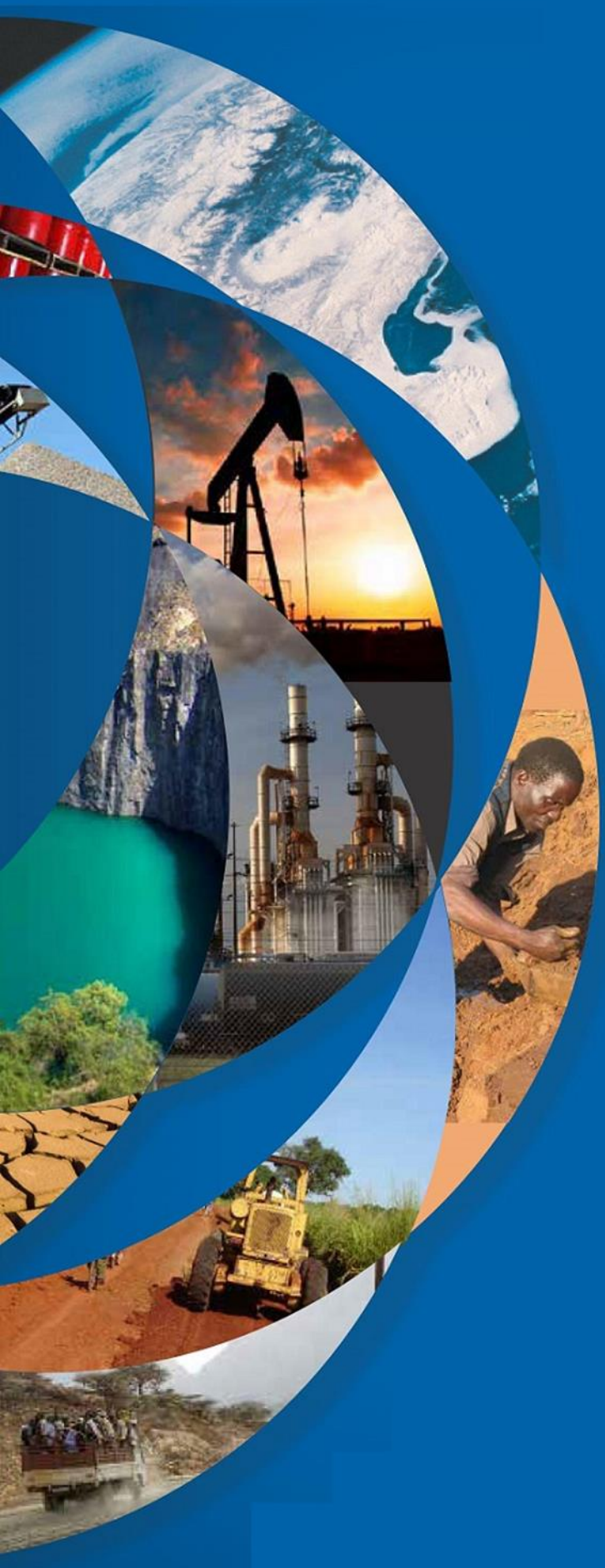

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Content

Global mining activities undermine substantial land carbon storage

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Abstract:

Rising demand for consumer products, infrastructure, fertilizer, low-carbon technologies have boosted massive mineral resources extraction. The resulting mining activities will destroy local ecosystem and reduce land carbon storage. However, the full scope of land carbon storage undermined by global mining activities is yet unknown. Therefore, we firstly build a global mineral- and site-specific mining land use database extrapolated from satellite maps. Then such database is combined with global biomass and soil carbon maps to estimate the mining-related land carbon storage loss (including aboveground, belowground biomass carbon and soil organic carbon). The results show that the carbon storage loss arising from global mining activities during 2012-2020 amount to 0.41 Pg C, roughly equivalent to annual land carbon sink of China. Metals (e.g., gold, iron, copper and nickel) and fossil fuels (e.g., coal, oil sands and oil shale) are the biggest contributors, accounting for 36.6% and 26.4% of total carbon loss, respectively. Carbon storage loss per weight output of different mine for a kind of mineral could differentiate by several orders of magnitude. On a national level, Australia (16.5%), the USA (12.4%) and China (10.2%) make up big slices of the pie, followed by Canada (9.8%), Russia (8.9%) and South Africa (5.6%). Our work provide new data for life-cycle environmental impact assessment of mineral-based products. The unevenly-distributed and often unmanaged impacts on ecosystems urges the need for targeting polices to restrict industrial mining encroachment into irrecoverable-carbon regions, promote post-mining rehabilitation and offset the climate impacts to achieve no-net carbon storage loss.

The CO_2 reduction potential of CCUS in China's iron and steel sector: A plant-level source-sink analysis

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Abstract:

Carbon capture, utilization, and storage (CCUS) represents a crucial technology in the pursuit of achieving net-zero emissions within the steel industry, particularly for China, which stands as the largest global producer of steel. However, the implementation of CCUS within China's iron and steel sector remains in its nascent stages of technological readiness. In order to inform policy decisions effectively, it becomes imperative to conduct a prospective analysis encompassing the potential for CO2 reduction as well as associated costs. To address this issue, this study employed a plant-level source-sink match analysis to assess the CO2 reduction potential of CCUS in China's iron and steel industry. Initially, we estimated and mapped the CO2 emissions of 304 iron and steel plants in China and ten primary geological sites for CO2 storage. Subsequently, we developed a CCUS transportation network based on geological information system (GIS) maps that included land cover conditions and existing oil and gas pipeline infrastructure. Ultimately, we analyzed the CO2 reduction potential and cost at the plant, provincial, and national levels. The study aims to provide timely and comprehensive guidance for the adoption of CCUS technology in China's iron and steel sector.

Dynamic source-sink matching CCUS model for net-zero target

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Abstract:

Carbon capture utilization and storage (CCUS) is a mature technology, with relatively high technical readiness and low economic cost, for the nations amid the transition to net-zero. However, the large-scale CCUS implementations are severely restricted due to the limited understanding of the CO2 source-sink matching, particularly the technology selection, environmental implication and economic cost in the long-term perspective. Here, a dynamic source-sink matching CCUS model is initially developed to examine the full-chain CCUS system, including the comprehensive analysis of uncertainties, techno-economic performance, and interactions among the CO2 capture, transport and utilization modules. Results indicate the revenue from the CO2 utilizations, in any manner, is higher than the total costs from the full-chain modules, that is, the bound revenue triggered by CO2 utilizations is from 3.09×1011 to 3.38×1011 yuan. Furthermore, among the various utilization ways, the CO2-EGR is the most promising due to its low CO2 emission and high revenue. The total CO2 capture at the low and high levels are 23.42 and 21.50 Mt, respectively. This model improves the accuracy of source-sink matching towards more eco-friendly and cost-effective manner.

Hydrogen and carbon disulfide production by methane reforming with H2S over LaFexAl12-xO19 hexaaluminate catalysts

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Abstract:

For sour natural gas, high separation costs are inevitably for purification and desulfurization prior to natural gas processing. Meanwhile, the separated H2S further undergoes the complicated Claus process to recover the sulfur, while the H2 content in H2S is under-utilized as low-grade team. Reforming of H2S and CH4 mixtures may be a viable approach to treat sour natural gas. H2S-CH4 reforming, like the H2O-CH4 reforming process, can generate hydrogen and carbon disulfide simultaneously. Particularly, carbon disulfide (CS2), valuable solvent and chemical feedstock, is produced in the H2S-CH-4 reforming instead of CO2, reducing the greenhouse gas impact.

Previous research about H2S-CH4 reforming mainly focused on thermodynamic or experimental investigation of its feasibility and kinetic study on the related catalyst. However, extremely high temperature is required for this reaction due to thermodynamic property. The easy collapse of catalysts under high temperature makes it difficult to obtain accurate information regarding the active species and reaction intermediates. Hence, it is of great significance to develop catalytic materials with high activity and high temperature resistance.

In this study, a series of Fe-doped hexaaluminate LaFexAl12-xO19 (LaFex, x=0, 0.5, 1, 3, 5) catalysts were prepared by coprecipitate method and used for catalytic reforming of hydrogen sulfide and methane. The physicochemical properties of catalysts were characterized by various technologies. Catalytic activity results showed that LaFe0.5 exhibited excellent catalytic activity and stability (Figure 1), wherein almost no carbon deposition was generated during the reaction process. The reaction process of H2S and CH4 on the catalyst surface was studied by TPSR-MS technology. The study showed that the reforming process of H2S-CH4 was that H2S first decomposed on the catalyst surface to form active sulfur species, and then the active sulfur species further attacked methane to promote the C-H bond fracture. Besides, systematically study the structure-activity relationship were also conducted.

Optimal design of a hybrid grid-connected biomass-based energy system for rural areas

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Abstract:

Biomass, viewed as a carbon-neutral fuel, can play a significant role in achieving the objective of global zero carbon emissions. Although waste biomass resources like crop straws and livestock manure are abundant in rural areas, they have often been overlooked. However, these resources can be repurposed and combined with other natural resources, such as solar energy, to meet the energy demands of rural villagers.

The present study proposes a grid-connected hybrid energy system for a village in Xinxing village, Songzi, Hubei province, China. Different resources such as biomass and solar energy are integrated to deliver stable electricity, with multiple energy conversion technologies considered, such as anaerobic digestion and biomass gasification. Both residential and agricultural electricity demands are considered. Moreover, the electric heating of a big pig farm is modelled and considered as a flexible load. The component sizes of the hybrid energy system have been optimised using genetic algorithm to reduce the net present value of the total system cost, with the seasonal variation of renewable energy resources considered. A system control strategy has been also designed to operate the system. According to the results, the energy cost of the optimal design is lower than that of obtaining power from the main power grid directly. Additionally, the optimal design significantly reduces carbon emissions in comparison to buying electricity from the main grid.

The booming non-food bioeconomy drives large share of global land-use emissions

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Abstract:

The non-food bioeconomy is widely recognized as a crucial strategy to address climate change. However, the growing demand for biomass for non-food purposes, such as bioenergy and bio-based products, in certain countries is leading to global land use changes and consequent greenhouse gas emissions. This study utilized a global region- and biomass-specific land-use emissions (LUE) inventory and the Food and Agricultural Biomass Input-Output Model (FABIO) to quantify the LUE embodied in global non-food biomass supply chains. The results indicated that in 2013, global LUE induced by non-food biomass demand (4,946 Mt) accounted for more than one-quarter of the global aggregated LUE, with Wood being the most dominant contributor (47%), followed by Live animals (17%) and Oil crops (13%). The top five countries/regions driving this trend were Brazil, India, Mainland China, Indonesia, and the USA. Additionally, over 876 Mt of LUE were associated with international biomass trade for non-food use, primarily from tropical countries/regions (e.g., Indonesia, Brazil, and Thailand) to large industrialized countries/regions (e.g., Mainland China, the USA, and EU27). This underscores the need for consumption-based accounting of non-food biomass uses, including emissions from land use changes, as well as demand-side measures such as improving international biomass supply chains transparency, establishing a LUE monitoring and certification system for certain bio-based commodities, and promoting multiple stakeholder collaboration to effectively reduce LUE.

Assessment on urban water-energy nexus characteristic in China and the U.S

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Abstract:

The concept of the water-energy nexus (WEN) provides a holistic perspective for understanding the sustainability of resources uses. The WEN system in cities is intimately connected and pressured by socioeconomic activities, but few studies were engaged to investigate the relationship between the WEN system and the socioeconomic system. This study constructs a three-dimensional coordinate system with embodied water in electricity, water scarce, and electricity scarce to calculate a vector Nexus Pressure Index (NPI) to assess the WEN system for a city. The length of NPI represents the severity of the pressure on the WEN system, while its direction represents the dimension requiring the most concern. The socioeconomic factors, GDP per area, and GDP per capita are analyzed to reflect the commons and differences between the two WEN systems in China and the U.S. in 2012-2019. The results showed that (1) NPI decreased by 22% in China and 27% in the U.S. during the 9 years, indicating an overall WEN pressure reduction; (2) GDP per area showed a positive influence on NPI while GDP per capita is negatively correlated with NPI of both nations, and the most prosperous cities adopted an unsustainable resource utilization mode that threatens WEN system via inefficient use of water. (3) higher- tier cities in agglomerations bear higher NPI in the U.S. suggesting a centralized trend of NPI in structured city agglomerations, and water scarcity is a fatal constraint in both nations. The results suggest an urgent need to assess the pressure of water and energy nexus system in cities, identify the locally specific weaknesses, and adopt a more sustainable way of using water and energy resources, from the perspective of water-energy nexus.

Sustainable infrastructure: a study of the water-energy-carbon nexus for drinking water treatment plant

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Abstract:

Water and energy are recognized as critical resources that can affect sustainable development and are closely intercorrelated. Drinking water treatment plants, as essential infrastructures, are vital for providing safe drinking water but are also highly energy intensive. With rapid urbanization and population growth, the size of drinking water treatment plants worldwide is expected to expand, with more stringent requirements for drinking water quality. Expanding the infrastructure may lead to higher energy consumption and carbon emission. This paper aims to study the water-energy-carbon nexus for a drinking water treatment plant that treats 40,000 cubic meters of raw water per day and the potential to reduce energy consumption and carbon emission by utilizing an on-site PV system. Water-energy-carbon nexus of each treatment process was evaluated. A modelling study of using an on-site PV system was conducted to reduce energy consumption and carbon emission. The cost-effectiveness of the system was also considered. It was estimated that using the on-site PV system will reduce energy consumption by around 1.9 million kWh annually and reduce carbon emissions by approximately 155 kg annually. The study provides valuable insight into the water-energy-carbon nexus for the drinking water treatment plant and identifies the opportunity to enhance the sustainability of the infrastructure.

Enhancing the explanation of household water consumption through the water-energy nexus concept: a case in Beijing, China

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Abstract:

Predicting household water demand can facilitate the management of infrastructure, facility, and municipal planning. Although there is a nexus between household energy and water consumption, few water prediction models take energy factors into account. In this study, a novel stepwise-like approach based on the comparison of traditional statistical (OLS) and machine learning techniques (random forest and XGBoost) is developed to examine the role of the water-energy nexus in predicting annual household water consumption. The original data were collected via questionnaires administered to 1320 households in Beijing in 2020. The vital features are first selected by deploying the least absolute shrinkage and selection operator (LASSO) and divided into four groups: household information (HI), water use (WU), energy use (EU) and electricity consumption (EC). These features are used as inputs for four models that were operated by OLS, random forest and XGBoost techniques. The models based on the XGBoost technique performed the best, and the coefficient of determination values (R2) after adding EU and EU&EC were 20.2% and 30.4% higher than those when only inputting HI&WU, respectively. The considerable improvement achieved by considering energy use and consumption factors implies the water-energy nexus contribution to household water prediction. Utilities could also be facilitated by these findings in terms of water-energy collaborative management and infrastructure planning.

Recovery of purple non-sulfur bacteria biomass from the treatment of gas-to-liquid process water: a potential food-water-waste nexus

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Abstract:

The global demand for feed protein cannot be met sustainably using conventional agricultural processes. Therefore, alternative protein sources are being explored to ease the pressure on scarce resources like freshwater and arable land. Purple non-sulfur bacteria (PNSB)-derived microbial protein has been highly regarded due to its efficient integration with wastewater treatment and desirable biomass constituents. This study proposes a circular economy approach to upcycle nutrients from gas-to-liquid (GTL) process water through treatment with PNSB to produce nutritionally valuable products like microbial protein, lipids, and pigments. The feasibility of this biotechnology was explored experimentally. A PNSB-dominated non-axenic culture was cultured in 3-day batch and fed-batch trials using bench-top fermenters under different photoperiods and pH regulation. Results showed that PNSB thrived in high-strength wastewater and was versatile in pollutant removal under all conditions, with biomass productivity ranging from 1.1-1.4 gVSS/L and pollutant removal rates ranging from 771-1070 mgCOD·L-1·d-1 and 43-56 mgNH4-N·L-1·d-1 in favour of the 24-h light groups compared to the 12-h photoperiod cycles. Biomass proximate analysis revealed protein was the major constituent (41% to 55%), favouring the 12-h photoperiod groups. Moreover, leaving the reactor pH unregulated was also associated with significantly higher biomass protein (56%) compared to operating the reactor at the optimal pH of 7.5. Lipids comprised 23% to 37% biomass and carbohydrates 10% to 13%, while minute quantities (<2.5%) of carotenoid, bacteriochlorophyll, and coenzyme Q10 were present. Overall, the results indicated that this biotechnology efficiently treated the high-strength wastewater and upcycled dissolved organics to nutritionally desirable value products under natural diurnal conditions. With the study region's long sunshine hours, high average irradiance, and abundance of GTL process water, the results support further development of this food-water-waste nexus approach to alleviate food and water security and reduce the energy burden associated with conventional wastewater treatment.

Bayesian vine copula machine learning (BVC-ML) method for evaluating climate change impacts on water resources in the source region of the Yellow river

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Abstract:

In this study, the BVC-ML method was proposed to predict the streamflow changes in the source area of the Yellow River based on climate projections from three GCMs under different climate change scenarios. The BVC-ML method was to (i) use the vine copula method to reflect the interdependence between predicted variable (i.e., streamflow) and predictions from different machine learning (ML) techniques, (ii) derive deterministic and probabilistic predictions from the vine copula model conditional on corresponding ML predictions, and (iii) integrate predictions from different vine copula models to generate the final results. The proposed BVC-ML method was then applied for future streamflow projections based on outputs from CMIP6. The results from the BVC-ML method show that the studied area would generally experience more streamflow increases in most months, and the increases would become more significant as the climate change shifts from SSP126 to SSP585. The outputs from different GCM models also lead to various streamflow changes in the studied area, with the projections from ACCESS-CM2 leading to the highest streamflow increases. Furthermore, the BVC-ML method is capable of deriving both deterministic and probabilistic predictions from the conditional distributions, and the 10% and 90% quantiles can reflect predictive uncertainties. The results from the quantile predictions show that May, July, and October would have the highest increases in streamflow, which are consistent with the mean streamflow increases. Overall, the proposed BVC-ML method is demonstrated to be a promising tool for predicting streamflow changes under different climate change scenarios. The findings of this study can provide valuable information for water resource management and decision-making in the studied region.

Assessing prospective metal requirements of China's wind power and PV development towards carbon neutrality by 2060

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Abstract:

Deep decarbonization of China's electricity sector is a crucial step towards carbon neutrality, which requires upscaled deployment of wind power and PV. Since the future pathways of both wind power and PV are uncertain, the associated metal requirements are faced with even larger uncertainty. In this paper, we conducted a prospective assessment of metal requirements (using 12 metals, i.e. Fe, Al, Cu, Zn, Ni, Nd, Dy, Cd, Te, In, Ga, Ag) after the establishment of a multi-model comparison framework. The energy scenarios made by energy system model (IAME3C-ENERGY) or taken from other literature sources are used to generate the multi-model comparison framework. The dynamic material flow analysis model (D-MFA) is then used to quantify metal demand under specific energy scenario. The results show that the average installed capacities of China's wind power and PV are 2435 GW respectively 3517 GW by 2060. The metal demand of wind power is larger than that of PV, mainly due to massive usage of iron and steel in the foundation and tower. The cumulative metal demand of wind power and PV will be 0.85-1.39 billion metric ton during 2000-2060, while outflowing metal volume reaches 0.33-0.55 billion metric ton in the same period. This implies major potential for secondary metal supply, but needs further progress in recycling technologies as well as a paradigm shift towards circular economy. Considering the resource angle of energy transition, it also stresses the importance of integrating resource constraints into energy system modelling to secure future energy pathways.

Wind power potential evaluation of high time resolution at provincial-level in China

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Abstract:

Zonal wind power potential evaluation is crucial for wind farm installation in short term and wind energy utilization planning in long term. Current evaluation approaches and performances are mainly focusing on wind resource analysis in geographical scale, lacking of feature extraction and study in time scale, which is able to play an important role for designing wind-solar, wind-storage or wind-hydro complementary power plants in the targeted zone. In this paper, based on the data from National Development and Reform Commission (NDRC), firstly three approaches are used to evaluate the annual wind power generation potential of 31 provinces in China within the ultra short-term time scale (time interval:15min), so as to obtain the reliable evaluation value in time domain.Then, the index named Impact Coefficient of Wind Power Resource (ICWPR) is proposed in this paper to evaluate the numerical impact influences of factors (temperature, location, wind speed .etc) to wind resource and power potential. Secondly three parameters which are Mean Wind Power Density, Annual Mean Wind Speed, and Annual Effective Wind Speed Hours are applied to evaluate the wind resources focusing on 31 provinces in China. In order to make the above discrete wind resource evaluation parameters continuous, Zonal Clustering Evaluation algorithm is proposed here to establish a wind resource classification model. The above model is corrected via comparing with the published zonal wind resource map by the Chinese government. Finally, the real-time daily and quarterly variation features of wind power output potentials in every province are obtained, which develop appropriate and reliable wind power potential evaluation in time domain.

Being unique for a common goal: innovative hybrids in Chinese provinces toward carbon neutrality

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Abstract:

Achieving carbon neutrality requires local innovation, especially in an emerging economy like China, faced with diverse provincial social and economic development scenarios to achieve the green economic transition. Carbon trading mechanism is considered as an effective policy tool for carbon emissions reduction, and has undergone a rapid domestic legitimization process in China in the post-Kyoto era. Since 2019, major economies in the world have been designing blueprints to achieve net zero emission by 2050 or 2060. Based on natural endowment of carbon sink resources and financing resources, provinces in China could be grouped into 4 categories: 1) Financially capable provinces with high natural endowment; 2) Financially capable provinces with low natural endowment; 3) Financially incapable provinces with high natural endowment; 4) Financially incapable provinces with low natural endowment. Four provinces are selected from each category to empirically present how they have carried out locality-specific public-private interactions to stimulate intrinsic motivations. Beijing Municipality, Ningxia Hui Autonomous Region, Hubei Province, and Jiangsu Province are taken as cases for analysis. Findings include the following: Firstly, public service units (PSUs), or state-owned enterprises (SOEs), have been pioneers supporting hybrid governance in the formulation and implementation of low-carbon measures. Secondly, pilot zone policies, like Beijing Pilot Free Trade Zones, Beijing-Tianjin-Hebei Free Trade Zone, etc., have been effective to accelerate the green transition process. Thirdly, public-private interactions and partnerships enable local low-carbon governance, with issue linkages to sustainable livelihood of local residents.

Estimation of carbon footprint using life cycle assessment for flexible pavement: emphasis on user stage

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Abstract:

The amount of carbon dioxide released into the atmosphere from flexible pavements during their lifespan is the crucial factor that indicates the sustainability of these structures. The objective of this study is to quantify the greenhouse gas in terms of kgCO2eq released during material production, transportation, construction, and the user stage of asphalt pavement. The scope of this study includes the synthesis of relevant databases, collection of the International Roughness Index (IRI), estimation of the volume of materials needed for construction, computation of the life-cycle of analysis and estimation of kgCO2eq during various stages of pavement service time. To differentiate and identify the impacts of design variables on carbon emission, two pavement sections with different design variables were chosen in this study. Though several research studies had explored the carbon emission potential from different pavement systems, this study offered a first-of-its-kind understanding that emphasized the carbon emission incurred during the user stage in the context of IRI and Average Annual Daily Traffic (AADT). Overall, it is envisaged that this study would provide important insights to the sustainability features of flexible pavement during the user stage, and thus advancing the state-of-the-art pertaining to the construction and maintenance of flexible pavement.

