre of Finland, Tampere, Finland

### Abstract

Reusable packaging solutions are emerging circular offerings in the single-use-dominated market, which currently holds significant environmental sustainability problems (Bocken et al., 2022). To accelerate the desirability of reusable packaging for consumers, these novel solutions need to be positioned for differentiation. This study focuses on customer value propositions (CVPs) as strategic tools for managing customer value for this purpose (Rintamäki et al., 2007). The research questions are: 1) What kind of contrasts between linear and circular models are highlighted in CVPs of reusable packaging? 2) How can these differentiation factors be managed?

We conducted a qualitative multiple-case study to examine the research questions. We investigated five reusable packaging cases in the fast-moving consumer goods context. The selected cases represented diverse reusable packaging models, such as exclusive and sequential reuse (Muranko et al., 2021). Each case included multiple actors in the reusable packaging value chain, and altogether 14 companies from Finland were included in the case study. The data was collected by conducting 13 company interviews and 15 company workshops.

As a result, we identified the differentiation factors of CVPs in reusable packaging according to the reflected value (Table 1).

Dimension of CVP	Differentiation factors	Management opportunities
Economic	Cost distribution or allocation across multiple use cycles	Validating the economic customer incentives by employing deposit systems or discounts
Functional	Participative customer role in the reuse process	Enhancing system convenience by enabling take-back logistics
Emotional	Enhanced sustainable consumption practices	Validating the sustainability impacts by including tracking systems
Symbolic	Emerging sustainable consumption communities	Enhancing customer status and self-image facets by communicating the novelty and sustainability orientation of the offering

Table 1. Summary of the results.

We suggest that in reuse models, differentiation factors are based on mutually determined value and value-in-use. However, tensions occur between e.g. the highlighted sustainability benefits and unlearning from linear economy-based consumption practices.

### References

- Bocken, N.; Harsch, A. & Weissbrod, I. (2022). Circular business models for the fastmoving consumer goods industry: Desirability, feasibility, and viability. *Sustainable Production and Consumption*, 30, 799–814.
- Muranko, Z., Tassell, C., van der Zeeuw Laan, A., Aurisicchio, M. (2021). Characterisation and environmental value proposition of reuse models for fast-moving consumer goods: reusable packaging and products. *Sustainability* 13 (5), 2609.
- Rintamäki, T., Kuusela, H. & Mitronen, L. (2007). Identifying competitive customer value propositions in retailing. *Managing Service Quality: An International Journal*, 17 (6), 621–634.

### Keywords

Circular business models, Reusable packaging, Differentiation, Customer value propositions, Management

## **233. Separation and characterization of brominated flame retardants (BFRs) containing plastics from electronic waste (E-waste) and assessment of disposal options for BFR plastics**

Andreas Bill<sup>1</sup>, Sampson Atiemo<sup>2</sup>, Gladys Adjei<sup>3</sup>, Dennis Adortey<sup>3</sup>

<sup>1</sup>Empa, Dübendorf, Switzerland. <sup>2</sup>Mountain Research Institute, Accra, Ghana. <sup>3</sup>Ghana Atomic Energy Commission, Accra, Ghana

### **Abstract**

WEEE (waste electrical and electronic equipment) is a complex waste stream, which contains many valuable recoverable materials but also hazardous substances. One example for the latter are Brominated Flame Retardants (BFRs), mostly found in WEEE plastics. Some BFRs are listed under the Stockholm convention as Persistent Organic Pollutants (POPs) and their removal from the material cycle is crucial. Actions have been taken around the world to regulate their use and disposal; however, in developing countries like Ghana where there is little to no regulation, recovery of highly valuable materials has encouraged the development of unregulated informal treatment facilities, with serious consequences for the environment.

To date, there is little evidence on the quantitative and qualitative presence of BFRs in Ghanaian WEEE plastics, making risk assessment difficult. This research: (i) Examined, segregated and quantified the plastic types in selected WEEE categories in Ghana (ii) analyzed the levels of elemental additives Br, Ca, Ti, Ni, Cu, Fe and Zn present in the BFR containing- and BFRs in the BFR-free fractions, and (iii) Appraised the disposal and treatment options for BFR plastics prior to recycling.