Sustaining the atmosphere through carbon emissions curtailment: Additional empirical evidence on the superiority of mandated cap-and-trade mechanisms

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Abstract:

Sustainability of the earth's atmosphere requires control of greenhouse gases (GHG). Reducing carbon emissions is considered an essential step in mitigating climate change. While some countries have implemented national-level regulations to reduce GHG emissions, the United States has not. Still, there have been movements toward regional and statewide regulations to curtail emission of harmful combustion by-products. The study reported on here examined whether mandated cap-and-trade mechanisms that allow free-market forces to achieve CO2 containment goals are more successful than voluntary efforts aimed at enhancing sustainability. The research focus is on fossil-fuel burning electric power stations. We use the extensive carbon emission dataset collected by the U.S. Environmental Protection Agency and find that 193 regionally regulated electric generating facilities and a control group of matched unregulated plants significantly reduced carbon emissions in 2011 (a post-regulation year) as compared with a pre-regulation year (2008). On further examination of these firms in the period from 2011 to 2015, though, only the regulated facilities were found to have reduced emissions successfully. Moreover, our analysis indicates that regulated plants significantly improved carbon emission efficiency—measured as carbon emissions volume per megawatt of power generated—over the period 2008 to 2011, while the closely matched sample group did not improve on this metric. These findings suggest that regulation is more effective in propelling power plants toward reducing carbon emissions and improving carbon emission efficiency than are voluntary initiatives. In a counterintuitive outcome, we could not find any evidence that the regulated firms—which achieved better sustainability results—unequivocally provided more extensive climate change disclosures than was reported by the matched control firms.

Enhancing anaerobic ammonium oxidation (anammox) for nitrogen removal from UK sewage using granular activated carbon

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Abstract:

Anaerobic ammonium oxidation (anammox) for sewage nitrogen removal is a promising approach reducing energy consumption by ~50%. However, the slow growth rate and high sensitivity of anammox bacteria pose challenges in engineering applications. A few studies have demonstrated that adding granular activated carbon (GAC) facilitated anammox performance, indicating potential development of future anammox technology. However, the feasibility of GAC-anammox in UK environment has not been investigated and the underlying mechanism of GAC-anammox system remains largely unclear. The present study aims to figure out above research gaps in the microbial community, function and biofilm morphology using metagenomic sequencing, qPCR, scanning electron microscope (SEM).

The study was carried out at room temperature with two parallel reactors, one with GAC (R1) and one without (R0). After 75 days, NH4+-N removal efficiencies (NRE) started to increase continuously and reached to 99.1% and 97.4% of R1 and R0 on day 172, respectively. R1 showed significantly ($p<0.05$) higher NRE and lower NO3--N accumulation than R0, but no significant difference was shown in NO2--N removal.

The SEM showed similar morphology of the cell aggregates, but the metagenomic sequencing showed difference between two reactors. Candidatus Brocadia (0.2% in seed sludge) dominated in both reactors but was lower in R1 (37.0%) than R0 (44.7%), indicating higher anammox activity with GAC in R1. Meanwhile, other functional nitrogen removal bacteria in R0 were also higher than those in R1. Nitrite oxidizing bacteria (NOB) was 0.041% in R0, but only 0.005% in R1. Denitrifiers in R0 was 0.54%, and 0.32% in R1. Higher NOB and denitrifiers in R0 might result in lower NRE and higher NO3--N accumulation, because of NO2--N utilisation. Thus, GAC might enhance anammox activity of competing for NO2--N through inhibiting the NOB and denitrifiers to keep sufficient NO2--N concentration for anammox bacteria.

Cross-scale characteristics and emission reduction pathways of embodied carbon flows from provincial trade in China

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Abstract:

In the context of the 1.5°C warming target, the increasingly frequent carbon flows between sub-regions are gradually drawing attention. However, the characteristics and pathways of cross-scale carbon flows between sub-regions and regions are still unclear, which becomes one of the main bottlenecks to achieve the emission reduction target. To this end, based on the nested input-output (MRIO) model and structural path analysis (SPA) model, this paper reveals the characteristics of carbon flows between 31 provinces, autonomous regions, and cities in China and major global economies, and identifies the key carbon emission structural paths and nodes in the carbon emission transfer network. The study found that: (1) Domestic embodied carbon flows are mainly concentrated in the eastern coastal, northern coastal, and southern coastal regions, while cross-scale embodied carbon flows are dominated by the United States, Japan, and Korea. (2) Manufacture of non-metallic mineral products (S09), production and supply of electricity and heat (S17), transportation, storage and post (S21), and metal smelting and processing (S10) are the main upstream sectors, while construction (S19) is the most important downstream sector. (3) Zhejiang - manufacturing of non-metallic mineral products (S09) → Shanghai - construction industry (S19) is the inter-provincial critical path with the largest embodied carbon emissions, and Liaoning - metal smelting and processing (S10) → Korea-construction industry (S19) is the international critical path with the largest embodied carbon emissions. This paper also considers the upstream and downstream sectors and the inter-regional carbon flows in the critical path, and the results provide a reference for regional emission reduction policy formulation.

Population aging and climate change: Evidence from China

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Abstract:

In 2020, China reaches 13.5 percent of the population aged 65 years and over (the elderly, 11.1% of urban population and 17.7% of rural population). Current studies generally demonstrate the negative effect of population aging on economic growth and structural changes in consumption expenditure between the youth and the elderly. With the issues of climate change standing out, the relationship between the aging and climate change (carbon emissions) is largely concerned and should be explored further. In this study, we choose 31 regions of China, combine the micro-level household survey data and multi-regional input-output model, quantify carbon emissions of different regions driven by household consumption expenditure by categories and ages, and investigate whether the aging process in China accelerates or curb carbon emissions produce. We find that (1) during 2005-2015, the percentages of the elderly in rural are larger than those in urban, while the growth rates are opposite. (2) The aging process in rural speeds up carbon emissions compared with the all-age growth rates of carbon footprint, while carbon emissions per capita in urban is generally two to three times as much as those in rural. (3) Carbon emissions per capita of the elderly is lower than the average of all-ages which evidences that the aging process in China contributes to carbon mitigation. Then, we could focus on Housing and Food to release the potential of carbon reduction under the background of population aging.

Life cycle greenhouse gas emissions and mitigation opportunities of High Speed Railway in China

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Abstract:

High-speed railway is considered as a clean mode of transportation that can reduce greenhouse gas (GHG) emissions in the transportation sector. However, the high-speed railway system involves complex composition, large infrastructure projects, and high energy consumption, leading to GHG emissions from multiple processes throughout its life cycle. This study aims to conduct a comprehensive life cycle assessment (LCA) of a conventional high-speed railway in China to analyze its GHG emissions.

The study will establish a GHG emission inventory by collecting data and conducting LCA, and will suggest ways to reduce emissions. The life cycle of high-speed railway will be divided into three stages: construction, operation and maintenance, and scrapping and dismantling. This study will calculate the total GHG emissions and identify the stage and process with the highest contribution. Options for disposal will be evaluated to determine the optimal approach with the lowest GHG emissions.

The results of this study will provide insight into the total GHG emissions of the high-speed railway life cycle and the contribution of each stage, offering useful suggestions for reducing GHG emissions in the high-speed railway industry.

Spatial spillover effect and driving mechanism of carbon emissions in new energy demonstration cities: from the perspective of urban agglomeration correlation network

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Abstract:

New Energy Demonstration Cities (NEDC) are an important strategic initiative for China to promote the priority development of renewable energy and build an ecological civilization system. An objective assessment of its impact mechanism on carbon emissions is important to promote urban energy transition and low carbon governance. To this end, this paper obtains carbon emission data of Chinese prefecture-level cities from 2006 to 2020 by fitting nighttime light remote sensing data (DMSP/OLS and NPP/VIIRS), and uses a spatial difference-in-difference (SDID) model to analyze the spatial spillover effect of NEDC and estimate its decay boundary. Then, a multivariate intermediary model is used to analyze the driving mechanism of NEDC on urban carbon emissions from the energy transition dimensions of energy consumption, energy efficiency and energy innovation. Further, combining with the city cluster association network, this paper analyzes the heterogeneous effects of NEDC on carbon emissions in different city clusters under the coordinated regional development. The results show that NEDC not only effectively reduces local carbon emissions, but also has a significant spatial spillover effect, promoting carbon emission reduction in neighboring cities. As the geographical distance between cities increases, the spatial spillover effect generally shows a trend of rising, then falling, then climbing, with a decay boundary of 600 km. reducing total energy consumption and improving energy efficiency are the main paths for NEDC to reduce urban carbon emissions. In addition, NEDC also has significant spatial spillover effects in the associated network of urban clusters, but it shows heterogeneity in different types of urban clusters. This study is based on the realistic situation in China, and the research results can provide references for further promoting the construction strategy of new energy demonstration cities and formulating effective urban energy conservation and emission reduction policies.

Urban energy performance improvement policy selection in China based on policy effect prediction: An analysis from the dimensions of economy, environment and well-being

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Abstract:

In order to effectively improve urban energy performance, various countries and cities have promulgated a series of policies. The complexity of policies make categories and utilities need to be further clarified, and the diseconomy caused by the lag of policy effect evaluation make the focus of policy implementation need to be clear in advance. Therefore, this study follows the idea of "prior analysis" and takes Chinese cities as the research object. Firstly, the collected energy performance improvement policies of Chinese cities were analyzed and classified, and the main utilities of all policies and the specific utilities of each category were summarized. Based on the multiple dimensions of urban energy performance research, this study summarized the policy utilities that help to improve the urban energy performance of each dimension, and also preset the policy utility values. Secondly, the effect prediction model for urban energy performance improvement policies in each dimension was constructed by Back-propagation neural network. Thirdly, according to the results of performance improvement, the energy performance improvement policies of Chinese cities were selected respectively from the dimensions of economy, environment and well-being. This study shows that: the energy performance improvement policies of Chinese cities mainly include six categories, namely energy conservation and emission reduction policies, energy development policies, ecological environment policies, finance and taxation policies, industrial policies and economic and social policies. It is needed to focus on ecological environmental policies, finance and taxation policies and industrial policies to improve urban energy performance from the economic dimension. For the environmental dimension, the key and priority policies are ecological environment policies. Compared with the economic dimension, the focus of implementing policies adds economic and social policies in the well-being dimension. This study can effectively help cities clarify which policies require higher implementation intensity and attention before and during policy implementation.

Measuring resource efficiency of global cement and concrete cycle: a multinational dynamic material flow analysis

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Abstract:

Cement and concrete are essential construction materials for human. Their stocks in buildings and infrastructure link service provision to flows of materials and energy, shaping patterns of resource use across the life cycle of these materials. However, their massive production and use contribute significantly to environment issues. Consequently, governmental and organizational entities have adopted economy-wide material flow accounting/material flow analysis (MFA) metrics to assess the progress of resource efficiency transition and provide a robust evidence base for policy formulation. To account for the upstream raw materials associated with imports and exports, a consumption-based material flow indicator (named material footprint) was developed by combining the input-output framework and the economy-wide material flow accounting framework. Material footprint provides a consumption-based account of the full material requirements of the world economy, allocating used raw material extraction to the final demand of an economy based on monetary values and aggregated sectoral levels. However, this method lacks a robust physical dimension and omits the technological life cycle of a specific material.

To address this gap, we developed an inflow-driven method to trace material flows and stocks along the technological life cycle of cement and concrete, encompassing raw material extraction, cement production, concrete manufacturing, construction, and demolition, across 184 economies. Using the logarithmic mean Divisia index (LMDI) method to attribute historical changes in resource efficiency to the changes that technical and demand-side indicators, we quantitatively evaluated the determinants of resource efficiency transition across 89 economies from 1990 to 2018.

Our results indicate that the resource efficiency of the cement and concrete cycle has generally declined across all levels, including global, regional, and national. This trend is mainly driven by demand-side indicators, suggesting that improvements in resource efficiency will rely on demand-side strategies, such as material-efficient designs, lifetime extension, lightweighting, and more intensive product use.

Element-based mapping to identify industrial symbiosis opportunities in the UK cement, steel, glass and ceramics sectors

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Abstract:

The foundation industries face simultaneous challenges to decarbonise, reduce extraction of raw materials, reduce flow of by-products to landfill, and generate additional income streams from by-products. Industrial symbiosis can help offer solutions to these challenges, and the foundation industries have successfully adopted numerous measures already. However, as each sector evolves with changes in heat production, product formulations and other factors, material streams will change in the coming years. These changes will likely give rise to new industrial symbiosis opportunities. So far, identifying industrial symbiosis 'matches' has typically been done using an ad hoc approach, reliant on fixed terminology to describe material streams (e.g. blast furnace slag). There is a need to develop more systematic and visual approaches to identify new industrial symbiosis opportunities. In this study, we developed a new approach to visualise flows of bulk inorganic elements in the cement, steel, glass and ceramics sectors, and to identify potential new opportunities for industrial symbiosis. Our visualisation approach used Sankey diagrams to show the quantity of key chemical elements present in different material streams. This encompassed input raw materials and by-products, and output products and by-products. The key findings were to describe chemical element flows for the UK cement, steel, glass and ceramics sectors, and using this data, to provide eight potential new industrial symbiosis opportunities across those sectors. The limitations of this approach are its reliance on obtaining quality input data, and its simplification of including only the key bulk inorganic elements. Nonetheless, this approach offers much clearer descriptions of waste composition than is possibly just by using European Waste Catalogue codes. It also offers a more visual, intuitive approach than typical current practice. The wider potential impact of this study is to help overcome both existing and potential future barriers to identifying new industrial symbiosis opportunities.

Reuse of construction waste (excavation material) in the recovery of public space. Case study of the San Miguel-Lima-Peru waterfront.

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Abstract:

Lima is the most important city in Peru, not only in demographic terms, since it is home to nearly a third of the country's total population (around 10 million people), but also because it accounts for more than half of the national GDP. This undoubtedly has an impact on the productive dynamics, particularly in the construction sector. According to various sources, Lima concentrates 60% of the sector's activity, and these are buildings with an average height of 10.5 floors, which in some districts can extend up to 20 floors. This implies the generation of large volumes of construction waste, particularly from the excavation process, which, in the absence of authorized and formal landfills, causes an environmental impact of singular importance to the city. The reuse of excavation material is an alternative for the recovery of public spaces, as it has been in the case of the waterfront of the district of San Miguel, where a total of 4 271 640 m3 of waste has been reused (2017-2023), coming from more than 1 400 projects that represents 30% of the total construction sites in the city; material that is characterized by presenting 90% of stone material and 8% of fine material. This material has made it possible to generate an area of 30 hectares and restore 60 hectares of public space. The experience described above shows the positive impact associated with the reuse of excavated material in the recovery of public areas in the city of Lima, with an economic value of 1,089 million dollars of urban land recovered and generated.

Keywords: Reuse of excavation material, construction waste management, recovery of public spaces.

The potential for residential energy conservation based on a comprehensive survey of occupant behavior and energy use in Beijing

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Abstract:

The building sector globally accounts for 32% of final energy consumption and represents a key element for a low-carbon and sustainable future. Despite the availability of energy-saving technologies for buildings, expected reductions in both final energy use and associated carbon emissions have not been seen. Significant energy-saving potential still remains untapped, largely due to insufficient understanding of human activities in relation to energy use in buildings, in particular a lack of empirical evidence at the city scale. Here, we present empirical evidence of the effect of occupant behavior on residential energy consumption, based on a large-scale survey in Beijing, China. We found that occupant behavior overall explains almost 25% of the variability in residential energy use, 28% in space heating energy use and 12% in non-space-heating energy use. Purchase behavior, especially occupants' choices for space heating and primary kitchen stove, is the most important behavioral category. Adding building characteristics and socio-demographic factors increases the explanatory power to 58%. Our findings suggest substantial energy reductions are possible from changing occupant behavior, with well-informed policies tailored to the local context. Moreover, for Beijing's residential energy saving, occupant behavior relating to space heating and cooking deserves more policy attention.

Towards sustainable manufacturing of polymeric components used in water treatment systems

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Abstract:

The continuous rise in water scarcity issues has increased the demand for water treatment systems, putting pressure on industries to provide timely and sustainable solutions. This study uses an Integrated Product Development (IPD) approach and focuses on the sustainable manufacturing of polymeric components utilised in water treatment systems. The methodology used PTFE-Fabric-EPDM layered diaphragms as a case study which are produced using compression moulding. The study involved process parameter optimisation to reduce the cycle time and energy consumption within the moulding process while maintaining and/or improving product quality. Data collection included preliminary testing on the EPDM material at a broad range of different time/temperature rheology analyses, followed by the mechanical testing of the elastomer to which energy consumption and product quality were monitored in a production trial at varied cycle conditions. This was followed by functionality and quality evaluation of the diaphragms in a five-month accelerated ageing test within service life. The study concluded that through the optimisation process, production output increased by 172%, and overall carbon footprint and energy consumption were reduced by 47.5%. Overall, the three IPD pillars were assessed to identify potential new process parameters through the product design pillar, in turn reflecting an improvement in the production processes to reduce energy consumption and keep up with the market pillar which follows an increase in demand while still pursuing a more sustainable process.

Dynamic and equilibrium interfacial tension and oil swelling during carbonated water injection: Implications for geological CO_2 utilization and storage

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Abstract:

Carbonated water injection (CWI) is an attractive geological CO_2 utilization and storage technique that can simultaneously enhance oil recovery. Oil swelling and interfacial tension (IFT) reduction are two important mechanisms. However, most previous studies address only limited temperature and pressure ranges. In this work, we investigated IFT and oil swelling in the carbonated water-decane system under conditions representative of subsurface formations. The rate of interfacial CO_2 mass transfer is revealed by the dynamic experimental results. IFT and oil swelling were measured by the pendant drop method in a high-temperature high-pressure view cell. Real-time images of the drop were captured and analyzed to determine the dynamic drop volume and the IFT, making use of the Young-Laplace equation and phase densities determined from the literature. We studied IFT and oil swelling at temperatures from 298.15 K to 353.15 K and at pressures up to the minimum miscible pressure. Mass transfer of CO_2 from the aqueous phase into the oil phase causes the drop to swell and the dynamic IFT to decrease until equilibrium is reached. The equilibrium IFTs decrease as the pressure is increased isothermally. At low pressures, the equilibrium IFTs decrease with increasing temperature while, at high pressures, the reverse is observed. At 333.15 K and 10 MPa, the equilibrium drop volume is 1.9 times the initial volume and the IFT is 15.2 mN/m lower than that between pure decane and water, exemplifying the two principal modes of action in CWI. Furthermore, equilibrium IFT is found to be linearly dependent on the CO_2 concentration in the carbonated water at constant temperature, and an empirical relation was developed accordingly. The results obtained in this work can assist the interpretation of CWI for geological CO_2 utilization and storage, and provide fundamental information for more reliable numerical reservoir simulation.

Shale-fluid phase behaviour in nanopores

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Abstract:

The phase behavior of shale fluids in nanopores plays a crucial role in understanding the transport and storage mechanisms of hydrocarbons in unconventional reservoirs. The confinement effects and interactions between fluid molecules and nanopore surfaces significantly impact the fluid phase behavior, leading to unique phenomena and challenges in shale reservoirs. In this study, we investigate the phase behavior of shale fluids in nanopores by Monte Carlo simulation and compare it with the bulk cases, including phase coexistence, critical properties (temperature, pressure, and density), and density distribution of confined fluids. Furthermore, we explore the impact of pore sizes and complex fluid compositions, such as hydrocarbons with varying molecular weights and impurities, on the phase behavior. Additionally, we propose a functional Monte Carlo model that incorporates both multi-component fluids and skeletons for nanoscale reservoir simulations. This work provides valuable insights into fluid behavior in nanopores and enhances our understanding of fluid storage and solid-fluid interactions in shale reservoirs.

Sustainable redox flow batteries using lignin-based electrolytes

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Abstract:

The valorization of lignin, an underexploited renewable feedstock that is composed of aromatics, has always been of interest. However, in today's society, with a high focus on resource sustainability, it is becoming increasingly important. In the present study, a novel aqueous electrolyte is developed using lignin from elephant grass (Miscanthus) and used as redox species in a redox flow battery (RFB) system. Lignin-based electrolytes have the potential to drastically reduce the cost of energy storage for stationary applications compared to, e.g., analogues flow batteries based on vanadium or Li-ion batteries. Oxidative depolymerization is used to modify the pristine lignin for generating electrochemical functionalities suitable for the RFB application. Response surface methodology based on a face-centered central composite design (CCD) is used to identify the optimal conditions for lignin-based electrolytes. The influences of four parametric factors, i.e., temperature (160–220 °C), pressure (5–15 bar O2), residence time (30–90 min), and lignin concentration (50–150 g/L), on the modification process are investigated. Preliminary electrochemical characterizations of the modified lignin show promising electrochemical reversibility and stability over 100 cycles. In addition, a substantial improvement is achieved in the discharge capacity and coulombic efficiency of the RFB using the modified lignin. The findings of this study pave the way for providing an RFB that is sustainable and potentially low-cost to manufacture on a commercial scale. The approach also adds an additional dimension to existing biorefineries and pulp and paper mills, by serving as low-cost storage sites for varying renewable electricity.

Highly sulfur-resistant Ni-based catalysts to recover hydrogen resource from acidic gas

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Abstract:

Acid gas containing H2S mainly comes from petroleum refining, natural gas processing and other chemical processes, and the amount of production is increasing. Thus, the rational utilization of acid gas H2S is of great significance to ensure national energy security and sustainable development of the national economy. At present, the Claus process is mainly used for the treatment and recovery of sulfur from acid gas H2S in the chemical industry. Depending on the source of acid gas, a certain amount of NH3 is present in the component. In order to avoid affecting the sulfur production, flame combustion (1200°C) in Claus furnace is used industrially to convert NH3 to N2, while H2S is converted to sulfur in the Claus recovery unit. For recovering hydrogen resource in acid gas (containing impurity NH3), we propose a segmented decomposition technical route.

The segmented decomposition method is to catalytically decompose NH3 first in acid gas, so the rest H2S can be transformed into Claus recovery unit or be decomposed to recover H2. The key to this problem lies in obtaining high-activity NH3 decomposition catalysts with high sulfur resistance. We prepared an Ni-based catalyst by in situ reduction, which could completely decompose NH3 at about 650 °C in the presence of a large amount of H2S. Although there is a certain amount of competing adsorption between H2S and NH3 on the catalyst surface, the adsorbed H2S had little effect on the decomposition of NH3.

These findings provide the possibility for synergistic recovery of hydrogen and sulfur resources. It is expected that our results will provide a more optimized method for the treatment of acid gas H2S and provide more promising energy applications in the chemical industry.

Optimization of the pyrolysis process for the production of cattle dung bio-oil and characterization of its properties

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Abstract:

Cattle dung is a lignocellulosic material with high carbon and moisture content, which is now considered a waste product that pollutes the environment as a result of the intensification of livestock practices. In the present study, pyrolysis of cattle dung was carried out for the production of bio-oil in order to utilize abundantly available livestock manure as a source of alternative energy. The pyrolsis process was optimized for maximum bio-oil production using central composite design (CCD) in Response Surface Methodology (RSM). Conversion parameters such as pyrolysis temperature, vapour cooling temperature, residence time and gas flow rate were taken into consideration for process optimization. The best conditions were discovered to be a pyrolysis temperature of 402ºC, a vapour cooling temperature of 2.25 ºC, a residence time of 30.72 min and a gas flow rate of 1.81 L min−1 to achieve a bio-oil yield of 18.9%. The cattle dung bio-oil was analysed using gas chromatography/mass spectroscopy (GC/MS), an elemental analyzer, a pH probe, and a bomb calorimeter. Furthermore, the ASTM standard procedures were used to determine the bio-fuel characteristics.

Techno-economic analysis of solar PV systems for different types of houses: a case study of social housing in the UK

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Abstract:

Under the Net-Zero target of eliminating greenhouse gas (GHG) emissions by 2050, great reduction opportunities could be explored for residential buildings worldwide. In the UK, GHG emissions from the residential building sector accounted for 16% of overall GHG emissions in 2019. Turning households from energy consumers to energy prosumers, who produce energy from renewable resources as well as consume it, is an efficient way to reduce GHG emissions. Solar Photovoltaic (PV) generation is considered one of the cleanest ways to produce electricity. This study develops a three-layer model to discover how Net-Zero targets for households could be delivered whilst simultaneously maximising the economic benefit, with application to the UK.

Three modules are developed to evaluate the feasibility of installing PV systems in the residential sector. The Data-Driven PV module estimates future PV generation using projected weather data. The housing module determines the installed capacity for PV. The number of solar panels installed is limited by rooftop area and the capacity relates to electricity consumption. The techno-economic analysis module evaluates the economic performance of the PV system by establishing Benefit and Cost Analysis (BCA) for each cluster.

Results show that the economic benefit of installing a PV system is closely related to the usage of the produced energy. Taking full use of generated electricity maximises energy bill savings. Low-interest or interest-free loans could significantly increase the economic benefit and reduce the financial pressure for property owners. Carbon prices and renewable obligations could raise the future electricity retail price, therefore, the benefit of installing a PV system increases. Increasing electricity export prices can also stimulate PV penetration, but this might increase the pressure on the grid as people may willing to sell the electricity rather than consume it.

Peering into the pantry: An analysis of behaviours behind the most wasted food products at home

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Abstract:

Household food waste is a critical global issue that has significant economic, social and environmental consequences. Yet, household food management behaviours associated with product-level food waste are less understood. This study analyses product-level household food waste and behaviours to identify the most wasted food products. The study uses a national-level dataset (n = 1462) that included food waste data for 745 products over 7 days, collected using an electronic diary method. Using a robust Tobit regression approach, the study identifies the top behaviours associated with the most wasted products by Australian households. Findings indicate that cooked beef, sliced bread and bread rolls, vegetable salads, bananas and cooked rice as the top five most wasted food products in Australia based on the monetary value of food discarded. Tobit regression results reveal that the correct amount of food preparation, last-minute changes in meal plans, consuming leftover food, purchasing the appropriate amount, consuming the oldest food first, and appropriate storage and serving portions were among the significant behaviours influencing product waste. Product-level food waste analysis is not only useful for targeting household interventions but also to ascertain the potential for re-purposing and value-adding food waste.

Air pollution induced productivity change? A decomposition analysis on air pollution-induced productivity change in Chinese manufacturing industry

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Abstract:

This paper examines the impact of air pollution on productivity change by using rich panel data of 75,167 manufacturing firms in 293 cities in China from 2002 to 2014. Using the change in mixing height as an instrument, air pollution led to decreased firm-level productivity by increasing firm's welfare and inventory costs (within firm effects), and reallocated market shares between firms towards higher-productivity firms (between firm reallocation effects). Air pollution accounted for 17.720% of the decrease in aggregate productivity estimated by the OP method and 11.975% estimated by the LP method mainly due to within firm effects. The heterogeneity results show that under the influence of air pollution, the productivity loss was only found in firms in eastern China and in non-SOEs, while the change in market shares and survival rates were only found in firms in eastern China, in non-SOEs, high-polluting and small firms. This study further implies that stricter environmental regulation to reduce air pollution is called for, especially in eastern China, and that firms should use greener technology to provide a better working environment.

Policy intervention simulation of residents' energy-saving behavior based on dynamic evolution perspective

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Abstract:

To further guide residents to implement energy-saving behavior and promote the whole society to save energy and reduce emissions, this study explores the influence of policy intervention on residents' energy-saving behaviors. This study combines psychological attribution theory and introduces the perception and attribution style of energy-saving behavior outcome. Based on the dynamic evolution perspective, the simulation evolution model of the sustainable development stage of residents' energy-saving behavior is established. The interactive intervention analysis is conducted from three dimensions: policy intervention intensity, policy response, and attribution style of energy-saving behavior results. The results show that policy intervention can significantly improve the utility and probability of energy-saving behavior of residents. The probability of residents' energy-saving behavior increases with utility. For residents with different attribution styles or in different intervention periods, the effect of policy intervention is different. In addition, under the fixed policy intervention intensity, the residents' utility and probability of behavior occurrence are the highest in the group with high knowledge and high support. The utility and probability of energy-saving behavior of residents with positive attribution style are significantly higher than those with intermediate and negative attribution styles. Finally, relevant policy implications are proposed based on the analysis of the simulation results.

Social "win-win" promotion of green residence under the four-subject evolutionary game

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Abstract:

Unlike the market-driven model of green residence development in most developed countries, the initial development of green residence in China is government-led and top-down driven. Therefore, relevant government departments should accurately grasp the payment behavior of residents, the micro demand-side main body in China's green residence market, so as to adopt more accurate and effective ways to promote the marketing of green residence; for realtors, it will be beneficial for them to more accurately grasp residents' preferences and adopt more accurate marketing strategies, ultimately achieving multi-win economic, environmental and social benefits. For the response level of social payment behavior, this study in-corporates the main stakeholders of green residence into the model and constructs a four-party evolutionary game model, introducing the "virtual game party" under the scenarios of no policy, incentive policy and mandatory policy. Matlab simulation results show that the greater the loss of neglect, the more likely the government chooses the incentive/compulsory policy; the greater the government penalty, the more likely realtors choose to develop and build green residences, which also promotes the choice of the government and residents; the greater the government subsidy, the more likely realtors choose to develop and build green residences, the more likely residents choose to pay for green residences, which also promotes the choice of the government; the greater the sub-sidy of realtors, the more likely realtors choose to develop and build green residences, which also promotes the choice of the government. The greater the subsidy coefficient of realtors, the more likely realtors will choose to develop and build green residences, when residents are instead less likely to choose to pay for green residences; the greater the trust coefficient/less risky to pay, the more likely residents will choose to pay for green residences, which subsequently also drives the choice of government and realtors.

Do regional economy, resource and environment always go hand in hand? Uncovering the evolutionary pathways towards their coordinated development in the Yangtze River Delta

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Abstract:

Under the background of tighter resource constraints and prominent environmental pollution, regional development is endowed with new connotations and implications. Whether the economy-resources-environment system can achieve coordinated development is a significant indicator to judge high-quality regional development. Taking the Yangtze River Delta region as an example, this study establishes a material flow account system, reveals the resource and environmental pressure and operation efficiency of the regional economic system, and clarifies the evolutionary trend of regional economy-resource-environment collaborative development based on the accounting of input resources, output resources and environmental impacts in the regional economic system. The MFA-SD model was constructed, and four scenarios including business as usual (BAU), economically sustainable degrowth (ESD), economic Accelerating development (EAD) and resource and environmental protection (REP) were set up to explore the correlation and restriction relationship between economy, resources and environment, and analyze the optimal path of regional coordinated development. The results indicated that during the year from 2006 to 2020: (1) In terms of total material requirements (TMR), Anhui, Jiangsu and Zhejiang showed an overall rising trend, while the data of Shanghai fluctuated little and showed a stable trend. (2) In terms of material productivity (MP), i.e., the resource utilization efficiency, four places show an upward trend (average annual growth rate of 8.35%), while regarding the waste intensity (WI), i.e., the resource utilization efficiency, the changes in the four places tend to show a gradual decline (9.3% per year on average). (3) In general, the YRD region presents a benign and coordinated development trend. Shanghai has a trend of coordinated development, while Jiangsu, Zhejiang and Anhui still need to improve. Between 2021-2030, (4) economy lags in REP, resource lags in EAD, and environment lags in BAU and EAD; economy, resource and environment can go hand in hand only in ESD.

Evaluating the Level of Integration in terms of Sustainability Between Public Transport Modes and Paratransit Systems: A Case Study of Kochi city, India

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Abstract:

Major Indian cities are experiencing numerous issues with traffic congestion and pollution. These issues might be partially resolved by increasing transit patronage. Public transit has a drawback compared to the door-to-door flexibility of private transportation. Improving efficiency and use of public transportation would depend heavily on integrating public transport and paratransit systems. Therefore, it is necessary to study and evaluate the existing integration level between these systems. The present study aims at assessing the current level of integration between metro, buses and autorickshaws in terms of sustainability in Kochi city, India. The set of indicators that would determine the level of integration between the economic, social, and environmental sustainability domains were identified from literature. Based on expert opinion survey, relevant weights were obtained for each indicator. Further extensive survey was carried out at major metro stations, bus stand and autorickshaw stands to obtain the user perception of level of integration of the various modes. The final "Sustainability Index" was computed and represented in the range of "0" to "100" using these acquired weights and homogenised values for each indicator.

In the present study, data collection was carried out at four selected locations Aluva, Maharajas College, Ernakulam South and Vyttila in Kochi city. From the results obtained it was found that Vyttila is better integrated having the maximum value of sustainability index of 51.36, followed by Aluva with 40.74, Maharajas College with 34.82 and Ernakulam South with least integration levels with a sustainability index of 30.21. The maximum sustainability index for Vyttila can be explained as result of most accessible autorickshaw stands with very large number of bus fleets serving, proper connections provided to access the bus stops and autorickshaw stands. Finally, suitable policies to improve/increase sustainability in terms of integration namely increasing bus service frequency and E-autorickshaws etc. were proposed.

"Translating" UN Sustainable Development Goals for an all-round data centre industry green transformation

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Abstract:

Digital infrastructure propels the digital economy, delivering considerable benefits to global society through various digital services. Digital infrastructure is housed in data centres, which in the most straightforward definition, comprise a building, IT equipment and supporting infrastructure. There are approximately 7.2 million data centres with an estimated 70 million servers worldwide, evolving together with ever-growing internet traffic and the number of connected users. Due to the industry's non-stop operations, the sector is recognised for its notable energy use and associated GHG emissions. However, the industry needs to address broader sustainability impacts, including impacts on physical and biological resources, such as energy, water and land use, and resource consumption, including Critical Raw Materials, to manufacture the extensive infrastructure.

UN Sustainable Development Goals (UN SDGs) is a common framework of objectives aiming to align governments, businesses and the public to ensure sustainable transformation. The data centre industry plays an integral role in the digital economy, which is one of the essential enablers of the UN SDGs Agenda. Although SDGs are valuable and concise guidance for sustainable development globally, enterprises in this specific sector need support to comprehend and interpret those ambiguous and ambitious SDGs according to their conditions. Moreover, low sustainability maturity, little SDGs awareness, lack of circular practices, and greenwashing are substantial obstacles to the industry's sustainable transition.

Therefore a whole-systems and life-cycle approach and a combination of critical thinking and creative problem-solving are necessary to understand the data centre industry's complex challenges. This research comprehends present-day scholarly and industry literature and qualitative data collected through semi-structured expert interviews and co-creation workshops analysed according to the ground theory principles. Findings reveal the needs and opportunities for improving the understanding of sustainability and SDGs and strategy for tackling the SDGs in the context of this unique sector.

Revealing the socio-Economic metabolism of steel: phases, patterns, and perspectives for sustainable development

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Abstract:

As the skeleton of industry, steel is an important factor in the development of material capital in society. To understand the role of this essential factor at different stages of industrialization, we focus on the steel cycle of three indicators, namely, final consumption (FC), in-use stock (IS), and end-of-life scrap (ES) through a socio-economic metabolism model with dynamic material flow analysis. Theoretically, this model enables the analysis of the three indicators with respect to phase-based characteristics (i.e., growth, peak, decline, and steady-state) and temporal patterns (i.e., proportionality parameters, per capita saturation levels, and service life). Based on the model, we provide an empirical analysis of the steel socio-economic metabolism for 190 countries from 1900 to 2018. Our results show that due to the time lag between flow and stock conversion, the steel cycle follows a sequential pattern: FC peaks first, followed by IS and, finally, ES. In particular, industrialized countries (ICs), e.g., the U.S., have flatter curves for IS accumulation; on the other hand, emerging industrialized countries (EICs), e.g., China, experience rapid IS peaking. However, when at IS peaking stage, socio-economic performance of EICs is significantly lower than that of ICs, suggesting inefficiency in transforming IS steel into productivity for EICs. In light of the above results, this paper concludes with recommendations for future steel resource management and industrial development policies for EICs, emphasizing the role of capacity reduction and replacement, interregional capacity transfer, energy conservation, low-carbon initiatives, and new technologies.

Research on China’s provincial carbon shadow price and carbon emission efficiency, based on Stochastic Frontier Analysis

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Abstract:

Background

Controlling negative externalities caused by global environmental problems has become increasingly challenging today. The Chinese government has made stringent commitments to reduce carbon emissions. However, as a country with lopsided regional development, such strict commitments are bound to come at a higher cost in terms of sacrificing economic development than developed entities.

Methodologies

This article examines Chinese annual provincial GDP loss per ton of additional carbon emission reduction (carbon shadow price, CSP) from 2000-2019 in perspective of marginal abatement cost. Provincial panel data, including producing factors such as labor, capital stock and energy consumption as input variables were analyzed, with GDP and carbon emissions as output bundles. Output-oriented Directional Distance Function is introduced as a rationale in the formulation of production frontiers, subject to the goal of increasing GDP while reducing carbon emissions, given the production technologies implicit in the translog production function. Parameter estimation is performed using maximum likelihood models from Stochastic Frontier Analysis, considering both provincial fixed effects and time effects. Chinese provincial CSP is calculated from aforementioned estimates by drawing on the Lagrangian optimization method with post-estimation on technical efficiency (considered as carbon emission efficiency).

Conclusions

The conclusions reveal several findings. First, provincial average CSP in China's eastern region (22339 Yuan/ton) is much higher than that of the developing regions (for example, 11472 Yuan/ton in western region), which implies the significantly higher cost of reducing carbon emissions in developed region. Second, the increase in provincial CSP over time is accompanied by a downward trend in carbon emission efficiency, showing that there is still an obvious divergence between CSP and carbon emission efficiency. Third, improvements in carbon emission efficiency will increase the corresponding CSP, indicating that it will cost more to reduce carbon emissions as provinces move closer to the production frontier when production is optimized.

Allocating carbon emission quotas in the textile sector using a double vortex model to promote cooperative energy conservation among carbon trading enterprises

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Abstract:

Under a market economy, carbon trading is an effective tool for lowering energy use, emissions, and climate change. Enterprise energy-saving decisions are significantly impacted by the distribution and modification of carbon quotas. The commonly used quota allocation methods currently have some operational shortcomings. In order to complement the quota allocation method, this research proposed a new carbon emission quota allocation method named the double vortex model based on microeconomics principles. This model makes use of the theory of a double vortex nest, which draws enterprises with comparable traits together into a vortex through the application of economic incentives, encouraging them to improve the efficiency of their emission reduction efforts. The textile sector's carbon trading enterprises were chosen to study how their allocation of carbon quotas changed before and after the model was applied. Low emission intensity enterprises were given more carbon emission allowances, whereas high emission intensity enterprises got less. The double vortex model emphasizes corporate conduct and provides a method to set up regulations for carbon emission quotas.

Country-specific strategies for water saving under carbon neutrality target of the pulp and paper industry

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Abstract:

The pulp and paper industry is an important contributor to global GHG emissions and puts enormous pressure on water resources. It remains unclear whether lifecycle water use will decrease or increase as lifecycle emissions are reduced in this industry, due to the lack of data to illustrate the interactions (synergy or antagonism) between GHG emissions and water use differ across stages. Furthermore, country-specific strategies are essential for the industry to achieve water saving under the carbon neutrality target by 2050, given its vast heterogeneities across countries. In this study, we develop a comprehensive bottom-up assessment of net lifecycle GHG emissions and water use of the pulp and paper industry for 30 major countries from 1961 to 2019 and explore strategies for water saving under the carbon neutrality target in 2050 through 2,160 scenarios covering critical factors along the paper lifecycle. Our results show vast differences across countries in terms of historical evolution trends and structure of GHG emissions and water use. All countries can achieve water saving under carbon neutrality by 2050, but with significantly different strategies. It is easy and flexible for most developed countries to achieve the target. In addition to the same efforts of improvement in water and energy efficiency, the priority should be promoting sustainable forest management for tropical developing countries (e.g., Southeast Asia and Latin America), and more attention should be paid to better paper recycling and waste management in other developing countries. These insights are critical for developing strategies customized for individual countries to lead to a more sustainable pulp and paper industry at the global level.

Towards Carbon Neutrality: Coordinated Integration of Alternative Fuels and Transport Technologies in Inland Waterway Network

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Abstract:

Achieving carbon neutrality in the transportation sector requires deep electrification of the passenger vehicle fleet (PF), and the carbon reduction potential is constrained by the low carbon level of power plants (PP) electricity generation. The mismatch between PF electrification and PP decarbonization schedules may cause the reverse carbon reduction. Nevertheless, the threshold of acceptable mismatch gap is currently not fully recognized, challenging the cross-sectors management. In this study, we built a high spatial resolution PF-PP system model, coupled a road scale PF electrification model with a plant scale PP model, to account China's carbon emissions. A set of technology-demand crossover scenarios was deployed to portray future schedules of PF electrification and PP decarbonization. The result shows that premature large-scale PF electrification can lead to an overall increase in system carbon emissions, mainly due to the low conversion of coal-fired power to renewable power. We found a spatial shift in emission characteristics from the road network emissions to the power plant point source emissions, which makes the role of end-of-pipe emissions reduction from power plants more critical in future. Further, advancing the deployment of CCUS for coal-fired power plants can mitigate the reverse carbon reduction from the overrunning PF electrification. However, considering that the cost of CCUS is difficult to be reduced quickly, we propose demand management as a better strategy. We found that the management of vehicles holdings and annual driving distance has a huge potential for PF-PP system carbon reduction. Our results on the carbon emission pathways and reduction potentials of China's PF-PP cross-sectors system would help inform tailored mitigation strategies and identify maximum combined effects of demand-side and technological strategies.

Analyzing synergies and trade-offs of carbon neutrality for sustainable urban transition

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Abstract:

Climate change has become a common challenge for humanity. Meanwhile, the 2030 Agenda for Sustainable Development marked for the human society a step into a completely new mechanism framework of sustainable development. However, the majority of existing researches focus on national-scale SDGs progress evaluations, thus the urban scale researches are lacking. Cities play a vital role in the process of global sustainable development and the realization of the Carbon Peaking and Carbon Neutrality Goals. Taking four cities in the Yangtze River Delta as a case, this study proposed a novel approach to simulate the trend of cities' emissions and sinks, which quantitively analyze the synergies and trade-offs of carbon neutrality for cities by combining a random forest approach and LEAP model. We found that the current characteristics of carbon sources and sinks of each type of city from 2005 to 2020 are significantly different due to diverse industrial structure, energy structure and ecological endowment. It is also found that the influencing factors have both variability and homogeneity in their impact on carbon emissions. In addition, there are significant differences in carbon emissions between cities at different stages of development within the same region, which require tailored strategies and actions for low carbon transition. The study provides a reference for cities of different types and stages of development to explore adaptive carbon neutral pathways.

How nexus approach can contribute to carbon neutrality from a sustainable perspective

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Abstract:

There is a growing global interest in developing a nexus approach that addresses sustainability and climate change simultaneously. The carbon neutrality target is closely related to 2030 sustainable development goals (SDGs), which requires considerable synergies and trade-offs in a system manner. The nexus approach aims to balance carbon emissions and sinks related goals to achieve sustainable and collaborative practices in the process of carbon peaking and carbon neutrality. However, there is currently a lack of holistic understanding of these goals in terms of their unified perception, composite approach and effective mechanisms, and the interaction of the carbon neutrality goal with other goals in the SDGs remains unknown. It is important to examine the impacts of social, economic, and environmental factors at global and local scale, including those related to population, economy, energy structure, land use, and ecological space. These impacts are described with an emphasis on how they may affect carbon balance and the related SDGs such as SDGs3, 6, 7, 8,11,13,14,15). The examination of these drivers provides insight on how to balance multiple requirements of human-nature systems. Designing a nexus approach is a complex process that requires boundary delineation, detailed data granularity, inclusive framework and clear pathway. This review summarized nexus studies on carbon neutrality and sustainability, including definitions of key terms, methodology, comparison of similarities and differences, the practices in different counties, regions and sectors, which can provide a scientific basis and methodological support for the development of a multi-objective nexus approach.

Achieving carbon neutrality and improving air quality in a more efficient, green and sustainable path: insights from synergistic research on greenhouse gases and air pollutants

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Abstract:

Climate change is an urgent global crisis, and carbon neutrality has become a consensus among countries. Meanwhile, billions of people still breathe unhealthy air, and air pollution is particularly severe in developing countries. The similarity in emission sources between greenhouse gases and air pollutants provides a basis for their co-controlling. We systematically review the research progress of the synergy between air pollutants and greenhouse gases at the global, national, and sectoral scales. Developed countries such as Europe and the United States were the first to pay attention to the co-benefits of carbon reduction policies, and in recent years, research in developing countries especially China has increased significantly. Relevant research primarily encompasses two dimensions: the co-effects of carbon reduction on air quality improvement, and the synergy from air pollution control to carbon reduction. In terms of temporal scope, the research includes evaluating existing policies, as well as simulating future scenarios. Integrated model coupling energy, climate, air quality and health risk is the most commonly used analytical approach, but there is still a lack of a unified and authoritative method. The results generally indicate that structural measures implemented at the source and process levels yield higher cost-effective co-benefits, while end-of-pipe technologies need to be careful to avoid non-synergistic outcomes. Compared with developed countries, developing countries lack mature carbon reduction technologies and policies, but their efforts to control air pollutants, such as China, have brought prominent co-benefits for carbon reduction. The dual pressure of carbon and air pollution reduction has prompted developing countries to place greater emphasis on “co-effect” in their future planning. If the concept of synergy is incorporated into policy design and technology selection, developing countries are expected to embark on a more efficient, green, and sustainable path towards carbon neutrality and air pollution improvement.

What is the mitigated environmental impact potential of solid waste resource digestion in the Central Plains Urban Agglomeration of the Yellow River Basin? Based on scenario assumptions

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Abstract:

Solid waste (SW) has the dual attributes of "resource & environment" and pollution "source & sink", and its proper management is of great significance to regional ecological protection and high-quality development. Constrained by natural conditions and carrying capacity, urban ecological environment in the Yellow River Basin (YRB) is always fragile. Strengthening SW disposal and utilization plays an important role in maintaining the water resources security and improving the ecological environment quality in the Central Plains Urban Agglomeration of the Yellow River Basin (CPUA-YRB). Based on the construction of SW resource digestion management system, this study evaluated the digestion capacity, environmental effects and four environmental impact potentials of general industrial solid waste (GISW) resource utilization in the CPUA-YRB, namely global warming (GWP), acidification (AP), nutrification (NP) and human health damage (HHD). The results show that: (1) GISW generation, comprehensive utilization, and storage change in an inverted "N", and the disposal volume continue to fluctuate. (2) For every 1% increase in resource utilization rate, the GISW digestion increases by 1,194,900 t. (3) In enhanced scenario, resource digestion capacity is 103,189,600 t, and mitigated environmental impact potential is 3.72×10-3, with GWP > HHD > AP> NP. (4) Level I cities and some level II cities have more advantageous potentials for emission reduction. The novelty is that the comprehensive impact of GISW resource digestion is evaluated combining socio-economic development differences. The results provide a reference for SW pollution prevention.

Accounting of greenhouse gas emissions in China's electricity generation and consumption

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Abstract:

The power sector is the largest contributor to China's carbon emissions, accounting for 41% in 2019. In order to meet the Dual Carbon Goals, reducing emissions from the power industry is a priority. In China, the power grid separation of generation and consumption creates complexity in calculating GHG emissions. The shift towards clean energy sources has changed the energy mix and highlights the need for updated carbon emission factors. Regional differences in energy structure and electricity trade also result in diverse carbon emission factors.

To address these challenges, this study aims to calculate direct carbon emission factors at both the production and consumption ends using the latest data from 2020 or 2021. The IPCC guidelines and the Quasi-Input-Output model will be used to calculate carbon emissions in six power grid regions and provinces in China. This study will serve as a foundation for the creation of a life cycle assessment inventory database for the power industry. The comparison of production and consumption carbon emission factors will also provide insight into the division of emissions reduction responsibilities among regions.