Physical tests (ISO tag identification) and chemical tests using limonene and acetone were used to identify and segregate target plastics. Density tests (salt water: NaCl (aq) and H<sub>2</sub>O) were applied for qualitative detection of BFR-containing and other heavy plastics. X-ray fluorescence spectrometry (XRF) was used to estimate the concentrations of Br, Ni, Ti, Fe, Ca, Zn, Cu, and other metals, while BFRs were measured using gas chromatography -mass spectrometry (GC-MS).

A total of 5701 kg WEEE plastics were sorted and the following composition was determined: 5.20% BFR+ABS, 43.78% BFR-ABS, 0.04% HIPS+BFR, 0.03% BFR-HIPS, 7.48%PS, 23.39% PC, 18.90% PC+ABS, 0.31% PP and 0.53% PVC. Trace metal levels (in mg/kg) in BFR-containing plastics varied from 6.5 – 2588 [Br], 22 – 47 [Ni], 2.2 – 3106 [Ti], 3.4 – 49 [Fe], 29 – 2732 [Ca], 1 – 7 [Cu], and 0.2 – 49 [Zn]. These trace elements are intentional plastic-manufacturing additives. The BFR-free ABS, HIPS and PC+ABS fractions were sent to a certified European laboratory for BFR analysis. None of the analyzed BFRs was found above the quantification limit, which confirmed the efficacy of the applied density separation for BFR-containing plastics. Conclusions drawn were; Establishment of a suitable repository for storage/disposal of BFR-containing plastics and establishment of a debromination pre-treatment laboratory(ies) for the removal of BFR plastics prior to recycling.

### **Keywords**

Circular business models, E-waste plastics, Informal sector, Built environment

## 234. Elaboration of an Integrated E-Waste Management Scheme for Ghana

Larry Kotoe<sup>1</sup>, Cornelia Stolzenberg<sup>2</sup>, Markus Spitzbart<sup>2</sup>, Sampson Atiemo<sup>3</sup>, Vincent Kyere<sup>4</sup>, Felix Atse<sup>5</sup>, Viva Bruce<sup>5</sup>, Letitia Abra-Kom Nyaaba<sup>6</sup>, Frank Acheampong<sup>2</sup>, Felix Mote<sup>1</sup>, Hobson Agyapong<sup>1</sup>, Kwabena Biritwum<sup>1</sup>, Melchizedek Mends<sup>1</sup>, Thomas Amponsah<sup>6</sup>, Kwadwo Darko<sup>3</sup>, Joseph Sikanartey<sup>2</sup>, Georg Kerkloh<sup>2</sup>, Samuel Adane<sup>4</sup>

<sup>1</sup>Environmental Protection Agency, Accra, Ghana. <sup>2</sup>GIZ, Accra, Ghana. <sup>3</sup>MRI, Accra, Ghana. <sup>4</sup>MESTI-PIU, Accra, Ghana. <sup>5</sup>E-Waste Fund, Accra, Ghana. <sup>6</sup>GNPCPC, Accra, Ghana

### Abstract

Ghana is one of the frontrunners in Africa in implementing sustainable & environmental sound e-waste management. Several legal instruments have been established since 2016. Key indicators such as the legal and regulatory framework of Act 917 as well as the collection of the Eco-Levy place Ghana as the forerunner in terms of sustainable e-waste management in Africa. This and other measures aim to improve the regulatory framework, establish a sustainable recycling economy and support the growth of a thriving private sector.

In 2022 the EPA – Environmental Protection Agency Ghana initiated the elaboration and implementation of the integrated national e-waste management scheme comprised of the following elements:

- overall collection and recycling scheme
- e-waste categorisation taking the specific collection practice in Ghana into consideration
- proposed material flows, recycling fee pricing mechanism for the defined e-waste categories
- recommended downstream options for hazardous fractions

Approaches and concepts for these topics, which are appropriate for the Ghanaian context, were discussed and elaborated in 3 different working groups. The process was supported by the following organizations, experts have been delegated to the working groups by them:

- EPA – Environmental Protection Agency/E-Waste & Hazardous Waste Secretariat
- MESTI – Ministry for Environment, Science Technology & Innovation Ghana/ Project Implementation Unit
- GIZ E-Waste Programme Ghana
- MRI – Mountain Research Institute
- Electrical and Electronic Waste Management Fund
- NCPC – National Cleaner Production Centre Ghana

The presentation will introduce the elaborated concepts by the working groups and explain successes and challenges in implementation.

### Keywords

Integrated E-Waste Management Scheme, Pricing mechanism, Material flows, collection and recycling scheme, Sustainable recycling economy