Resource sustainability and the bubble of carbon neutrality in cement manufacturing industry

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Abstract:

The cement manufacturing industry is a significant contributor to global carbon emissions. Over the years, several techniques have been identified and introduced for approaching carbon neutrality in cement manufacturing. However, most of these techniques are contingent on the availability of either low-value natural resources or by-products from other industries. The lack of self-sufficiency in low-carbon resources shows that the cement manufacturing industry is heading towards a bubble of carbon neutrality. The growing awareness of resource sustainability is bringing reforms in other sectors and reducing the availability of low-value resources and by-products for cement manufacturing. Continuing this trend will create a shortage of low-carbon resources for cement manufacturing and burst the bubble of carbon neutrality. It is important to recognize the short-term and long-term availability of resources and transition towards solutions which ensure self-sufficiency of carbon neutrality in cement manufacturing.

The present study reviews the various techniques used for carbon neutrality and analyzes them with respect to resource sustainability. The methods used for carbon reduction are broken down in terms of required resources, which are investigated in terms of availability (abundant, long-term dwindling, short-term dwindling), generation (circular, co-dependent, independent), sensitivity (to cross-industry innovations), impact on carbon reduction (significant, substantial, minimal), viability (short-term, long-term), and secondary environmental impacts (at the source, at the sink). The study will also present a systematic solution for transitioning from short-term to long-term solutions. The study will aid the self-sufficiency of resources in cement manufacturing and prevent the growth and collapse of the carbon neutrality bubble.

Electrification and carbon reduction in public buildings: A provincial analysis in China

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Abstract:

China has proposed the full electrification of public buildings to achieve carbon reduction, yet the decarbonization degree of electricity determines the effectiveness of the measure. Considering regional power grids zoning, energy structure, population and building size, this study estimates the changes in carbon emissions caused by electrification of public buildings in China's 30 provinces in period 2004-2020. The results show that: (1) From 2004 to 2020, the share of electricity-related carbon emissions to total carbon emissions increases from 62.96% to 68.34%; (2) The electrification of public buildings has had the opposite effect on carbon reduction in two periods. Electrification of public buildings achieves a carbon reduction contribution of -9.62 $MtCO_2$ in period 2004-2012, while it contributes 114.4 $MtCO_2$ in period 2012-2020; (3) At the current rate of electricity decarbonization, full-scale electrification of public buildings could mean a rise in carbon emissions. From 2004 to 2020, only six provinces have achieved carbon reductions from electrification of public buildings. In addition, this study gives recommendations in terms of both decarbonization of electricity and rhythmic advancement of electrification of public buildings. Overall, this study provides a reference for other end-use energy consumption sectors to quantify the carbon reduction contribution of electrification and provides policy insights into achieving cross-sectoral net-zero management.

Determinants of embodied CO_2 transfer through electricity trade within China

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Abstract:

There is unequal spatial distributions of resource endowment, population density, industrial structure, economic level with diverse differences in labor, energy, and capital productivity in China. The electricity trade has alleviated the shortage of electricity supply in developed regions by outsourcing electricity to the less-developed energy-rich regions. The large-scale electricity trade has changed the embodied CO_2 flow through electricity network within China. Economists use the comparative and absolute advantages to explain the interregional product trade. Previous studies paid little attention to the reasons of embodied CO_2 transfers through interregional electricity trade within China. In this study, we use both the comparative and absolute advantage theories to reveal the determinants of embodied CO_2 transfers within China. Results show that electricity sector has higher labor productivity but lower asset efficiency and energy productivity than manufacturing sector and mining sector in China. Electricity trade has alleviated unequal CO_2 emission embodied in electricity consumption per capita. Econometric analysis shows that regional differences in labor productivity between electricity and non-electricity industrial sectors are the main forces determining the patterns of embodied CO_2 flow across China, and asset efficiency and energy productivity play only a limited role. Our finding provides more details about the power grid expansion planning in the future.

Modeling vehicular emissions using international vehicle emission model

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Abstract:

Vehicular traffic is considered the main source of air pollution, and it has a huge impact on air quality as well. It is one of the major sources of greenhouse gas emissions, toxic pollutants, and criteria pollutants such as PM, SOx, NOx, etc. The current regime of vehicle technology, fuel standards, and the high growth rate of private vehicles is likely to nullify all the past emissions reductions by the end of the century. In developing nations like India, there is substantial growth in the vehicular population. It is necessary to address the environmental impacts of the transportation sector. For this purpose, monitoring of vehicular emissions is done in studies using several models which incorporate various factors such as traffic data, vehicle category, etc. The present study use the International Vehicle Emission (IVE) model, to model vehicular emissions. Traffic data was collected along the NH 48 stretch, toward Chennai Road in Trichy, Tamil Nadu, India. Further parameters like speed variations of vehicles, vehicle activity, and vehicle count for a particular time duration etc. are extracted as per the demand of the model. Results show that among the criteria pollutants, CO had the highest rate of emissions of approximately 10,000 mg/hr, followed by VOC (1000 mg/hr), NOx (1000 mg/hr), SOx (10 mg/hr), and Particulate Matter (1 mg/hr). Also, LMVs and 2-wheelers have higher emissions than other vehicle categories. Among the toxic pollutants, benzene had the highest rate of emissions of approximately 100 mg/hr, followed by ammonia (80 mg/hr), formaldehyde (1 mg/hr), acetaldehyde (0.9 mg/hr) and 1,3 butadiene (0.8 mg/hr). Among the global warming pollutants, CO2 had the highest rate of emissions of approximately 10,000 mg/hr, followed by CH4 (1500 mg/hr). The study of vehicle emissions can offer the potential to plan better pollutant reduction strategies for the transportation sector.

The characteristics and determinants of household carbon emissions in China: empirical findings from China Family Panel Studies

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Abstract:

Reducing household carbon emissions, which accounts for 52% of China's total greenhouse gas emissions, is crucial to reaching China's pledge to reach a carbon peak by 2030. Therefore, it's crucial to comprehend its emission patterns and drivers for uncovering household's undiscovered potential. Utilizing 2014–2018 China Family Panel Studies (CFPS) survey and energy statistics data, the study compiled a household carbon emissions (HCEs) accounting inventory and analyzed the characteristics of and variations in HCEs in China at micro scale. Then, the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model was built to investigate the factors associated with HCEs, thereby providing support for actualizing a low-carbon economy and sustainable development in China. The results indicate that (1) from 2014 to 2018, the HCEs per household exhibits an increasing trend with a decreasing growth rate, while the rate of increase of HCEs per capita is increasing. Although the proportion of HCEs from life-supporting consumption (e.g., food, clothing, and residence) has decreased continuously, it is still a dominate component. The disparity in the structure of carbon emissions between urban and rural households has shrunk, but the gap in carbon emissions continues to grow, indicating that carbon inequality remains an issue. (2) The household size, income level, and average consumption tendency are the key drivers contribute to the increase in HCEs, whereas the adoption of carbon control technologies is the primary restraint. In particular, we find that income level and average consumption tendency indeed have an inverted U-shaped effect on the growth of HCEs. Factors such as population structure, Internet dependence, and online shopping expenditures have a significant impact on HCEs by altering the household consumption structure. The findings of the study provide useful information for developing targeted energy saving and carbon reduction initiatives from a household scale perspective.

Growing climate change perception but rising regional disparities in China

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Abstract:

Climate change perception is essential for effective adaptation and mitigation. This study for the first time maps the shifts in subnational climate change perception in China, based on datasets from two large-scale surveys conducted over 13 years. Our findings reveal significant increase in perceived climate change priority and impact (19% and 13%, respectively) at the national scale but wider regional disparities ($t = 19.84$, P-Value < 0.001, $t = 25.45$, P-Value < 0.001). We highlight the needs for tailored and targeted communication strategies to mitigate the spatial mismatch between climate change perception and risk exposure.

The relationship between school energy consumption and children's Body Mass Index: evidence from Chinese kindergartens

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Abstract:

The increasing prevalence of obesity may hinder efforts to achieve carbon neutrality targets by contributing to higher greenhouse gas emissions. However, there is limited research on the determinants of obesity in the context of energy economics. To address this gap, we conducted an empirical study on the relationship between school energy consumption and children's Body Mass Index (BMI) using a dataset that combines physical health information of Chinese children, kindergarten energy consumption data, and kindergarten geographic information data. Our findings show a negative correlation between school energy consumption and obesity, with variations observed between kindergartens located in cold areas and severe cold areas, as well as between young boys and girls. These results are robust to sensitivity analysis. Furthermore, we found that children's capacity for exercise plays a key role in mediating the relationship between school energy consumption and the likelihood of obesity.

The sense of consent facilitates plastic waste separation at the household level: survey evidence from Tsukuba, Japan

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Abstract:

Properly treating and recycling plastic packaging waste is one of the critical waste management issues in many countries. In many Japanese municipalities, plastic packaging waste separation at source has been introduced in recent years, and continuous commitment by residents is vital for thorough plastic waste separation for recycling. In the present study, we focused on the “sense of consent” (nattoku in Japanese) as a psychological factor that encourages continuous plastic waste separation at the household level. The present study aimed to clarify the relationship between plastic waste separation and the sense of consent.

The present study collected data on the sense of consent and plastic waste separation and pre-treatment before discharging from adults residing in Tsukuba City through an online questionnaire survey (n = 391, male 50.64%, mean age = 42.01). Correlation analysis and multiple regression analysis were conducted to confirm the associations between the sense of consent and plastic waste separation and pre-treatment and to examine the factors that facilitate the sense of consent.

The correlation analysis indicates a positive relationship between the sense of consent and waste separation regardless of the degree of dirtiness of the plastic waste, suggesting that the improvement of the sense of consent promotes plastic waste separation, in which the positive association becomes weak as waste dirtiness gets severer. The multiple regression analysis indicates the sense of consent is positively related to injunctive norms, experience-based efficacy, and plastic waste separation habits, while it was hindered by a sense of burden and stereotype (i.e., separation unnecessary). These results suggest that designing and disseminating appropriate separation methods and providing feedback on waste separation effectiveness will enhance residents’ sense of consent in plastic waste separation and lead to continuous cooperative behaviors.

What drives household segregation of recyclables in Vietnam?

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Abstract:

In January 2022, Vietnam ratified its new Law on Environmental Protection that requires households and individuals to minimize and classify domestic solid waste at source (Art 60) by 2025. Yet, ensuring residents will “classify” and segregate their household waste is a challenging task - not only to ensure that some change behaviour but also that it is conducted reliably. Analysis of previous studies in Vietnam campaigning for and launching waste segregation initiatives shows that they typically lack a systematic approach to identifying and targeting behavioural drivers affecting waste segregation. To address this gap, this study utilized the Risks-, Attitudes-, Norms-, Abilities-, and Self-regulation (RANAS) theoretical framework to identify behavioural factors related to recyclables separation in the case study of Tuy Hoa City in Phú Yên Province and develop evidence-based behaviour change strategies for implementation. Results of the RANAS surveys conducted in households show that attitudes and norms such as factual knowledge, feelings of care and satisfaction, personal obligation, and guilt are drivers of recyclables segregation behaviour. Furthermore, ability and self-regulation drivers, including action knowledge, confidence in performance and continuation, remembering, and commitment, were identified as drivers. Based on this analysis, the study proposes a set of behaviour change techniques to implement for promoting recyclables segregation at the household level.

Assessing the sustainability of household food consumption in rural and urban China

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Abstract:

The need to assess sustainability implications of food consumption and explore its drivers is increasingly recognised in academic research. However, studies tend to focus on high-income countries and selected diet patterns while sustainability assessments of food consumption in developing and transitional economies remain limited. This represents a critical knowledge gap given the rapidly increasing patterns of food consumption in many non-western markets. This current study conducted a holistic sustainability assessment of household food consumption (HFC) in rural and urban China at a national scale based on the early established sustainability assessment indicator system (SAIS) in the Chinese environment. Then the key drivers of HFC sustainability were determined by using regression analysis. The results indicate that economic sustainability is relatively lower while environmental sustainability is higher. 99.5% of households have relatively sustainable or relatively unsustainable over sustainability. The overall sustainability varies with month, area, household income and size. The results of the regression model indicated that household income has a significant positive impact on overall sustainability ($P<0.01$), while household size, lose weight, and the occurrence of COVID-19 have significant negative impacts ($P<0.1$, $P<0.05$, $P<0.01$). The study conclusion provides references and a scientific basis for increasing the sustainability level of HFC and fulfilling sustainable food consumption in China. The conceptual framework and the approach used in the current study can also provide insights for research in other countries/regions.

Corporate social responsibility and organizational citizenship behavior for the environment. Mediation moderation analysis

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Abstract:

The study examines relationship between employee corporate social responsibility (CSR) perception and organizational citizenship behavior for the environment. Especially, the influence of employee CSR perception on employee's citizenship behavior for the environment by considering the mediating role of employee well-being and green innovation via a structural equation model (SEM). Using a sample of 606 employees, the study documents three key findings: (1) CSR perception has a significant positive impact on employee's citizenship behavior for the environment; (2) employee wellbeing mediated the effect of CSR perception on employee citizenship behavior for the environment; and (3) green innovation mediated the effect of CSR perception on employee citizenship behavior for the environment. Findings enrich our knowledge of CSR perception and employee's citizenship behavior for the environment and provides important implications for companies' top managers. The implications and future directions are also discussed in this research.

Could information intervention effectively reduce food waste caused by consumers' misunderstanding of food date labeling

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Abstract:

Confusion and misunderstanding of food date labeling at the retail and consumer stage result in large amounts of safe, healthy, and quality food being wasted, aggravating global food security. Food date labeling could be essential to reduce food waste (FW), yet we know little about it. We collected 2282 valid survey samples online in March 2023 in China and used an information intervention experiment to obtain the data on participants' cognition and food-discarding decision behaviours before and after the intervention. Subsequently, we used the fixed-effect model to explore the intervention effect and the interaction terms to explore influencing factors. The results show that consumers generally use food date labels ineffectively because they misunderstand labels. Literal understanding is the most common channel for consumers to acquire the meanings of labels. The per capita amount and monetary cost of FW due to their misunderstanding are 7.92 kg/year and 199 yuan (RMB unit) /year, accounting for 40.43% and 44.08% of the total FW, respectively. Information intervention significantly improved consumers' cognition of three kinds of food date labels from 6.40% to 58.24%. The age of consumers, per capita income, risk preference, dependence and degree of confusion on food date labels, as well as whether they have planned food purchases, requirements for food freshness, and perception of resources, all affect the change of food-discarding behaviours through their perception of food safety. Last but not least, consumers prefer manufacturing and use-by date labels, especially for the perishable food. We measure the amount and monetary value of FW due to the misunderstanding of food date labeling in transition economies initiatively, and quantitatively discuss the direct influence of the popularization of labels meanings on consumers cognition and food-discarding decision behaviours for the first time worldwide, providing feasible methods to reduce food waste to achieve UNSDG 12.3 empirically.

Fundamentals of an overall Sustainability Label for Products: Flagging Product Recyclability, Recycled Content and Reparability for Consumers within a Merge Approach

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Abstract:

Sustainable product policy is one pillar of the European Green Deal and the Circular Economy Action Plan. The European Commission is to begin to address recycling, recycled content and repair under the Ecodesign Directive and very likely in the announced European Sustainable Products Regulation. In addition, initiatives on recyclability and other aspects of sustainable products can be observed in France under the Ecomodulation Approach for some electrical and electronic products. Neither the Commission's ambitions nor the Ecomodulation Approach have so far led to a crucially better ecodesign of products.

Therefore, at the EU level, indices for reparability (already developed for smartphones and tablets), recyclability and recycled content of products are being discussed within the Ecodesign legislative framework in an attempt to achieve better ecodesign through advanced consumer purchasing decisions. The product standards requested by the European Commission to assess the recyclability (EN4555) and recycled content (EN4557) of energy-related products have already been published, but are purely based on a mass-based approach. Material-specific aspects such as the environmental impact or the financial, technical and redesign efforts required by manufacturers to facilitate the recycling and use of recycled materials are not addressed. Materials that are easy to recycle and use and have a high recycled content, such as copper, are treated in the same way as plastics that are difficult to recycle and use in products as post-consumer recycled plastics. Including such aspects would be essential to trigger environmentally relevant and significant improvements in product design.

This study analyzes opportunities to better flag recyclability, recycled content, and repairability. Since the indices are intended to guide consumer purchasing decisions toward the most material-efficient products, the study also discusses how the indices could be merged into a single consumer-friendly and easy-to-understand material efficiency index - possibly an Ecodesign index.

Consumers and self-repair: What they repair, what skills they have and what they are willing to learn

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Abstract:

Supporting repair is among the key strategies for achieving the circular economy by 2050 in the EU. In fact, the EU Right to Repair Proposal introduces new tools aimed at, for example, supporting the civic repair initiatives and independent repairers. Although consumer surveys show that the willingness to repair (vs replace) is high – the lack of repair and diagnostic skills are often preventing repair. Thus, to promote the repair of goods among consumers, we need better understanding of consumers' current self-repair activities, as well as their repair-related skills and willingness to develop them further. To investigate this, we collected a nationally representative sample (n=1,000) of the Finnish adult population in terms of gender, age, education, and the place of residence. The respondents were most confident about repairing everyday household goods (e.g., photo frame), bicycles, clothing, and home textiles. Overall, the results indicate that the respondents do not consider themselves as very skilled repairers (only 17.3% of them considered themselves as skilled or very skilled). Still, more than two-thirds of the respondents indicated their willingness to use their time for learning general repair skills, and over half of them would also like to learn how to repair furniture, textiles, and bicycles. The respondents were least willing to use time for learning how to repair large household appliances or mobile phones. Women were more willing than men to learn to repair textiles, and men were more willing to learn to repair technical devices (e.g., household appliances and mobile phones) and bicycles. There were no gender differences in willingness to learn general repair skills or furniture repair. We suggest that achieving the full potential of supportive policy and educational activities for self-repair requires precision concerning the notable differences between product categories and consideration of consumer interests.

A complete electric generating unit level analysis on the driving factors of carbon mitigation in China's power sector

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Abstract:

Considering that China is the world's largest contributor to carbon dioxide (CO2) emissions and the power sector is responsible for almost half of the country's total CO2 emissions, decarbonizing this sector is essential to achieving China's climate goals. Although previous studies have largely identified driving factors from a macro-level perspective with further disaggregation on technology efficiency depending on top-down statistical data, none of them have investigated the specific contribution of changes in the composition of different types of electric generating units (EGUs) to mitigating CO2 emissions. Hence, we construct a comprehensive bottom-up EGU-level inventory of fuel consumption and CO2 emissions in China's power sector from 1997 to 2018 to identify detailed driving forces and provincial heterogeneities.

We find that the power sector has undergone significant structural changes and fuel efficiency improvements, accompanied by dramatic scale expansion during the past two decades. Overall, electricity-related CO2 emissions have continued to rise, while electricity demand and power-related CO2 emissions have been relatively decoupled. Total electricity demand, followed by the change in cooling technology mix has driven a threefold increase in the total CO2 emissions and the effects of fuel mix change, energy efficiency improvement, unit mix change, line loss reduction and increased share of combined heat and power (CHP) have together offset 31% of the potential emission growth. Dominant driving factors by the province have spatial cluster features with fuel mix change making the largest contribution in approximately half of the provinces including most of China's southeastern, southwestern, and northern regions. Subsequently, heat rate decrease serves as the underlying determinant in some eastern, northeastern and northwestern provinces in China.

Atomic location-modulated electronic metal-support interaction for boosting water-gas shift reaction

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Abstract:

The electronic metal-support interaction (EMSI) is critical for the catalytic performance of supported catalysts. In this work, Pt1 single atoms with different electronic structures supported on ceria nanorods were constructed by the atomic layer deposition (ALD) technique, which was applied in the water-gas shift (WGS) reaction. According to combined experimental studies and theoretical analysis, it was revealed that the strong EMSI modulated by anchoring location effectively tuned the activation of CO adsorbed on Pt1 sites, thus lowering the energy barrier of the whole WGS reaction process.

During the ALD process, Pt atoms preferentially embedded into Ce vacancies and coordinated with five oxygen atoms to form stable Pt5c species. With the increase of loading, Pt gradually loaded on the CeO2 surface and coordinated with three oxygen atoms (Pt3c) as the Ce vacancies were depleted. As revealed by H2-TPR, XPS, EXAFS technologies, and DFT calculations, strong EMSI caused the Pt5c species to possess higher oxidation states and more unoccupied 5d orbitals. PtCe-2 catalyst dominated with Pt5c species exhibited higher catalytic activity and superior stability in the WGS reaction. DFT results confirmed that the strong EMSI affected the adsorption and activation of CO on Pt5c, resulting in an excellent catalytic performance for the WGS reaction. This work gives an atomic-level insight into the electronic metal-support interactions between Pt1 single atoms and CeO2 for WGS reaction, and it could provide guidance to enhance the catalytic performance of single-atom catalysts (SACs) by modulating the EMSI and optimizing local coordination structures.

Statistical impact quantification of peer-to-peer energy trading on distribution network flows

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Abstract:

Peer-to-peer (P2P) energy trading is gaining widespread interest due to the emergence of distributed energy resources. However, a comprehensive and universal analysis of the impact of P2P energy trading on distribution network flows has not yet been conducted. This paper proposes a novel statistical evaluation method based on statistically similar networks to obtain universal rather than case-specific findings. A quantification indicator is proposed to represent the overall distribution network flow loading level. Moreover, a two-stage optimization model is developed to optimize both the customer and network benefits of P2P, with the first stage minimizing the energy cost and the second optimizing the proposed indicator. Numerical results based on a British low-voltage energy system are provided to validate effectiveness of the proposed method.

Regional Sensitivity Analysis to identify key parameters for forecasting material flows and assessing the circularity of PV panels

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Abstract:

Regional Sensitivity Analysis (RSA) is a graphical approach in global sensitivity analysis based on Monte Carlo simulations to identify the parameters that have a significant impact on the values in the simulation model. In this study, RSA is used to analyse the uncertainty in material flows that arises when various techno-economic factors are considered simultaneously, and to identify key parameters for a reliable assessment of the future material flows and the circularity.

The demand for decarbonisation and energysecurity has led to the rapid installation of PV panels. While some studies have evaluated the impact of used PV panels emissions, these estimates are mainly based on the consideration of failure. Therefore, we applied the RSA method to the PV panels' material flow analysis (MFA) based estimation. The novelty of the research is the incorporation of the sensitivity analysis method to take uncertainty into account in simulations based on MFA, considering both technical and business condition factors, and enabling the evaluation of the state of the resource cycle intertwined with various techno-economic factors.

In the model, each utility makes business decisions about the installation or removal of panels based on many different factors over the life of the project.

As a result of RSA, based on more than 1000 simulations simultaneously differentiating 16 parameters, it was found that the material flow of PV panels has high uncertainties, especially in the emissions from utilities and the capacities of decommissioned plants; parameters such as the price of electricity sold and the lifetime threshold for distribution as used panels play a particularly important role in improving the estimation of material flows and the evaluation of circularity indicators. RSA works particularly well in identifying key parameters in a techno-economic context through MFA and contributes to the reliable assessment of material flows and circularity which is necessary for resource sustainability.

How will carbon trading policy and green certificate trading policy have a coordination and optimization in China's electricity market?

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Abstract:

The Chinese government has pledged to achieve carbon peaking before 2030 and carbon neutrality before 2060, which is meeting The Paris Agreement Targets. The power industry is the main carbon emissions in China. Carbon emission trading policy and green certificate trading policy have extensive development space in the low-carbon transitions of the power industry. First, a dynamic computable general equilibrium model of the power industry segmentation is constructed. This paper introduces carbon trading module and green certificate trading module based on the traditional modules. Second, there set a baseline scenario, a "double carbon" scenario (carbon emissions peak in 2030 and carbon neutrality in 2060) and an enhanced policy scenario (finish the target in advance). Simulations are conducted from 2020 to 2060, which analysis the effects of a single policy instrument and a combination of two policies, like carbon price, green certificate price, power supply structure and social welfare. Finally, the effect of the differentiated combination policy is examined through a multi-scenario simulation. Various scenarios such as carbon quota auction mechanism, policy coverage and renewable electricity consumption penalty mechanism are set and simulated to explore the policy effectiveness under the market mechanism reform. The results show that carbon quota auction mechanism can pull up carbon prices, while the green certificate penalty mechanism inhibits the rise of green certificate prices. Carbon market makes more contribution to reduce carbon emission intensity and optimizes power structure, but green certificate policy pays more economic costs than carbon trading policy in realizing the emissions target. Although the enhanced policy promote emission reduction targets, it reduces social welfare and decreases total social benefits. Coordination between the two low-carbon policies can avoid policy redundancy and achieve effective emissions reduction. This study provides theoretical reference for electricity market to set clean and low-carbon policy objectives and optimize market mechanisms.

CEEG, an energy efficiency grade dataset for white goods in mainland China at regional and household levels

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Abstract:

To improve energy-saving management, the energy efficiency grade (EEG) was introduced by the Chinese government in the 2000s and implemented on white goods (WGs) in early stages. However, due to the lack of actual statistics, it is still not clear how effective the promotion of high EEG WGs has been in China. The China Energy Efficiency Grade (CEEG) dataset for white goods described here comprises (i) EEG-related data of 5 kinds of WG at regional (national, provincial) and household levels in China and (ii) predictions of future average EEG trends by deploying econometrics and machine learning methods. By web crawling, retrieving and processing in SQL, the average EEG data weighted by sales in 30 provinces in mainland China from 2012 to 2019 are provided. Household WG survey data, including household information and average EEG, are collected by distributing questionnaires to 1327 households in Haidian District, Beijing, China. The CEEG dataset will facilitate the advancement of research on household energy consumption, household appliance consumer choice, and the assessment of energy-efficiency-related policies.

Green and low-carbon recovery of critical metal resources in energy materials: a comprehensive technology and evaluation system

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Abstract:

The materials required by energy industry have achieved rapid development and so many kinds of critical metals are required in the complex energy material industry. Many wastes are generally produced in the recycling of energy materials, and the environmental load is heavy with huge pressure of pollution reduction. Therefore, green and low-carbon recovery of critical metal resources in energy materials should be paid special attention for exploring the recycling mechanism, establishing efficient and short-range resource recycling processes. In our research, an effective resource recovery technology and comprehensive evaluation system is established for typical energy material recycling processes. The main contents and conclusions are as follows:

For the recovery technology, a recovery process of high purity lithium carbonate from the waste cathode material of spent lithium-ion batteries (LIBs) was developed under the use of formic acid. In the sight of the problem that the recovery of waste cathode scrap is very complex, the recovery process of spent LIBs was analyzed and evaluated comprehensively. It was found that the leaching rate of inorganic acid was stronger than that of organic acid, and all inorganic acids can react with Al completely, while the organic acids can be used to separate the aluminum foil from cathode material.

To establish a comprehensive pollution control evaluation system for the entire industrial process, a multi-objective overall optimization is established under economy, environment, and resources perspectives. The whole process economic minimization model was developed based on the material cost, energy cost, water cost and additional cost. The comprehensive environmental impact assessment methodology mainly evaluates the pollutions, combining with life cycle assessment and carbon footprint analyzation. Finally, the green and low carbon evaluation model was established for the typical energy materials (i.e., V2O5, light-emitting diodes (LED)) to guide the classification of recycling technologies and the formulation of comprehensive policies.

Generic prospective quantitative sustainability assessments for lignin-first biorefineries

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Abstract:

Recently, the transition from a fossil feedstock-based to a biobased economy has become a priority. Lignocellulosic biomass is the most abundant biomass type, consisting of lignin, cellulose and hemicellulose fractions. Primary focus has gone towards the valorization of cellulose and hemicellulose, while lignin was typically burned for energy. However, lignin-first biorefineries are emerging technologies (at low technology readiness level) which target lignin depolymerization to create value-added chemicals.

To investigate the environmental impact and economic potential of emerging technologies, LCA and TEA are the current state-of-the-art methods, respectively. However, both methods rely on a system boundary, functional unit, context-dependent parameters (location, feedstock availability etc.) and a specific background system including (i) certain technologies, (ii) the system of a certain region and (iii) specific assumptions (e.g., set of indicators). This specific information makes that different studies are not comparable and often contradictory. Moreover, such information is also not standardly available, making it not applicable at low technology readiness levels (TRL).

Therefore, the potential of generic statistical entropy-based methods (which are less data-intensive) as proxies for LCA and TEA at low TRL is investigated for two simulated lignin-first biorefinery concepts: reductive catalytic fractionation and dithionite-assisted organosolv fractionation. Both processes fractionate (and depolymerize) lignin in a reactor, followed by separation of carbohydrate pulp (cellulose and hemicellulose) derivatives, lignin-oil (containing lignin-derived monomers, dimers and oligomers), and other components.

The results indicate that the statistical entropy-based methods comply with LCA and TEA results, but do not address all aspects LCA and TEA cover. Therefore, as a conclusion, a perspective is presented on how these methods and data from different sources can be integrated to generically assess the sustainability of emerging biobased process technologies.

Environmental and cost evaluation of advanced bio-jet fuel: a bottom-up chemical process-based LCA and TEA for low-C aviation

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Abstract:

Growing global demand for air travel in the coming decade along with nearly full dependence on petroleum-based fuels with limited options for electrification has raised the need to develop low carbon (low-C) fuels to mitigate climate change. Biomass is a promising renewable feedstock for conversion to sustainable aviation fuel (SAF) to mitigate near-term greenhouse gas (GHG) emissions. Through metabolic engineering, sugars derived from pretreated and hydrolyzed cellulose and hemicellulose can be directly fermented to isoprene and catalytically upgraded to 1-4-dimethylcyclooctane (DMCO), an environmentally beneficial alternative to petroleum-based jet fuel. Cellulosic sugars may allow for greater GHG emission reduction compared to first generation sugars1 and meet scaling needs to reduce dependence on petroleum-based kerosene. Here, we assess the environmental impact and economic feasibility of utilizing direct isoprene fermentation from biomass sugars as an intermediate step in the production of DMCO via life cycle assessment (LCA) and techno-economic analysis (TEA). We use chemical process modeling to simulate the conversion of sugars from biomass to isoprene, dimerization to dimethylcyclooctodiene (DMCOD) and catalytic hydrotreatment to DMCO. The bottom-up process model serves as the basis in constructing the life cycle inventory (LCI) to assess environmental impacts and the TEA to predict economic feasibility. To address thermodynamic data gaps in building the model to generate the LCI, molecular dynamics is used to predict select chemical properties. Results show a negative GHG intensity of -41 gCO2e MJ-1 that is significantly lower than that of current petroleum jet (85 gCO2e MJ-1) when using Zea maize residue (corn stover) as feedstock. The TEA indicated that the target costs have the potential to be competitive with a minimum fuel selling price of DMCO between $1.06 - $1.26 L-1. Direct fermentation of isoprene could improve overall process efficiency and reduce energy consumption, while also enhancing the environmental sustainability of the process.

Understanding the benefits and challenges of wood-based products in response to climate change from life cycle perspective

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Abstract:

Wood-based products not only provide essential resources for human society but also play a crucial role in mitigating climate change through carbon capture and storage from the atmosphere and substituting fossil-based materials. Nevertheless, the overall effect of large-scale deployment of wood-based products is not fully recognized, threatening the sustainable transformation from fossil-based economy to bio-based economy. Therefore, this review study comprehensively analyzes the benefits and challenges of wood-based products in response to climate change from life cycle perspective. We firstly establish a life cycle material flow chart of various wood products from harvesting to processing, use and end-of-life treatment, aiming to understand the roles of wood products play in different industries and regions. Then an analysis of the impact of carbon storage and substitution of wood products on climate change mitigation is conducted according to different product categories and countries. Additionally, we analyze the natural, economic and social challenges faced by the sustainable use of wood products. We found that wood-based products have enormous potential in response to climate change, and calculate a baseline for greenhouse gas emissions reduction in the construction sector through the substitution of wood products for steel and cement. However, the effectiveness of mitigation varies among product categories in different regions, especially in bioenergy sector, due to resource endowment, technical development, and management policies on the one hand, and product lifespan, production emission, and carbon intensity of substitutions on the other. The results also show that the factors including biomass resources distribution, forest harvesting impacts, carbon leakages during international trade, and policy institutions, present challenges to the large-scale deployment of wood products. Our study suggests that the utilization of wood-based products in response to climate change requires to maximize the emission reduction as well as coordinate the restrictions.

Life cycle environmental and economic assessment of Tetra Pak recycling technologies

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Abstract:

Recycling of low-value waste is one of the great challenges faced by municipal solid waste management. Thus this study takes one of the typical low-value wastes, Tetra Pak, as a case study in Shanghai, China to evaluate the environmental impacts and social costs of different recycling technologies. Life cycle assessment method is employed to analyze the environmental impact of four Tetra Pak recycling technologies. The indicator of social cost that integrates both the environmental impact and economic impact are innovatively proposed for holistic comparison of different technologies. We found that Chemical Separation of Aluminum-plastic technology (abbreviated as technology 2) had the least environmental impacts. From perspective of end-point damage impact, the inhibitory effect of three recycling technologies all exhibited better environmental performances than incineration technology. Particularly, climate change and resource consumption impact of technology 2 was 2.5 times and 3.8 times that of incineration, respectively. While from economic perspective, plastic-wood technology (technology 4) was the optimal technology for Tetra Pak recycling, with net economic benefits being 1592 Chinese Yuan per ton. Finally, social cost analysis that combined both the environmental and economic impacts revealed that technology 2 was also the best technology for Tetra Pak recycling.

Techno-economic analysis and life cycle environmental assessment of green and low-carbon ethanol production by low-value tail gas

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Abstract:

Conversion of low-value tail-gas from industries into ethanol (TG-ethanol) was a promising cutting-edge route for value-added utilisation of tail-gas. However, a systematic and objective understanding of the technol-economic analysis (TEA) and environmental impact benefits is still lacking. In this work, this technology's TEA and environmental footprint are systematically evaluated by life cycle assessment (LCA) and compared with its competitors. Results show the TG-ethanol is the most environmentally benign option, whose environmental impact value is 22%-25% lower than that of the Corn-ethanol and Coal-ethanol. By taking the tail gas from the Chinese steel industry as an example, it is found that TG-ethanol's carbon reduction potential can achieve 5.6 Mt CO2/year by 2060, with 19.9-23.4 billion RMB economic profit compared with TG-originated power route. In addition, the carbon reduction potential of technologies was more focused in the context of carbon neutrality. To address the low carbon efficiency of TG-ethanol, we proposed an upgraded technology of TG-ethanol coupled with Electro-catalytic CO2 reduction (ECR), which is modelled by modular engineering process with Aspen Plus and then performed the TEA and LCA analysis with Monte Carlo simulation. Results indicate that ECR 0.7 scenario was more attractive with a net present value (NPV)>0 in considered 17 scenarios. Furthermore, the enormous carbon reduction potential of CO-70% at an ECR-0.9 was 63%, which is an exciting result for the carbon neutrality target. Furthermore, a sensitivity analysis was performed to identify the high-impact variables for this research. We can conclude that the ethanol price and photovoltaic (PV) cost are the key factors affecting NPV, and coal-to-steam, PV and grid-power are the driving factors dominating LCA carbon reduction potential. Finally, we hope this work allows researchers and stakeholders to see technology's economic potential and environmental impact while it is still in development based on experimental and modelling work results.

Comparative LCA-MCDA of high strength eco-pervious concrete by using recycled waste glass materials

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Abstract:

Construction and demolition waste (C&DW) and waste glass (WG) share a considerable part of the overall solid waste generation. Recycling C&DW and WG is a significant concern in Hong Kong as the nature of finding disposal outlets challenging and virgin resources depletion. Previous studies have shown that recycled aggregates from C&DW and WG can be used for various end-use applications in Hong Kong. Recent works have found the possibility to maximize the reuse of WG by producing pervious concrete as paving blocks with high permeability and compressive strength. In this study, an integrated life cycle assessment - multi-criteria decision analysis (LCA-MCDA) was conducted to compare the production of high strength eco-pervious concrete made with different mixtures of recycled materials and conventional pervious concrete made with natural resources. The LCA considered the boundary of cradle to site, from raw material extraction to the implementation of applications with site-specific data. A set of good alternatives for concrete production were determined by employing VIKOR MCDA method, considering environmental, economic, and mechanical performance. The results showed that the best option for producing high strength eco-pervious concrete was the use of maximized recycled WG materials, considering equal weight on environmental, economic, and mechanical criteria. The study also identified alternatives to further improve environmental performance of eco-pervious concrete by replacing natural sand fines with recycled waste concrete fine aggregates. Overall, the study highlights the potential of eco-pervious concrete made with recycled WG materials as a more sustainable selection to conventional pervious concrete, and provides insights on further improvements.

Assessing the impact of an oil spill through Life Cycle Analysis: development of effect factors (EFs)

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Abstract:

Oil spills represent a major environmental problem worldwide, generating multiple hazards to the local biota of the areas affected. The diversity of crude oil components and changes in its composition through weathering processes tend to magnify environmental impacts through time. The lack of studies that consider the contaminants present in crude oil under a Life Cycle Assessment (LCA) approach limits the capacity to empirically measure these chronic effects. Therefore, this research seeks to establish a framework for evaluating the impact of an oil spill from an LCA perspective through the development of appropriate characterization factors for freshwater eco-toxicity. A first for this is the development of effect factors (EFs) following the guidelines of the USEtox approach. The parameters considered as oil components were HTP (aromatic and aliphatic), BTEX and Polycyclic Aromatic Hydrocarbons (PAHs), the most relevant oil components. The HC50 was determined based on the EC50. The EC50 of PAHs and BTEX were obtained from the ECOTOX database and safety data sheets, prioritizing the information from ecotoxicological tests in freshwater and using toxicity values corresponding to three trophic levels (according to data availability). For HTPs, EC50s were obtained from extrapolations from Veith and Broderius (1990). All acute EC50s were extrapolated to chronic EC50s using the factor 2. Finally, the EFs were calculated as follows; EF=0.5/HC50. The results obtained indicated that the HTP of aliphatic chains had the lowest EF values, while PAHs had the highest EF values, highlighting their greater toxicological potential. These preliminary results will be subsequently used for future characterizations of oil spill impacts once fate and exposure factors are also developed.

Resource criticality in life cycle sustainability assessment

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Abstract:

Shifting economic sectors to a resource-efficient economy with zero net greenhouse gas emissions by 2050 faces major challenges for the European Union (EU), which is highly dependent on (raw) material imports. The EU has published a list of critical raw materials (CRM) at 3-year intervals since 2011. The underlying methodological approach is based on the criteria of supply risk (SR) and economic importance (EI) of the materials. The last update in March 2023, classifies 34 materials as CRMs. As CRMs play a key role in emerging technologies (e.g., renewable energy, batteries, e-mobility, digitalization), both supply risks and environmental impacts of CRMs need to be assessed. Hence, the continuous development of evaluation methods is needed to address these issues.

The SH2E project, co-founded by the EU, which is developing guidelines for Life Cycle Sustainability Assessment (LCSA) of fuel cell and hydrogen systems, is introducing an indicator for assessing the criticality of materials. Based on the EU approach, a new characterization factor (CF) linking SR to the amount of material (Massm) has been developed (eq 1). The new CF combines SR and the European consumption of a material (Cm) involving import reliance (IR) and recycling input rate (EoLRIR) (eq. 2).

$$Criticality_m = Mass_m * CF_m \quad [1]$$

$$CF_m = SR_m / [C_m * (1 – IR_m * (1 – EoLRIR_m))] \quad [2]$$

For the time being, EI is not included in the calculation of the new criticality indicator because its maturity level is not yet sufficient for many materials. However, the discussion about criticality is a lively ongoing process.

Subsequently, this new approach will be tested on a case study (manufacturing of various electrolysis stacks). The new approach is compared with various other criticality assessment methods and the results obtained are discussed.

Design of a Sustainable Hydrogen Supply Chain: An empirical approach through the Case of Chilean Seaports

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Abstract:

The conventional use of energy sources has resulted in global environmental issues. In response, global commitments like the Paris Agreement have been established, setting targets for renewable energy production from unconventional sources. Against this backdrop, the production and usage of green hydrogen has emerged as an eco-friendly energy solution, owing to the use of clean energy sources in its production.

The related literature uses multicriteria methods, which incorporate the Analytic Hierarchy Process (AHP) to assign weights to the considered criteria, among which the following stand out: population, potential demand, and environmental impact. Furthermore, the literature focused on the design of supply chains, using multi-objective optimization, presents a particular emphasis on economic and environmental factors while leaving behind social and political factors. The main goal of these studies is typically to minimize the total daily costs of the supply chain while considering constraints such as demand, capacity, and production-related factors. Most of the literature on hydrogen supply chains also considers three key phases: hydrogen production, storage, and distribution.

This study proposes a new approach to designing a sustainable hydrogen supply chain that incorporates five sustainability dimensions in its objective functions and constraints. The proposed method uses a multicriteria assessment that considers the opinions of local researchers and a multi-objective optimization model. The case study presented in this work involves the implementation of a hydrogen production plant and the distribution of hydrogen among different seaports in Chile. This is particularly relevant for Chile, given its high potential for renewable energy and its policies for green hydrogen outlined in the National Green Hydrogen Strategy developed by the Ministry of Energy. The results demonstrate the importance of incorporating the opinions of local expert researchers to achieve optimal and sustainable hydrogen production and distribution throughout the supply chain.

Systematic literature review on local food manufacture and food cold chains

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Abstract:

The global economy is still struggling to recover from COVID-19 and the food crisis is further deepened by the Ukrainian crisis. One major benefit in developing a localised food supply chain is to ensure food availability during disruption of food supply chains. Furthermore, there is a need for developing sustainable cold chains while decreasing energy-related emissions in global food systems and reducing food loss and waste. This paper presents a systematic literature review on decentralised food systems and cold chains to explore the extent to which resilience and sustainability have been considered. Key emerging themes and research gaps are identified from the systematic literature review. Results show the urgent need for considering decentralised food cold chains that can enhance resilience and reduce greenhouse gas emissions. The literature search was split into three parts: systematic literature search of decentralised food systems (DFS), systematic literature search of food cold chains (FCC) and authors personal search on DFS and FCC. The results show very limited publications on the DFS, whereas a considerable number of publications could be found on FCC. The decentralised food system publications focus is to compare decentralised and centralised food manufacturer of specific food types (ice cream, cereal and porridge). This review highlights that it is possible to replace decentralised food systems with localised ones which could be the cheaper option. However, the switch from decentralised to centralised food manufacture is highly dependent on food types. For example, decentralised porridge manufacture is more profitable than centralised manufacture, however, this does not apply to bread production due to lower profit margin per unit due to lower selling price for bread. In contrast, the FCC publications concentrate more on the storage, production and transport aspects of the food supply chain due to them being the more energy-intensive part of the process.

Global supply chain drivers of agricultural antibiotic emissions in China

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Abstract:

Antibiotic pollution causes serious environmental and social issues. Agriculture is one of the main sources of Antibiotic emissions. On the one hand, agricultural antibiotic emissions are directly caused by production activities (e.g., animal husbandry and aquaculture). On the other hand, they are driven by both local and remote supply chain activities. China is one of the largest antibiotic users in the world, with a large share used in agriculture. This study quantified agricultural antibiotic emissions of mainland China in 2014 as well as critical drivers in global supply chains. Results show that China's agriculture emitted 4,131 tons of antibiotics, including 2,480 tons of tetracyclines, 988 tons of quinolones, and 663 tons of sulfonamides. Final demand and primary inputs (e.g., labor and capital) of Eastern China contributed largely to the emissions in mainland China. Foreign final demand drove 9% of agricultural antibiotic emissions in mainland China and led to 5% - 40% of emissions in each province. In particular, 40% of Shanghai's agricultural antibiotic emissions were driven by foreign final demand. Foreign primary inputs contributed 5% of agricultural antibiotic emissions in mainland China and led to 2% - 63% of emissions in each province. Critical international drivers include the final demand of the United States and Japan for foods and textile products, as well as the primary inputs of the oil seeds sector in Brazil. This study also recognizes important supply chain paths contributing agricultural antibiotic emissions in mainland China. The results indicate the uniqueness of supply chain drivers for antibiotic emissions compared with other emissions. Our findings reveal supply chain hotspots for multiple-perspective policy decisions to control China's agricultural antibiotic emissions as well as for international cooperation.

Timber flow analysis in UK

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Abstract:

This study presents a comprehensive analysis of timber stocks & flows within the UK timber industry, utilizing the material flow analysis (MFA) framework to shed light on the intricacies of production, consumption, waste generation, and recycling and treatment of various timber products. The research employs data from multiple sources, such as Eurostat, FAO, and DEFRA, to construct a detailed Sankey diagram that visualizes the flow of timber in the UK for the year 2018. The analysis reveals the industry's heavy reliance on imports, particularly for roundwood and sawn wood, as well as the significant role of recovered post-consumer wood in the production of new products and energy.

Moreover, the research highlights the importance of wood products, such as wood chips, particles, residues, and fuelwood, in the energy sector, with a substantial portion of these materials used for energy production. The study also investigates the recovery and recycling of waste timber products, uncovering areas for potential improvement in waste management and circular economy.

By providing a comprehensive understanding of the UK timber's stocks & flows, this investigation lays the groundwork for further exploration of circular economy principles and policy implications within the sector. Ultimately, the insights garnered from this research can inform future policy interventions aimed at enhancing resource efficiency, waste reduction, and overall sustainability in the UK timber industry.

Resource integration superimposed revenue mechanism of sustainable supply chain under sudden public risks

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Abstract:

This paper proposes a general and improved sustainable supply chain risk emergency theory. The load capacity of the supply chain of the public emergencies risk is revealed, and the analytical solution of the emergency interruption rate of the sustainable supply chain crisis is derived. A renewable cooperative superposition benefit mechanism suitable for sustainable supply chain risk emergency response is proposed. The improved sustainable supply chain risk design threshold scheme provides an effective choice for the risk nodes of the cooperative sustainable supply chain and realizes a favorable compromise between system performance and the regeneration cost of the target sustainable supply chain node. This study helps to reduce the complexity and cost of sustainable supply chain risk node reorganization. Sustainability studies of sustainable supply chain risks are of support to ensure flexibility, sustainability, and flexibility in the engineering supply chain.

Food consumption and environmental implications for digitalization of food delivery

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Abstract:

Digital technology is changing the way people live, and eating habits are changing accordingly. Online food delivery ordering provides an important medium for exploring changing food consumption patterns and their impacts on the environment. By combining text mining techniques, national online takeaway food ordering, and takeaway recipe data, this study proposes a data-driven computational framework to explore the takeaway food consumption and environmental impacts in China. The results show that animal-based foods account for the largest share of takeaway food consumption patterns in China (33%), followed by grains (31%) and vegetables (28%). Compared to household food consumption, the proportion of take-out animal food consumption increased by 20%. There was no positive correlation between take-out food meat consumption and disposable income per capita. Regions with high per capita disposable income have a low proportion of meat consumption (e.g., Beijing, Shanghai, Zhejiang). Online food consumption generated 6,312 kilotons of carbon dioxide equivalent, of which animal foods accounted for 64%, and the nitrogen footprint and phosphorus footprint were respectively 64 kilotons and 6.9 kilotons. Due to the COVID-19 pandemic, Chinese takeaway food delivery orders will surge to 36 thousand million orders in 2025. If the takeaway food consumption structure in 2025 is as recommended by the China Dietary Guidelines, the takeaway food carbon footprints will be 212% higher than the baseline scenario. Replacing animal-based diets with plant-based diets reduces the needs for feed, water, and fertilizers, helping to ease pressure on food supplies. The study provides a novel analytical framework that reveals the impact of online take-out orders on individual eating habits and the environment. Our findings provide a scientific basis for understanding and optimizing individual takeaway dietary habits and promoting sustainable food consumption under the influence of new consumption patterns.

Study on industrial solid waste metabolism from the perspective of network and supply chain: the case of Tianjin

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Abstract:

The coordinated development of urbanization and industrialization is of great significance for promoting high-quality socioeconomic development in cities. As urbanization and industrialization continue to advance, cities face environmental pollution problems associated with industrial growth, resulting in imbalances in urban ecological systems and posing challenges to sustainable development, with industrial solid waste pollution being particularly prominent. Optimizing the industrial structure to promote source reduction of industrial solid waste is an important measure for promoting the coordinated development of urbanization and industrialization. Therefore, exploring industrial solid waste management based on system thinking and methods is of great significance for achieving source reduction and full-process management of industrial solid waste.

This study takes Tianjin as an example and constructs two types of industrial waste metabolic systems, 2007-CISW (common industrial solid waste), 2007-HW (hazardous waste), 2012-CISW, 2012-HW, 2017-CISW, and 2017-HW, based on the urban input-output table. Using ecological network analysis and structural path analysis based on input-output, the study quantifies the characteristics of industrial solid waste generation in each economic sector within the metabolic systems, identifies the controlling and dependent sectors in the metabolic systems, as well as the metabolic relationships among the sectors, and determines the key metabolic sectors and their main supply chain pathways for producing industrial solid waste. This study aims to identify the temporal-production-structure patterns of the industrial waste metabolic system from the urban and economic sector perspectives and provide technical support for source reduction and full-process management of industrial solid waste.

Global spread of water scarcity risk through trade

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Abstract:

Water scarcity is increasingly perceived as a great challenge to the sustainable development of human society. The economic output loss due to water scarcity is defined as water scarcity risk (WSR), which constitutes local water scarcity risk (LWSR, local economic output loss in water-using sectors due to water scarcity) and virtual water scarcity risk (VWSR, the spread of LWSR through trade systems). However, the traditional water stress index used in the existing WSR assessment research is limited in its accuracy and descriptiveness. Here we address these limitations by quantifying the LWSR with the consideration of environmental flow requirement, water intensity, economic output, and further assessing the VWSR. Results show that the WSR of the world is around 2.7 trillion US dollars in 2016. We also identify the hotspots of WSR at the national and sectoral levels. Our findings help lay the foundation for nations to develop strategies for mitigating WSR.

Breaking down barriers: inclusive leadership and its effect on hospitality employee performance

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Abstract:

Drawing on the social exchange theory, this research advances the understanding of leadership and task performance in the hospitality industry in China by exploring the impact of inclusive leadership on the task performance of subordinates working in dyadic forms. The current literature is scarce on the role of leadership in increasing the task performance of employees working in teams in dyadic forms. Multi-level sample of 410 leaders-subordinates in the hospitality industry was used to derive the research findings using PLS-SEM. The results indicated a positive influence of inclusive leadership on the task performance of subordinates. Psychological empowerment mediated this direct relationship. In addition, trust in leaders strengthened the direct link of inclusive leadership with task performance and psychological empowerment. The findings demonstrate that leaders in the hospitality industry should adopt an inclusive leadership style as it contributes to employee task performance, which improves the industry's performance.

The impact of green finance on the upgrading of regional industrial structure: A case study of western China

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Abstract:

Since the development of the western region, the western region has made full use of its own advantages to accelerate development, and constantly narrowing the development gap with the eastern and central regions. However, while the industrial structure has been optimized to a certain extent, the ecological environment problems have gradually become prominent. As an important ecological barrier in China, how to maintain the sound development of the ecological environment while improving the quality of economic development, green finance may be an important force to promote the upgrading of the industrial structure in western China and promote the green and high-quality development of the economy. Based on the theoretical analysis of the impact of green finance on the upgrading of industrial structure through the mechanism of capital orientation, information sharing, resource integration, capital financing and risk diversification, this paper uses the panel data of each province in western China from 2007 to 2020 to explore the impact of green finance development on the upgrading of industrial structure. The results show that the correlation between green finance and the output value of the tertiary industry is the largest in the western region, and the green finance in the western region has a significantly positive impact on the industrial structure upgrading, but the impact of green finance on the industrial structure upgrading in the southwest is much higher than that in the northwest.

Unraveling the green consumption puzzle: A comprehensive meta-analysis of attitude-behavior determinants

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Abstract:

Green marketing within commercial praxis has amplified the significance of theories elucidating the relationships between attitudes and intentions. Our studies focuses on identifying several determinants affecting green purchase behavior and addressing the attitude-behavior inconsistency. We synthesized the research findings of 226 studies (242 samples, n=207040) and employed meta-analysis to investigate the associations between the constructs of our integrated framework. The findings substantiated support for the integrated framework and revealed a complex mediation role of GPA, GPI, and GT in predicting green consumption behavior. Furthermore, predicated on the univariate meta-analyses and the moderator analyses, we deduce that the principal causes for the attitude-behavior gap and potential agenda for future research have been proposed.

Towards sustainable product returns: collaborating with returns providers for circular and sharing economy

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Abstract:

Recent retail studies have identified CE strategies in product returns, including reselling via secondary markets and donating unwanted returns. Product returns service providers increasingly offer more sustainable solutions that help retailers move towards the CE model. However, it is less clear how the current practices of ‘sustainable’ returns solutions score in comparison with each other. Therefore, we employed a desk research method and semi-structured interviews with 6 leading returns providers. We found that the current sustainable solutions focus on reducing waste, increasing the resell probability of returns, and potentially generating additional revenue, which expands the current concepts of CE and sharing economy principles to utilise resources. Some providers typically offer product-specific refurbishment and redeploy restored products to a wide range of appropriate third-party resellers. Although such solutions may help retailers achieve their CE model by extending the lifecycle of returned products, they may not be suitable for all types of products or return volumes, especially for lower-value products. Other providers focus on 'recommerce' through sharing three distinct types of platforms that provide: (1) online secondary markets that increase retailers’ probabilities to resell the returned products directly, (2) warehouses and the secondary market to absorb the responsibility of the returns and resale from the retailers without third-party involvement, and (3) Peer-to-Peer (P2P) returns platforms that enable returners to ship the unwanted products to new buyers directly. While such solutions support and expand the sharing economy principles to increase the probability of reselling and reduce waste via an integrated platform, they typically lack quality control of the returned products, which may result in reputational damage for the retailers. Our findings provide crucial implications for not only circular and sharing economy researchers, but also retailers to collaborate with returns providers based on their specific types of products, sustainability goals, and economic needs.

A Product Market System framework for Sustainability Assessment for business early decision-making

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Abstract:

The private sector has a growing interest in sustainability, but there is still a gap between their interest and actions. Despite the existence of definitions and tools for Sustainable Business Models (SBMs), they cannot assess the consequences that internal business decisions will have on the external system. This research focuses on developing a Sustainability Assessment (SA) to evaluate early business decisions' impacts and potential benefits, including feedback from external stakeholders to model the specific context within which the business operates.

The Bellagio STAMP and the conceptual framework for a SA proposed by Pope et al. are used to define the SA requirement and understand SBM conceptual gaps. The Product-Market System (PMS) is then introduced not to substitute the SBM concept but to work in conjunction with it, focusing on sustainability considerations in the business decision-making process. In contrast, the SBM focuses on financial considerations.

The PMS numerical model has been studied to simulate the system that extends beyond the business boundaries. External actors, both human actors, such as clients and other company stakeholders, and non-human actors, such as biosphere, environmental resources, social goals, etc. The inclusion of non-human actors and their needs assessment, in accordance with the Max-Neef framework of needs, has been used to model delivered and destroyed value as a proxy of the potential impacts of the business decisions towards sustainability. The PMS model then combines Life-Cycle Sustainability Assessment to assess material impacts, modelling value proposition features, barriers, and needs' satisfaction with non-linear activation functions, and the groups' priorities computed with the BH approach to estimate the external actors' response. The result is a unified model to assess product or service alternatives depending on the specific context where the business operates and including a variety of actors representing the Triple Bottom Line (TBL).

Managing Business Sustainability: A new framework for sustainability measurement in the private sector

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Abstract:

Managing business sustainability is complex, with multiple interconnected aspects including emissions reduction, responsible investment, management of material flows, waste and resources to reduce harmful impacts on the environment and society. This empirical study measures the economic, environmental and social activities of company operations, to evaluate their overall sustainability performance based on the Triple Bottom Line (TBL) concept. Data collected from participating companies has provided insight and a basis for a holistic sustainability framework that goes further than the established TBL model. We propose a '7E' sustainability framework that measures seven facets of business sustainability inspired by existing frameworks and calculates an overall sustainability index with a dashboard of scores. The study analyses activities across seven areas of the organisation (7Es) including economic, environment, expertise, energy, ethics, empathy (social), executive (governance) and decarbonisation activities. The data collected from strategic and operational indicators, is used to measure overall sustainability performance. The outputs of this analysis aims to help companies identify potential savings, improve materials and energy choices, and highlight areas for future sustainability planning. Four company case studies within the tea production and processing sector have been analysed, via a mixed methods approach to collect the relevant data, including a company sustainability survey, data submissions, employee surveys and interviews. The results show that the 7E model provides more detail about a firm's sustainability practices with increased granularity and comparability, and the potential to improve corporate sustainability management through benchmarking and best practice. Interviews with corporate leaders have supported the findings of the study including best practice insights and challenges faced. A wider study incorporating a larger sample of companies in varied industry sectors is in progress to explore the practical aspects and outcomes of applying this approach to corporate sustainability management.

Understanding the challenges of applying circular economy principles to product returns

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Abstract:

Connecting to the Circular Economy (CE) more effectively is fast becoming a core goal for all types of retailers. Recently, the economic loss/waste and environmental damages caused by product returns in retail have been attracting attention from researchers and the media, including social media. However, how to apply the CE concept remains under-researched in the product returns field. Research is needed to explore the challenges and opportunities. Therefore, we employed an interactive research method to collaborate with 18 practitioners who work with/for large retailers, including returns managers, CEOs, and returns technology providers, to identify the barriers to CE in product returns from organisations' internal perspective via interviews, workshop discussion, and feedback meetings. First, we found that the insufficient intra-organisational collaboration between departments resulted in a lack of knowledge about the negative impact of product returns. Therefore, the field of product returns is typically not integrated into a company's wider CE plans. Second, most organisations prioritise the economic aspect of circular strategies for returns. If the financial costs associated with implementing circular strategies outweigh the immediately perceivable benefits, retailers may be reluctant to adopt these strategies, especially for fast fashion retailers. Third, we further identified that the challenge of measurement and data collection of the full economic and environmental cost of product returns is the critical underlying inhibitor. Most practitioners highlighted that the cost of product returns is often too complicated to measure precisely, and the existing environmental assessment approaches are not designed to develop circular strategies in returns. Therefore, our study highlights opportunities for researchers to facilitate the implementation of CE in product returns and proposes future research directions in this field.

Measurement of ecosystem services value loss due to highway construction in China

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Abstract:

Highway construction to meet the increasing demand for transportation can lead to a significant conversion of land use and a consequent decrease in the ecosystem services value (ESV). Nonetheless, there remains a dearth of clarity surrounding the magnitude of ESV loss that can be attributed to highway construction. This study collected data from 184 highway completion environmental protection acceptance survey reports from 24 provinces in China. The land occupation of each project was extracted and a modified ESV measure model was employed to calculate the extent of ESV loss. Furthermore, the study sought to examine the heterogeneity of ESV loss in distinct regions by stratifying China into eastern, central, western, and eastern regions based on their levels of economic development. The results indicated that:(1) Highway construction typically involves the occupation of six land categories, namely cultivated land, forest land, grassland, water area, construction land, and unused land. Notably, cultivated land and forest land emerged as the primary land types affected by highway construction. (2) On average, the construction of one kilometer of highway results in an ESV loss of 313,400 yuan, with the loss attributed to water and forest land occupation accounting for up to 80%, thus significantly contributing to the overall reduction in ESV. (3) The extent of ESV loss resulting from highway construction was observed to vary across different regions, with the eastern region exhibiting a substantially greater loss of ESV than other regions. This study contributes to the development of a theoretical foundation for rational land allocation and the formulation of effective ecological compensation policies.

Investigating surface water flood impacts on road transport via integrated analysis of physical vulnerability and news media data

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Abstract:

Surface water floods are occurring more frequently and intensively due to climate change and rapid urbanisation. The immediate impact of surface water floods is on road transport, especially in densely road areas. Vulnerability assessment has been investigated as an important approach to give potential flood damages to road infrastructures. However, disaster preparations and responses based only on vulnerability assessment do not offer sufficiently resilient measures. Integrating vulnerability assessment and news media analysis could enhance the awareness of stakeholders and communities to minimise flood damage. Taking the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) as a case study, this research developed an integrated framework to assess flood damages on road transport in the GBA. Firstly, vulnerability assessment was adopted to measure the physical damages of surface water floods on road infrastructures in different GBA cities. Then, the temporal variation of news media reports was investigated to track the emotional responses from the communities and flood occurrence time frame on surface water floods. Finally, affected roads and major impacts (e.g., accident, collapse) were extracted through word frequency analysis of road-related and impact-related information. These results indicate that cities with high physical vulnerability tended to demonstrate more negative emotions but may not have higher media records. Emotional responses to floods exhibit strong seasonality, and there is an increase in negative emotions from morning to afternoon within a day. Word frequency analysis revealed that public transport and logistics services (i.e., freight and express postal) were most affected. Most hot flood spots and roads were located in Shenzhen and Guangzhou. This study demonstrated the utility of integrating flood vulnerability assessment and news media analysis for improving flood resilience. Lastly, the findings of this study help stakeholders to develop better disaster preparation and response strategies and deliver sustainable development in the GBA and elsewhere.

Local natural resources for the construction of an emergency “green road” on recent volcanic lava in a biosphere reserve territory

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Abstract:

Building infrastructures in sensitive territories with high environmental protection is a difficult challenge given the need to harmonise the conservation of natural and cultural heritage, the sustainable economic and social development, the use of ecological, recyclable and non-polluting materials —reducing petroleum-based products—, minimising energy consumption and emissions, and reducing impacts on the hydrology.

These difficulties are multiplied if the infrastructure is also an emergency work necessary to restore transport links and basic urban services between the villages that were isolated after the recent volcanic eruption on the island of La Palma (Canary Islands), allowing their social, agriculture, tourism and business recovery after the natural disaster. As an added problem, the very recent volcanic lava flows keep temperatures a few metres below the surface that are too high for construction works and for certain materials such as asphalt pavements, and probably maintained beyond the infrastructure lifespan. However, these abundant geomaterials from the volcanic eruption have favourable pozzolanic and binding properties.

The recent road (LP-213) on volcanic lava flows at temperatures between 150 and 300 ºC at a depth of 3 m is an example of building infrastructures in these difficult conditions. Previously, convection temperatures were monitored by means of boreholes, infrared thermal maps and probable subsoil lava channels were drawn up, and topographic survey were prepared using unmanned aerial vehicles (UAS). All the materials come from the volcanic eruption or are locally produced: volcanic ash, aggregates and rockfill; and lime concrete, which is resistant to high temperatures as an alternative to asphalt pavements. All of them are 100% recyclable, thus guaranteeing the sustainability of the resources.

The results show that it is possible to build in a sensitive environment in extreme conditions by combining modern surveying techniques with the exclusive use of locally-sourced natural geomaterials, reducing energy consumption and emissions by more than 65%.

Parametric pavement life cycle assessment reveals high spatial variability in greenhouse gas emissions of road infrastructure in China

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Abstract:

Road infrastructure plays a vital role in shaping the built environment and promoting socio-economic growth by facilitating daily mobility, job access, and goods distribution. Nevertheless, the construction, use, maintenance, and end-of-life management of road infrastructure consume significant natural and financial resources, energy, and emit greenhouse gases (GHGs). Moreover, the spatial configuration of road infrastructure can impact the distribution of accumulated materials and the material and energy metabolism. Therefore, a spatially refined and accurate mapping of material stocks and GHG emissions associated with road infrastructure can provide valuable insights into the patterns of material stock efficiency and contribute to the development of more resource-efficient spatial configurations.

Against this backdrop, we constructed a parametric life cycle assessment (LCA) model for China's road infrastructure to capture the spatial variability of pavement GHG emissions by identifying the parameters that contribute the most to this variation.

Our analysis shows that China's road infrastructure accumulates a staggering 24 Gt of materials in 2015 , and its embodied GHG emissions are estimated at 567 Mt, assuming current technologies for material production, transport, and pavement construction. Additionally, our analysis reveals that GHG emissions are highly variable across space, with material production-related emissions strongly correlated with air temperature and construction-related emissions with slope. Therefore, our analysis highlights the importance of developing a regionalized pavement LCA model that can capture local or regional conditions, especially for countries with substantial spatial variability in geographic factors.

Sustainable consumption of geomaterials and production of asphalt pavements in sensitive environments: low energy asphalt with waste materials from volcanic islands

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Abstract:

The manufacture of hot mix asphalt (HMA) for paving is one of the most energy-intensive and emission-intensive activities in the construction industry, whose annual global production is estimated at nearly 1.2 billion tonnes. Low-energy asphalt technologies, such as Warm Mix Asphalt (WMA), would allow these fundamental materials for transport infrastructures to be used sustainably in the long term.

In asphalt mixtures, aggregates account for around 90% of their mass, which represents an economic and ecological problem, given the impact of extraction and the limited territory in volcanic islands. A significant portion of volcanic rocks is discarded because of the unsuitable mechanical properties for structural materials, due to their extreme porosity. Therefore, the use of residual aggregates is also vital for the sustainability of the construction industry.

Furthermore, end-of-life tires (ELT) are also a major environmental problem. However, reclaimed granulated rubber from waste ELT can improve the mechanical performance of asphalt (rubberized asphalt, RA), although increasing the asphalt viscosity. Thus, coupling RA with WMA technologies is crucial.

The combination of these three technologies enable cleaner and more sustainable asphalt mixtures for paving and even with increased durability. For this purpose, the main technological properties of these rubberized warm asphalt mixtures (manufactured at different low temperatures by using a chemical surfactant additive composed of renewable components) with waste aggregates are analysed in the laboratory and compared with conventional mixtures. The results show that it is possible to produce these warm asphalt mixtures with rubber and highly porous residual volcanic aggregates in compliance with the specifications for pavements, while improving the performance of certain properties such as the resistance to water action and to plastic deformations. The analysis using eco-efficiency indicators concludes that the energy consumption can be reduced by nearly 25%, reducing emissions by 20% and using waste materials by more than 95% by weight.

Comparative assessment of the sustainability value of jointed plain concrete pavements and fibre reinforced concrete pavements

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Abstract:

Concrete pavements have longer service life and require less maintenance compared to asphalt pavements. Since road transport handles majority of freight and passenger traffic and is often subjected to over loading, it is required to construct large scale road network and concrete surfaces seems an apt solution. However, the sustainability aspect of utilising concrete for large volume constructions is still under debate. To reduce the overall harmful effect on environment due to the construction of pavements, it is necessary to utilize new material technologies such as fibre reinforced concrete (FRC), that result in higher performance with increased service life. At the same time, it should be investigated whether these technologies are beneficial or not, in terms of economical as well as environmental impact. Main objective of the current study is to conduct a life cycle assessment (LCA) of both jointed plain concrete pavement (JPCP) and fibre reinforced concrete pavement (FRCP) and compare the impacts majorly in terms of endpoint indicators such as human health, resource utilisation etc. Design of JPCP based on Indian Road Congress (IRC) 58:2015 and FRCP using mechanistic-empirical design method (MEFRC) is incorporated in this study. LCA includes a cradle to grave analysis, starting from the extraction of raw materials to construction and maintenance of pavement surface. The impact assessment is performed using SimaPro software. The functional unit used is 1 km stretch of road designed for the same traffic spectrum and service life of 30 years. The inventory includes primary data of fuel and energy consumption for construction operations collected from actual sites. All other background data is taken from existing literature, databases, and other sources available on the web. The work is intended to facilitate state and national transportation agencies to implement "green design" policies and practices, resulting in a more sustainable road transportation network.

Thermosetting phenolic resin-based carbon fibers for VOCs adsorption: electrospinning, pre-oxidation and carbonization

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Abstract:

In this work, to reveal the inner association between pre-oxidation and the subsequent carbonization, we set out from powdered thermosetting resin (resole), and obtained 4 types of electrospun raw fibers with different contents of auxiliary agents. The field emission-scanning electron microscope (FE-SEM) was employed to investigate the morphology of fibers and helped choose viable spinning parameters. Secondly, the elemental analyzer and attenuated total reflection-Fourier transform infrared spectroscopy (ATR-FTIR) unveiled the curing process of phenolic fibers, especially the changes in chemical bonds. Finally, the static and dynamic adsorption tests of benzene were performed on different carbon fibers, and the related mechanism was further explained by Raman spectroscopy and texture properties. The results indicate that a proper amount of auxiliary agent promises continuous fibers and chemically associate with resole in the process of electrospinning and pre-oxidation. Moreover, proper time of cure and high carbonizing temperature lead to carbon fibers of high surface area and excellent performance in dynamic adsorption. Essentially, small size of basal planes and amorphous sp2 clusters in carbon fibers readily adsorb benzene with the strong π-π interaction. Hopefully, this work serves as a guideline, providing researchers with more freedom to fabricate and modify carbon fibers from the beginning procedure of spinning.

Constructing 8S management system for sustainable sanitation value chain towards Toilet Revolution

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Abstract:

The Toilet Revolution is a systematic project. China began to promote the rural Toilet Revolution in 2015 and has achieved some progress. However, the implementation of Toilet Revolution still faces many challenges and problems at present. Among them, the management system remains to be much improved.

Based on the current investigation results, this paper constructs a chain of rural household toilet system in China, through the whole system analysis and influence factor matching. Next, the HSE Management System is improved and optimized through the Green Supply Chain theory. And then, the Green Supply Chain Environmental Management 8S System and the Improved HSE Management System have been constructed. The 8S in the newly constructed system are: Sanitary facility, Standardized system, Safe reuse, Social-acceptance, Scientific management, Service water, Sustainable operation and Surrounding environment impact minimum. Based on this, this paper constructs a management system that is more suitable for China's rural toilets, puts forward five management modes of environmental health management system of Chinese rural Toilet Revolution, and analyzes the areas where these five management modes are applicable.

Adapt to local conditions. It is of great significance to realize the construction of toilets and the upgrading of transformation technology and guarantee the long-term operation of toilet system in rural China.

Advancing the circular economy for E-commerce packaging waste in India by closed loop models

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Abstract:

The exponential growth in e-commerce has led to an increase in packaging waste with various environmental impacts. Due to the lack of effective waste management strategies, the issue of packaging waste is a matter of concern. Corrugated cardboard boxes (CCBs) are one of the most common packaging materials used by e-commerce and are linked to deforestation and carbon emissions. This study developed a closed-loop approach for e-commerce deliveries based on a circular economy and gave a holistic assessment of environmental impacts in India. It was based on the implementation of reusable packaging made from polyethylene terephthalate that can replace multiple CCBs. A life cycle assessment (LCA) was performed to compare the environmental impact of this packaging with a conventional CCB of ~200 grams. System boundary includes lifecycle stages of production, transportation and disposal for one successful e-commerce delivery. By varying the recycling rates (%) of CCB and total successful cycles of the reusable package, this study presented four scenarios: low recycling, low cycles; moderate recycling, moderate cycles; high recycling, high cycles; and very high recycling, very high cycles. This study suggested that a significant reduction in environmental impacts is possible. By adopting the reusable packaging approach, damage to human health and resource availability can be reduced significantly by more than 90% across all scenarios. The damage to marine, terrestrial and freshwater ecosystems was relatively more significant for reusable packages in only the first two scenarios. It can be further be reduced by increasing the total successful cycles. The findings of this study could serve as a foundation for a circular e-commerce packaging strategy for India and other countries, contributing towards sustainable solid waste management.

Sustainable solutions for the management and recycling of pharmaceutical blister packaging waste

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Abstract:

Pharmaceutical blister packaging waste has been increasing in recent years due to the widespread use of blister packaging in the pharmaceutical industry. Blister packaging is a common form of packaging for many types of medication, including tablets, capsules, and pills, and it typically consists of a plastic film and an aluminum foil layer. The use of blister packaging has several advantages, including improved medication safety, enhanced shelf life, and easier identification of individual doses.

However, the increasing use of blister packaging has also led to a corresponding increase in the amount of waste generated by this form of packaging. One of the main challenges associated with blister packaging waste is that it is composed of multiple layers of materials, including plastic and aluminum, which makes it difficult to recycle. This waste is typically disposed of through incineration or landfilling, which can have negative environmental impacts and contribute to climate change, such as air and water pollution and greenhouse gas emissions.

To address this issue, there is a growing need to develop more sustainable packaging alternatives that are biodegradable, compostable, or made from recycled materials. Additionally, pharmaceutical companies can take steps to minimize packaging waste by optimizing packaging design, reducing the size of packaging components, and implementing take-back programs to facilitate the safe disposal and recycling of unused medication and packaging materials.

Another approach is implementing circular economy principles, which aim to reduce waste by keeping materials in use for as long as possible. This could mean implementing take-back programs in the pharmaceutical industry, where unused or expired medications are returned to the manufacturers for proper disposal or recycling.

Ultimately, addressing the issue of pharmaceutical blister packaging waste will require a concerted effort from all stakeholders, including manufacturers, consumers, and policymakers, to promote sustainable practices and reduce the environmental impact of the pharmaceutical industry.

Construction, demolition, and excavation waste management in the U.K.: A analysis based on the European Waste Catalogue statistics

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Abstract:

The construction industry is the largest consumer of materials and generates the largest waste stream by mass in the U.K. In 2021, 36 % of the total waste generation in England was attributed to construction, demolition, and excavation (CD&E) waste. U.K. Government has set out an ambitious goal to 'eliminate avoidable waste of all kinds by 2050'. The European Waste Catalogue (EWC) is a standardized classification system used to identify and categorize different types of waste generated in the European Union. In 2005, the EWC codes were incorporated into U.K. law via the List of Wastes (England) Regulations 2005, which implemented a was implemented 6-digit waste coding and tracking system to classify waste generated in the U.K. This development has opened up new opportunities for the management of CD&E waste in the U.K. from estimating waste generation to referring to waste statistics. In this study, we first performed a bookkeeping-type material flow analysis to demonstrate the state quo of the CD&E waste generation and treatment in England in 2021. Then we further analysed the spatiotemporal characteristics of the CD&E waste generation and treatment in England from 2006-2021, including the waste composition and form, original region of CD&E waste generation, the fate of each CD&E waste stream, and recovery rate. Based on the findings, we identified the hotspots for enhancing CD&E waste management in the U.K. and proposed potential policy implications to achieve the 'zero avoidable waste' goal in the U.K. In addition, we also discussed opportunities and challenges of the current statistics in support of CD&E waste management.

Distinguishing phosphorus loss categories for its sustainable management

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Abstract:

Phosphorus (P) deficiency in agricultural systems is essentially caused by excessive P loss along the seaward terrigenous P flow chains in the anthropocene. While, P loss can be contributed by complicated and diverse factors with expanding P flows and the changes in the interacted socioeconomic-environmental systems. Discriminating P loss categories and clarifying their leading drivers are necessary for formulating effective and feasible countermeasures for intercepting terrigenous P loss to extend its available duration and quantity in the anthropocene. Based on systemic view, P loss categories were distinguished according to their respective decisive driving factors, and systematically classified into an extensible scheme for sustainable P management. The scheme consists of 3 categories which are divided into 11 subcategories. Expected characteristics of each subcategory was distinguished for formulating effective P loss retention measures, including expected determinant-induced loss mechanism, action media, driving way, and loss behaviour features of P loss and effective scope of P loss reduction measures. According to its driving factor of each P loss subcategory in the scheme, corresponding P retention measures can be systematically derived from current dispersed and fragmented results of P loss analysis. Moreover, this scheme would provide a gross framework for future profound studies on the relationship between P loss categories and sustainable P management by broadening our understanding the mechanism of the critical factors affecting P loss.

Environmental footprints of beverage cups based on their different materials and management methods

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Abstract:

We compared the environmental performances of alternative ways to serve with beverage cup in coffee shops considering the entire process associated with cups, i.e., from the production to disposal. we built five alternative scenarios considering the commonly used single-use cups (paper and polypropylene (PP) cups and the uses of reusable cups (PP and stainless steel cup) in line with governmental policy to reduce the uses of single-use products: (i) incineration of single-use cups (ii) recycling of hand-washed single-use cups (iii) recycling of single-use cups with dishwashing machine (iv) reusing hand-washed reusable cups at shop (v) using reusable cups with dishwashing company service. We set the functional unit to the weight of a 380 mL volume cup commonly used in coffee shops, and the reference flow is the uses of 300 single-use cups, or 300 times reuses of the reusable cups to quantify carbon, water, and resource depletion footprints of each system. Compared with the incineration alternative, the recycling alternative had the largest reduction in carbon footprint for the paper cups and the single-use PP cup. For water footprint, the recycling had higher than paper cups and higher than single-use PP cups. For the resource footprint, the recycling had lower than paper cups and higher than single-use PP cups. Compared with the single-use cup recycling and the reusing alternatives, the carbon and water footprints for the reusable PP cup were higher, whereas the resource depletion footprint was lower than the paper cup. The carbon and water footprints of the stainless-steel cup were high, and the resource depletion footprint was lower than the paper cup. This study can be used to establish environmental policy to reduce the environmental impacts related with the uses of beverage cups.

PlastiCity: capturing lost urban plastics for circular applications

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Abstract:

PlastiCity was an Interreg2Seas project (2019-2022) that aimed to increase commercial and industrial plastic waste recycling rates in The Hague (NL), Southend on Sea (UK), Ghent (B) and Douai (F). The project explored both technological aspects of sorting and processing waste plastics, especially plastic films, as well as innovative logistics for collecting plastics in urban environments. Different collection scenarios were developed and modelled to help stakeholders understand the various challenges that come with the use of alternative vehicles, such as CargoBikes, CargoTrams or CargoBoats, and the handling, sorting, clearing and shredding of waste plastics. We learned that the energy mix available in a country or region have a significant influence on the desirability of electrical vehicles. Furthermore, general recycling without clear purpose is far less interesting than targeted recycling, where a waste material source (e.g. a certain type of plastic used in gastronomy) is identified as the material to be used for a specific application, e.g. the production of eye protectors / visors for medical and laboratory use by a local company. Whenever possible, local applications for the recyclate should be identified, as opposed to selling the materials on the open market and often to buyers in the Far East, which brings price insecurity as well as long distance transportation.

Potentials of no single-use plastic initiatives in plastic waste management in island communities in Central Vietnam: Implications from local stakeholder interviews

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Abstract:

Vietnam is considered one of the most significant contributors to marine plastic pollution and has conducted some local island initiatives to tackle this issue. Still, little has been studied on how such initiatives have changed and maintained pro-environmental practices among local people. This study aimed to evaluate the benefits of plastic waste initiatives in terms of awareness and practices among local island residents.

Qualitative data were collected through interviews with major stakeholders, i.e., the local authority and residents in fishery, farming, and tourism sectors, in two popular tourism islands in Central Vietnam: Island A (with the initiatives of no single-use plastic, n = 13) and Island B (without, n =16). Data were analyzed using thematic analysis and SWOT analysis.

Island A respondents were more concerned about local plastic pollution issues and stated more specific events regarding plastic waste than the other island respondents. Also, they had continued daily anti-plastic practices such as avoiding plastic bag use, avoiding littering, and joining beach clean-up, while such practices were much less stated among the respondents of the other island. This difference may be explained by the initiatives of no single-use plastic being done in Island A. Involving important local unions (e.g., women, farmers, youth) in the initiatives also contributed to systematic and continuous implementation. To fully understand the potential of the initiatives, however, we must also consider some other factors including tourism characteristics, policy priorities, and political will. The common challenges in plastic waste management were a lack of fundamental waste management capacity including collection, treatment facilities, and budgeting, which also impede proper waste separation among local people.

The present results suggest local government initiatives play a crucial role in shaping people's behaviors and attitudes toward mitigating marine plastic pollution.

Analysing the environmental footprints of domestic air source heat pumps

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Abstract:

Air source heat pumps (ASHPs) are increasingly being recognized as a low carbon alternative to traditional heating systems for residential buildings, with many countries targeting their mass deployment to meet their emissions reduction goals. However, the environmental impacts of ASHPs throughout their entire life cycle have not been fully evaluated. This study conducts a review of academic studies that have quantified the life cycle impact of domestic ASHPs. Alongside the review, the study also focuses on environmental product declarations (EPDs) and compares different industry assumptions, such as the widely used TM65 methodology. The main objective of this study is to identify the hotspots in the life cycle of ASHPs that contribute the most to their environmental impact.

The review analyses emissions during the embodied and operational stages and concludes that the majority of the environmental impact for ASHPs occurs during the operational stage, with the life cycle impact being highly dependent on the energy source used to power the device. It also identifies that, compared to the attributional approach, a consequential life cycle assessment approach can lead to an average reduction in the environmental impact of heat pumps. The review of EPDs highlights the importance of considering specific device characteristics based on typology, along with the analysis of the useful insights and limitations of industry assumptions such as TM65 and PAS 2050.

Several hotspots in the life cycle of ASHPs that require further attention are identified, including the production of refrigerants, the energy source used to power the device, and the end-of-life disposal of the unit. Based on the analysis, recommendations are presented to provide insights to the scientific community to help policymakers and industry stakeholders identify areas of improvement for ASHPs in terms of their environmental impact.

Global multi-stage footprints of iron and steel elaborate material basis of economy: integrating physical material cycle analysis and monetary multi-regional input-output analysis

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Abstract:

Iron and steel are regarded as the backbone of industrialization and urbanization. The relationship between socioeconomic metabolism of steel and economic output has long been investigated to measure material productivity. Traditional indicators constructed from economy-wide material flow analysis (EW-MFA) or consumption-based metal footprint (MF) only captures the dependency on raw material extraction, which can not reveal the metal-economy linkages through the entire supply chain. This study integrates physical-unit multinational anthropogenic steel cycle and international trade network of steel-containing products into global monetary multi-regional input-output (MRIO) model to quantify multi-stage steel footprints. Material efficiency indicators based on multi-stage MFs, including iron ore, crude steel, castings, finished steel, and final steel products, are then compared with conventional indicators based on domestic material production (DMP) and domestic material consumption (DMC).

We find multi-stage MF indicators exhibit a much stronger linear correlation with gross domestic product (GDP) than DMP and DMC. For example, the correlation coefficient (adjusted R2) between per capita finished steel footprint and per capita GDP is 0.787, compared to 0.380 for DMC and 0.152 for DMP. Moreover, the footprint indicators highlight the significance of international transfer of embodied metals in the global steel cycle. Despite that direct trade of crude steel only comprises 3.2% of its global total production, the share of embodied trade of crude steel footprint amounts to 42.5% in 2018. In addition, multi-stage MF indicators have more equal distributions among countries than DMP and DMC. The Gini coefficient of finished steel products is 0.419 for MF, compared to 0.460 for DMC and 0.471 for DMP. Multi-stage footprints can also adjust traditional indicators to reveal material intensity or productivity through a supply chain perspective. For example, material productivity of China is increased from 12.7 EUR/kg based on DMP of crude steel to 16.2 EUR/kg based on crude steel footprint.

Advancing high-impact pro-environmental behaviors: a comprehensive review and development of a novel carbon footprint calculator

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Abstract:

The integration of carbon emissions assessments into social science research on pro-environmental behavior is critical in the face of climate change. Our analysis of 24 existing carbon footprint calculators reveals inconsistencies in methodology, reference data, user inputs, output presentation, and adherence to scientific standards. To better understand these discrepancies, we conducted a profile test on current calculators, which revealed significant variations in their output, further underscoring the need for a more consistent and reliable tool. To address these gaps, we developed an R package and a Qualtrics template for social scientists, drawing insights from the tested profiles of current calculators. Our novel carbon footprint calculator prioritizes transparency, customization, and scientific rigor, employing clearly explained methodologies, well-referenced data sources, and established scientific standards such as ISO and GHG Protocol. Our calculator aims to assist social scientists in conducting more accurate and impact-focused studies on pro-environmental behavior, contributing to the advancement of climate change mitigation behavior and the promotion of sustainable practices across various social contexts.

The dynamic environmental impact of household laptop consumption in the UK from 2011 to 2020: a full life cycle assessment

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Abstract:

Global waste generation has increased substantially in recent years with no sign of slowing down, causing both economic and environmental issues. These issues are particularly notable for waste of electrical and electronic equipment (EEE) as critical metals are increasingly used in manufacturing modern EEE and the recycling rates are significantly low. However, the understanding of the flow of end-of-life EEE and the associated environmental impacts remains poor, posing significant barriers to develop strategies to increase reuse and/or recycling. We overview the current literature, government/industry reports, and inventory data on the end-of-life EEE and provide a comprehensive analysis to identify the flow in the UK between 2011 and 2020 and evaluate the dynamic environmental impact of every major stage of a typical household EEE - laptop, including manufacturing, purchase, in-use stock, waste collection, reuse (resell or give away), repair/refurbishing, recycling and recovering, and waste treatment, by combining a material flow analysis with a full life-cycle assessment. For end-of-life laptops, our estimates indicate that not more than 40% were collected for secondary use, while the recycling rates decreased from 43% in 2011 to 34% in 2017. The estimated global warming potential of household laptop consumption in 2011 in the UK was nearly 1 million tonnes of CO2 equivalent, which has been more than doubled by 2020. The estimates generated in this study are essential for developing a circular economy model for end-of-life EEE.

China capital service accounts 2003-2020: a perspective of capital endogenization in input-output tables

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Abstract:

China has maintained the largest scale of economic growth over the past two decades, mainly driven by investment. It is suggested that approximately 40% of China's CO2 emissions are associated with the production of capital goods, making it an attractive issue to investigate China's carbon emissions through a capital goods perspective. Traditionally, capital goods have been treated as exogenous demand in input-output (IO) tables utilized in consumption-based carbon accounting. However, capital goods have an extended life span compared with other commodities and offer long-term productive inputs for the functioning and development of the social economy, commonly referred to as capital services. This study constructs an updatable inventory that includes capital services within the context of 42 sectors in 31 provinces of China, spanning from 2003 to 2020. The methodology implemented is consistent with the national economic accounting system and mitigates the limited consideration of inter-period inputs of capital goods from previous studies on endogenizing capital transactions in IO tables. This inventory can facilitate the development of a multi-regional input-output table for China, including the endogenization of capital goods, and enable the examination of China's emission patterns at both the national and regional levels.

Waste flow and environmental analysis of the municipal solid waste management in England

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Abstract:

The UK generated approximately 26.4 million tonnes of household waste in 2019 (12% of overall waste generation), with England responsible for 83% of the UK total. The recycling rate for wastes from households was 46.2%. An open-access WasteDataFlow database published by the UK government contains high-resolution local authority waste management data for England including waste categories, quantities, waste origin, and destination. This study compiles this data to map waste arising and existing waste processes in England to answer the following two questions: How and where are municipal solid wastes in England generated, transported, and treated? How can the findings be used to inform waste management strategies to minimise the environmental impacts? The geospatial analysis in this study addresses the data gap of waste transport by using the geocodes of the recycling facilities and a Python script to model the transport distances and duration. The extended dataset is analysed through material flow analysis and life cycle assessment and visualised to facilitate an understanding of current waste management in England. The results highlight the potential for reducing the environmental impact by optimising transport routes and recycling processes for wastes. The findings can inform decision-making to optimise waste management strategies when planning new recycling.

The environmental impacts of emerging lignin-first biorefineries: A consequential life cycle assessment approach

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Abstract:

The innovative reductive catalytic fractionation (RCF) and its lignin-first valorization strategy aim to entirely valorize wood into high-value end products. Although the RCF process has already proved its novel high-value applications among many innovative approaches, the extent of environmental impacts and consequences of the RCF process implementation and its lignin-first valorization strategy is not fully known.

Therefore, a demand-driven consequential life cycle assessment is conducted to study the expected environmental changes as a consequence of a change in demand for the RCF products – pulp, monomer, and oligomer – using Belgian long-term electricity and heat mixes. The RCF products are compared to their alternative counterparts (unbleached sulfate pulp, fossil oil-based phenol, and bisphenol A).

Spatially explicit life cycle assessment of China's power sector in 2020

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Abstract:

The transition in China's power sector has already reduced carbon emissions noticeably. However, other associated environmental impacts should also be assessed in a spatially explicit way to understand localized environmental consequences. This paper analyzes the spatial distribution of a wide range of environmental impacts of China's power sector in 2020 from a full life cycle perspective. For the first time, we established spatially explicit life cycle inventories (LCI) of China's power sector in 2020 at a provincial level, covering the main electricity generation technologies such as coal, natural gas, hydro, nuclear, wind and solar power. IMPACT World+, a regionalized life cycle impact assessment (LCIA) method was adopted to evaluate spatially explicit environmental impacts. Our assessment shows that coal power contributes the most in the majority of impact categories due to its 62% share in the national generation mix. However, 81% of mineral resource depletion impact was attributed to wind power due to its high impact intensity of 7.4g mineral deprived/kWh, which is one to two orders of magnitude higher than other technologies. Hydropower contributed most (43%) to the land transformation (biodiversity) impact due to its higher impact intensity at 1.2 cm2 arable land eq/kWh compared with other technologies (ranging from 0.024 for nuclear to 0.43 cm2 arable land eq/kWh for coal). Spatially explicit impact results show that electricity generated by a single technology in one province can have a widespread environmental footprint nationally and globally, depending on the spatial distributions of processes and associated elementary flows along the life cycle. This study not only provides up-to-date references for the average impacts of the national power system but also informs targeted spatially explicit interventions to mitigate life cycle environmental impacts.

Developing a green economy framework for sustainable development goals: circular supply chain and green resources productivity

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Abstract:

Nowadays, business performance is not exclusively measured based on dollars and cents but also supports balance growth by maximising the use of green resources to improve corporate brand, productivity, equality and human well-being. In addition, it can lessen the environmental risk and dependence on the scarcity of raw materials derived from nonrenewable materials. In the transitional phase of the green economy, the industrial sector has been accelerated to practice low-carbon operations, but a lack of advanced technology, expertise, and green legislation has hampered the smooth sailing implementation. Aware of the importance of a green economy, this study aims to develop a framework to achieve sustainable development goals. The framework has been developed based on enablers of the circular supply chain and its impact on green resource productivity. In addition, this study examines how the firms allocate green resources in production and offer better consumption value to participate towards current and future prosperity. The data collected from multiple industrial sectors in Malaysia contributed to better conceptualisation and achieving green economic outcomes. Case studies drive the initial development of the green economy framework, which has been validated using a multi-analytical hybrid structural equation modelling-artificial neural network (SEM-ANN) technique. The results indicate that government support, legislation, and knowledge as drivers of the circular economy have become critical for implementing green resource productivity. This study provided the theoretical framework for scholars and practitioners interested in exploring the circular economic concept that can impact green resource productivity with good utilisation of value chain practices.

Can higher resource utilization be achieved in fisheries supply chains? -Status and challenges from Iceland and Norway

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Abstract:

Amid a climate, food, and biodiversity crisis, reducing the negative impacts of global fisheries is necessary. Most of the harvested fish from Norway and Iceland is from sustainable, but fully exploited fish stocks. Increasing the harvest is therefore not considered a sustainable option to meet the future demand of seafood protein in a growing population. Simultaneously, there are significant amounts of under-utilised rest raw materials (RRM), such as heads, skins, viscera, and food loss and waste (FLW) occurring in the fisheries supply chain. Increasing resource utilisation has the potential of creating more circular supply chains and meet global sustainability targets such as SDG #12 (Ensure sustainable consumption and production patterns), which will contribute to higher value-added products.

A holistic view of the fisheries supply chains is needed, including transport, secondary processing, storage and retail. We propose a conceptual model of the fisheries supply chain in Norway and Iceland based on material and information flows modelling technique (MIFMT). Here we aim to identify where FLW occur and where there is a potential to increase the use of RRM, and which regulatory, technical, and logistical barriers and opportunities exist for increased sustainability and resource efficiency in fisheries supply chains.

Several drivers for FLW in fisheries chains have been identified for example catch technology, communication, over purchase, cold chain inefficiency, packaging, rejection due to quality issues. Our findings show that regulatory interventions during harvest and improved RRM traceability could improve the use of RRM in fisheries supply chains. Information sharing between the fishing fleet, seafood processors and the marine ingredient sector will allow improved resource utilization through better management of supply and demand. A focus on the retail stage will result in larger savings of FLW which could reduce GHG emissions.

Sustainable supply chain design for palm oil wastes in the regions of Indonesia

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Abstract:

Palm oil is a crucial commodity that contributes significantly to the well-being of numerous communities, the gross domestic product, and the attainment of Sustainable Development Goals. Nevertheless, the accumulation of palm oil wastes generated by the palm oil industry is growing alarmingly in many regions of Indonesia and most of them are underutilized. In order to overcome these issues, the efficient utilization of palm oil wastes is necessary to transform them into value-added products, such as electricity and fertilizers. It can benefit economic profit while addressing environmental issues. Regional or geographical differences greatly influence the optimal supply chain design to achieve sustainability. The objective of this study is to optimize the supply chain planning and design model with consideration of by-products, namely, electricity and fertilizers. This study proposes a multi-objective mixed-integer linear programming model to maximize profit while minimizing greenhouse gas emissions. The model takes into consideration of various wastes, technologies, and modes of transportation to reflect the current state of the oil palm industry in Indonesia as closely as possible. Various scenarios will be examined by taking into account current policies and new practices leading to sustainability. It is hoped that these findings will provide insights for policymaking to maximize regional economic gains from the palm oil industry by considering palm oil waste and supporting the sustainability targets in Indonesia.

Analysis on the resource-environment net benefit and equity in the global trade of rare earth

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Abstract:

To solve the inequity of resources and environment in rare earth resource products trade, this research evaluated the actual net benefits in resources and environment of all countries involved using Life Cycle Assessment combined with Cost-Benefit Analysis. This paper also assessed the impacts of trending developments in the global manufacturing industry under three main scenarios. Results show that in 2018 the actual net benefits reached 8.5 billion dollars, mainly contributed by trading raw materials of rare earth. Under future scenarios, policies associated with green development and climate change goals are estimated to reduce net benefits by 17%. In contrast, they remain the predominant policy path for solving the inequity problem. The transfer and reconstruction of global industrial chains lead to an 11% decrease in net benefits, meanwhile exacerbating the inequity issue in low-income countries. Developments in the emerging manufacturing industry increase net benefits by 76% while leaving the severe inequity situation in low-income countries unresolved.

Integrated product development model oriented to green supply chain management – application in a furniture industry in the south region of brazil

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Abstract:

For environmentally sustainable products development and Green Supply Chain Management (GSCM) activities, it is important that environmental limits are respected and the consumption of natural resources is reduced. To meet these needs, companies have sought to create environmentally sustainable alternatives for products and processes, due to government, market, and legislation pressures. Thus, the problem question of this study is: “How to relate the activities of GSCM and Product Development Processes (PDP) in a model that organizes the main operational factors? This study aims to propose a conceptual model of PDP that is oriented to the GSCM. As specific objectives, the present study intends to present models that are related to the themes of GSCM and PDP published; correlate existing activities in the PDP and GSCM using IDEF0; present a conceptual model of PDP oriented to GSCM, present the application of the conceptual model in an experimental case in a Brazilian furniture industry located in the south region of Brazil. By classifying the research according to the scientific objective, the present research is classified as exploratory, concerning the approach the qualitative method was chosen, it is applied research and the technical procedure used was the literature review and experimental cases, those that were results of the systematic literature review and content analysis. As a result, it was found that due to the competitive market and the lack of demands for compliance with regulations, environmental practices are reactive, that is, they are only met when there is a demand from the customer or regulatory pressures.

Implications of deglobalisation for sustainable supply chain management: an exploratory study

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Abstract:

Deglobalisation has mainly emerged as a backlash against free trade after the collapse of the globalised world due to the 2008 financial crisis. The deglobalisation or “slowbalisation” has been gaining attention in the management research to describe the situation wherein international value chains and multinational activities are becoming more regional and/or national due to higher labour costs, geopolitical tensions, trade wars, risks of global sourcing, export controls, just to name a few. For instance, the supply chain chaos and disruptions due to COVID-19 and insular phenomenon such as Brexit encouraged the UK manufacturers to bring the production back home in a “reshoring” push. Similarly, construction spending related to manufacturing has reached the highest level on record in the US. The impact of deglobalisation, reshoring or localisation on sustainable supply chain management particularly environmental and social sustainability needs more investigation. For example, taking deglobalisation initiatives in supply chains can raise various questions in relation to environmental footprint, supply chain configuration, location selection decision, product design, supply chain performance, economic productivity, and potentially many other factors. This study first aims at consolidating and synthesising previous research in the areas of international business and supply chain management to identify the antecedents of deglobalisation for the global supply chain management. Second, it aims at developing a theoretical framework such as a thematic map to propose new unexplored future research directions. This study seeks to answer the following research questions: (1) What are the antecedents of deglobalisation in supply chain management? (2) How can deglobalisation contribute to a sustainable supply chain management, resource sustainability and a circular economy? This study adopts a qualitative research approach to answer the research questions.

Can industrial agglomeration increase the wood resource efficiency?

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Abstract:

The use of wood resources would replace high-energy-consumption materials, which can achieve the goal of sustainable resource utilization and play an essential role in mitigating climate change. China is the major timber importer and wood processing country with a complete upstream and downstream industrial chain. The features of industrial agglomeration are important to promote the wood processing industry. Therefore, China's wood resource efficiency has a crucial influence on the global wood utilization rate.

This study aims to explore the impact of industrial agglomeration on wood resource efficiency and evaluate the possibility of improving efficiency by building or expanding wood processing clusters. We employed semi-parametric estimation to calculate the total factor productivity (TFP) of Chinese wood processing enterprises and analyzed the TFP's spatial-temporal evolution. Furthermore, we discussed the relationship between spatial agglomeration and China's wood resource efficiency based on the econometric regression model and heterogeneity analysis.

We also found that the spatial agglomeration of China's wood processing industry has a significant positive impact on TFP through three aspects: "labor", "goods" and "innovation", which proves that it is feasible to improve the productivity of enterprises and enhance the utilization efficiency of wood resources by rational utilization of agglomeration effect. In the aspect of land price, it brings negative externalities to the agglomeration effect of the wood processing industry, and high land price offsets the economic externalities brought by agglomeration. As for the heterogeneity of natural forests, the promotion effect of agglomeration on productivity has little to do with different natural forest stock in areas. By contrast, planted forests in China provide raw materials like logs for enterprises. In areas with larger forest plantations, agglomeration can give full play to the advantages of economic externalities and promote productivity.

Trade-offs perspective highlights the potential of rooftop photovoltaic development in cities

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Abstract:

The sharp rise in urban energy demand points to the urgency for clean energy utilization. Photovoltaic (PV) power generation provides a chance to increase the resilience of urban energy systems, and ground and rooftop spaces show the potential for PV development. This study establishes a methodology framework that could serve as a decision-making tool for developing ground-mounted PV (GPV) and rooftop PV (RPV) at the city scale. The framework integrates (i) the geographic information system to extract the potential areas for PV systems, (ii) life cycle inventory analysis from the perspective of energy-water-land-carbon nexus, and (iii) multi-objective optimization based on the life cycle impacts, technical potential for power generation, and the levelized cost of electricity for urban PV systems. We further take Beijing, China as the case to demonstrate the utility of the methodology framework. The detailed life cycle inventory results show that RPV outperforms GPV in terms of life cycle energy consumption, water consumption, land occupation, and carbon emissions. More than 80% of the life cycle impacts are concerned with the material production stage of both GPV and RPV. Through the environmental-economic-technical multi-objective optimization, cities tend to develop RPV due to their relatively conservative life cycle impacts, which is the positive feedback on the national policy of RPV implementation in China. The results could direct the optimal development scenarios for urban GPV and RPV based on the trade-offs of environment, investment, and generation, and offer development possibilities for GPV and RPV.

Circular economies on green sustainability: a review

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Abstract:

Global sustainable development can be defined as the linear, throughput flow of energy and materials between the natural world and the economy. Linear flow systems cause the global ecosystem to shrink, and the deterioration of the system itself, both qualitatively and quantitatively from increasing resource demands. Consequently, materials and products become unsustainable and progressively downgraded upon recycling, which can become harmful to human health and the environment. Therefore, a cyclical flow of energy and materials needs to be implemented in its place, in the form of circular economies (CEs). CEs have the potential to address sustainability and sustainable development from a truly holistic approach. Hundreds of journal articles on CEs have been published, all composed of fragmented and integrated ideas of CEs as a concept. However, the literature lacks depth in certain aspects, and CEs are not without their limitations. In order for CEs to embody truly green sustainability in the long-term, there must also be significant changes that encapsulate a truly holistic mindset on various spatial-temporal scales and dimensions. Three papers were examined from the Web of Science database. Sustainability was regarded as an intrinsic part of CEs, albeit the literature lacks depth in their relation to each other and does not explore a holistic perspective for either concepts, with no explicit utilisation of approaches like multi-criteria decision making (MCDM). Discussions are also limited to the economic and environmental aspects of CEs, without consideration to long-term viability, and often neglecting the social and political dimensions. Therefore, it is imperative that new frameworks are developed that provide the often-neglected social perspective, as well as clearer links between green sustainability and CEs.

Valorization of aquatic plant biomass resource: A strategic approach towards closed-loop technologies, circular economy, and sustainability

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Abstract:

A large amount of biomass of fast growing and invasive aquatic plants pollute the water bodies in various tropical and temperate regions of the world and is a huge health and environmental concern. One promising strategic approach to address this waste and environmental crisis is valorization of the plant biomass. This work highlights our efforts towards sustainable management of waste aquatic plant biomass, including water hyacinth, duckweed and water lettuce, abundantly available in the Indian waterbodies by generating multiple value added products from them. Aquatic plants biomass, mixed with other fibrous organic waste has been used to make a novel paper pulp that is converted to various pulp-based products including handmade paper, packing material and packing board. Slow pyrolysis of the biomass yielded biochar that has been used as an adsorbent and soil conditioner. Biochar is a carbon rich product and has been known to improve the microbial load of soil, increase the water holding capacity of soil, generate carbon sink, cause enhanced nutrient buffering, decrease nitrate leaching from soil, along with increasing the overall soil texture and productivity. Different biochar variants of aquatic plant biomass, upon fortification with multiple organic materials, yielded a rich soil conditioner that increased the dry plant mass of fenugreek, green gram, millet and wheat by 62.1, 26.8, 50.9 and 50.7% respectively. Both seed treatment and soil applications yielded positive results with fortified biochar. With the property to increase the water holding capacity of soil from 69.5% to 80%, this value product is a promising application in low rainfall or drought hit areas of the world. A strategic public-private partnership can aid in the logistics involved in procurement of the biomass, strengthen the commercial opportunities for establishing a promising circularity in waste management sector, establish entrepreneurship, and support the efforts towards attainment of the various sustainable development goals.

Evolution and endogenous mechanism of platinum trade dependence network from the perspective of industrial chain

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Abstract:

As a key catalytic material, platinum is important for the global green transition, as it is currently used primarily as a catalyst for automobiles and increasingly for emerging and renewable energy technologies. Due to the difference of resource endowment and production level, the international trade of platinum has formed a network structure of mutual influence and interdependence. This paper takes the countries (regions) participating in the trade of platinum products in the world during 2011-2020 as the research object. From the perspective of industrial chain, this paper uses the method of complex network to construct the platinum trade dependence network in the upstream, midstream and downstream stages of the platinum industrial chain. Different from the traditional trade network analysis, we set up the platinum product trade dependence network with dependence relationship as the edge and global dependence index as the weight. At the macroscopic level, the overall scale of the network and the evolution trend of the trade structure are analyzed. The evolution trend of network community and motif is analyzed in mesoscopic level. On this basis, the time exponential random graph model (TERGM) is used to analyze the endogenous mechanism of the formation and evolution of platinum trade dependence networks at each stage from the microscopic level. The results show that the platinum trade dependence network presents a "center-edge" distribution structure, that is, several major countries (regions) are in the center position in the network, and most countries (regions) are in the edge position in the network. Platinum industry chain product trade is highly concentrated. Developed and emerging economies tend to import a lot. The formation and evolution of the trade dependence network at each stage of the industrial chain shows the characteristics of dependence and is significantly affected by the endogenous driving mechanism of the network.

Taxonomy for circular capital project delivery

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Abstract:

Infrastructure assets, both private and public, are delivered through capital projects, often called “megaprojects,” “major projects,” or “major programs.” The capital projects delivery process is based on a linear life cycle where the asset use/maintenance and end-of-life are given limited attention during the design and construction phase, resulting in value leakage and raising barriers to potential value creation opportunities. This paper addresses this problem by developing a taxonomy for a circular capital project delivery model tapping into additional value creation through Circular Economy (CE) based on a whole system approach.

This paper first adopts the scoping literature review methodology to understand the linear capital project delivery model. The review findings report a heterogenous linear capital delivery process with multiple nomenclatures and different value chain stages in the literature. Thus, findings unify the linear value chain with six distinct phases. A second scoping review was performed to develop further layers in taxonomy for the transition to circular capital project delivery. The study revealed limited attention in the literature on circular capital project frameworks, with existing attempts mainly focused on the built environment. Thus, it shows an academic gap in the literature on capital projects, making this paper the first attempt to address the intersection of capital projects and circular economy literature.

The paper introduces a taxonomy that addresses pain areas across different project phases and proposes circular economy intervention strategies to unlock value-creation opportunities at each stage using the systems approach. Additionally, it identifies system-wide enablers, such as net-zero carbon initiatives, business model innovation, data utilisation, and social engagement, as critical factors for transitioning towards circular capital project delivery. The taxonomy is substantiated by case studies drawn from secondary literature. Moreover, it presents an innovative methodology to tackle the UK's net zero carbon goal within the infrastructure sector.

Business resilience through circularity

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Abstract:

In the scope of the PlastiCity project, which was an Interreg2Seas project (2019-2022) aiming to increase commercial and industrial plastic waste recycling rates in urban environments, we conducted a study on how companies in the plastics recycling sector coped with the pandemic. We interviewed 24 different stakeholders (waste collectors, processors, recyclers, and city councils) during 2020-21 in the Belgium, France, Netherlands and the UK to understand the impact of Covid-19 disruptions on how organisations responded the crisis. In contrast to many other sectors, we found that the recycling sector was coping very well, showing a surprising degree of resilience. There were some disruptions due to staff absences caused by illness and the need to self-isolate, but these could be balanced out by shifting staff from lower priority services to higher priority services. The pandemic in combination with the low oil price did lead to a reduced demand for recycled materials, but demand picked up again afterwards, and stock could just be kept until then. We speculate that recycling businesses were resilient during the pandemic due to their engagement in the circular economy, and we explore the validity of this idea in this paper.

Thermal seawater desalination in Almería – exploring the trade-offs of the circular economy

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Abstract:

Water scarcity in arid regions like Almería, in Spain, has led to the spread of desalination systems that split seawater into pure water and brine. These systems contribute to satisfying water demands but come at an intensive energy cost, and lead to brine discharge and associated environmental impacts. This work is focused on a demonstration project for a solar desalination technology in Almería, which aims to recover water and salts from desalination brine. To investigate the potential trade-offs around desalination and resource recovery, we worked with the technology developers in a Value Sensitive Design (VSD) exercise. We found tensions between different sustainability aspects, the distribution of benefits and costs, and long-term sustainability impacts. For example, while some stakeholders argued that the marketization of recovered resources would pay for those costs, the amounts of recovered salts are so large that the feasibility of placing them in a market was put into question. Therefore, there is a risk of turning brine discharge into solid residues or more concentrated wastewater streams. Nevertheless, the recovery of higher-value resources, was pointed as an alternative to explore in further detail. Land use also emerged as a prominent issue. Particularly, the coast in Almería is largely occupied for agricultural production, and the transportation of seawater inland is limited by the surrounding mountains. These observations brought questions over the contribution of the proposed innovation to a desirable circular economy, where there would be high costs to avoid the environmental impacts of increasing water access, in a region where water demand is driven by agricultural export. At the end, most participants concluded that desalination and water efficient agricultural production in Almería would be desirable, and led to two implementation scenarios and recommendations for desalination in the region.

Critical minerals, circular economy roadmaps, and the UN resource management system

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Abstract:

The UKRI Met4Tech Circular Economy Centre focusses on the technology metals such as lithium, cobalt, rare earth elements, etc. that are essential for key applications that support the energy transition to net zero, in particular renewable energy (wind, solar, geothermal, etc.) and electric mobility (batteries, magnets, etc.). Most of these tech metals are now considered critical raw materials in many jurisdictions worldwide. The UK's new critical minerals strategy 'Resilience for the Future' was released in 2022 and describes the steps for addressing the resources for critical minerals. The recent refresh of the critical minerals strategy in 2023 outlines many key action points and plans. The Met4Tech project is conducting several strands of research on circular economy and sustainable resource management that can help to realise these strategic goals for critical minerals. This includes detailed case studies on the value chain for Rare Earth Elements used in magnets for traction engines and wind power to identify points for circular interventions from the view of UK government; and the application of the UNRMS (United Nations Resource Management System) framework to development of the multiple technology metals (lithium, tin, tungsten) and geothermal projects in Cornwall (SW England) from the point of view of regional government. The research underpins the main aim for development of the overall Tech metals circular economy (CE) roadmap for the UK. The roadmapping activity is looking at several value chain examples such as REEs in magnets, and lithium-ion batteries for EV mobility and energy storage. The new Tech metals CE roadmap and agent-based modelling will examine different policy interventions to promote more circular approaches and sustainable management of key critical mineral resources for the UK.

Developing an optimal mode of operation in frozen food processing with the circular economy perspective

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Abstract:

A substantial portion of the food market is occupied by the frozen food industry, which is also becoming more and more popular as a result of socioeconomic change and technological development. Food losses and wastes are prevalent in food processing which utilizes a considerable amount of natural resources, with the production of frozen food causing particularly high energy consumption. The circular economy aims to transform wastes into resources and creates continuous value by establishing a restorative or even regenerative system. Despite many researchers having presented ideas for introducing the circular economy into the food supply chain, they lack in following the production stage closely. As a result, it is critical to take into account the circular economy as a strategic factor when processing frozen food.

The objective of this study is to propose an optimal operation mode for frozen food processing using a multi-objective programming method. It discusses the utilization of resources, including materials and energy, from the concept of circular economy, while also prioritizing the environmental impact, which is a critical issue in the food sector that has not been adequately addressed. To verify the effectiveness of the proposed approach, a case study is conducted with frozen seafood, and the practical implications of the findings are discussed in the paper. The research proposes a significant opportunity for the frozen food industry to transition toward circularity.

Strategic Implementation of Sustainability Philosophies: A systematic review

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Abstract:

Sustainability efforts have increased tremendously over recent decades, some examples of which include the development of novel technologies, promoting and orchestration of global campaigns at intergovernmental and NGO levels, the investment at national and regional levels into ambitious research programmes, and the continuing formulation of methodologies and frameworks for sustainability integration. Examples of such frameworks include Circular Economy, Sustainable Development Goals, Natural Capitalism and many more, all of which are defined to inspire, set goals and guide towards improved sustainability behaviour. As the tempo of sustainability awareness has picked up, so has the number of sustainability frameworks – or philosophies. Whilst each sustainability philosophy has its own reason for emerging and target group(s) to inspire, in some cases, it is sometimes difficult to tell the philosophies apart and understand the nuance differences. Particularly when viewing sustainability philosophies from a corporate perspective, it is often difficult to know which to adopt and how to relate the company efforts to a particular sustainability philosophy. This study sets out to review the current sustainability philosophies in operation, in an attempt to understand pathways to the philosophies' origination, similarities and synergies between and across certain philosophies and gaps as to sustainability aspects that current philosophies do not cover. In addition, patterns are identified, of geography, industry sector, and general application area, to provide an overview and to question, to which extent certain philosophies achieve to guide the sustainability transition that they are intending. Fourteen sustainability philosophies were identified, and the study examined key characteristics of each philosophy, such as the dominance and prevalence of sustainability dimensions, fulfilment of societal needs and integration of philosophy elements into company business processes. In addition, the study examined the sustainability application areas, main contributions, and how philosophies have been translated into strategic, tactical and operational parts of organisations.

Effects of rangeland collaborative management on diversity practices of pastoralists from the perspective of institutional fit: based on the ALAAM modelling

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Abstract:

Regional sustainability relies crucially on a good coupling between society and ecology, it is thus vital to understand the adaptative behaviors of both systems, especially in ecologically fragile areas. Natural scientists have conducted extensive and deep research on ecological adaptation, but the adaptation of social systems remains elusive, especially on the collaborative adaptation of actors from the SES perspective. Using a field survey data from pastoral areas on the Qinghai-Tibet Plateau, the paper empirically examines the effects of the collaborative behaviors of pastoralists that aims to achieve social-ecological fit on their diversity practices, which are one key principle of enhancing resilience, by building a two-layer network of information exchange between pastoralists and ecological connectivity on rangeland parcels, and using the Auto-Logit Actor Attribute Model (ALAAM). The results show that information exchange and pasture sharing between herders can help them flexibly adjust production plans and adapt quickly to market fluctuations. The building block of the closed inverted social-ecological triangle significantly contributes to the increase of the diversity in bred livestock species, indicating that joint management of rangeland and information exchange are conducive to enhance the livelihood resilience of herders. However, such a configuration has no significant effect on the diversity of forage sources. The grazing experience of household head, the frequency of participation in collective activities, the herd size and the income of household all have a significant positive impact on the animal species diversity grazed by herders. To improve the livelihood resilience of pastoralists, it is suggested that information exchange and collaborative management that strives for social-ecological fit should be strengthened.

Can faecal sludge management be standardized?

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Abstract:

Safely managed sanitation services include not only sanitation facilities but also safe disposal of excreta. 2.7 billion people globally are still faced with the threat of unsafe faecal sludge management (FSM). Lack of standards or overly strict standards may lead to the failure of FSM. The design of FSM technology has many forms of coexistence due to the characteristics of different regions, making it very difficult to standardize FS technology. China has launched a series of sanitation and FSM standards since 1980s, which include not only public toilet and faecal sludge (FS) treatment plant in urban areas, but also toilet retrofitting in rural areas. Generally, most sanitation standards focus on toilet (frontend) and present limited information about FS (backend). Recently, ISO 31800: 2020 was launched. This standard focuses on non-sewered FS treatment units with the purpose to specify technical requirements and recommendations for FS treatment units in terms of performance, safety, operability and maintainability. This study will analyze the FSM standardization status in China and around the world to identify the gap to realize sustainable FSM towards UN sustainable development goal 6. The problems and potential barriers for FSM standardization include overlapping standard, lagging standard, incomplete value-chain standard system, unbalanced regional development. Accordingly, the corresponding suggestions are put forward. All potential FSM standards should be attributed under the same governmental department. The group/association and enterprise standards should be promoted along with the paradigm shift from government-dominated to market-oriented model. The development of standard system in urban and rural areas should be coordinated, and distinctive local standards should be enforced. Technical requirements for FS treatment, resource recovery, FS recycling should be standardized. Product certification system could be introduced to regulate access to international market.

Modeling fine particulate matter concentration and potential improvement strategies in urban areas

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Abstract:

Fine particulate matter (PM2.5) is a harmful air pollutant that poses serious health risks. To improve air quality in urban areas, this study developed a Random Forest PM2.5 Model (RFPMM) using machine learning algorithms. The RFPMM was trained and validated using hourly data from the Taipei City Guting air quality monitoring station from 2018 to 2019. It considered factors of local traffic flow, leaf area, observed concentrations of pollutants, temperature, wind, precipitation, and humidity to predict the hourly concentration of PM2.5. Three potential improvement strategies were evaluated by scenario analysis to determine their effectiveness in reducing PM2.5, including creating public transportation incentives, providing electric vehicle subsidies, and planting evergreen trees. Results showed reasonably good performance of RFPMM with mean error, mean absolute error, and coefficient of determination (R2) of 0.16 μgm-3, 4.30 μgm-3, and 0.64, respectively. We found that the accuracy of predictions was influenced by the standard deviation of the observed values for each month and varying between years. At the same time, CO, leaf area, O3, and SO2 were sensitive factors affecting the model's performance. Evaluation results of the three potential improvement strategies were found to reduce PM2.5 concentration effectively. Creating public transportation incentives and providing electric vehicle subsidies can reduce PM2.5 by 6.7% to 33.3% depending on the strength of the policy, whereas planting evergreen trees can reduce PM2.5 by 0.3% to 12.7%, indicating that planting suitable evergreen tree species and maintaining a certain level of green infrastructure can mitigate the problem in urban areas. Based on the results, we demonstrate the use of RFPMM as a policy tool to quantify the influence of environmental and meteorological factors on PM2.5 concentration and provide effective strategies to improve urban air quality.

Delaying the renewable energy transition: An examination of the effects of subsidies on energy industry concentration and competition

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Abstract:

The transition to clean renewable energy is urgent in a climate emergency, but there are barriers to this transition due to incumbents. If a market is competitive, the theory is that new renewable energy entrants offering better solutions should be able to out-compete old fossil fuel and nuclear energy incumbents. However, across many nations, these latter incumbent industries have received subsidies in various forms and for a variety of reasons. Subsidized industries may form powerful oligopolies that reduce competition and lobby governments such that better solutions cannot surface. Therefore, this research aims to investigate the expected effect of energy subsidies on market competitiveness in national energy markets. If governments are subsidizing established industries, then lower market competitiveness is predicted. The potential implication is that a transition to renewable energy cannot be successful. An empirical analysis uses data to relate increasing subsidies to increasing market concentration in fossil fuel and nuclear industries. Theory and data analysis will also explore possible influences on and solutions for bolstering the renewable energy transition. For example, trade policies by powerful international actors such as the European Union's policy supporting green hydrogen could influence trade in hydrogen and, thereby, other nations' choices of internal industry incentives. This research makes recommendations for dealing with oligopolies such as: subsidizing new industries, removing subsidies to incumbents, and external international policies, and in the future, once the competition is renewed, preventing a convergence to any single or narrow set of technological standards so as to avoid the development of oligopolistic industries.

Comprehensive evaluation and policy practice of co-benefits of greenhouse gas reduction and air pollution control: Literature review

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Abstract:

Promoting co-benefits of air pollution control and greenhouse gas (GHG) reduction is the general starting point for advancing the comprehensive green transformation of economic and social development, which is helpful for the construction of a beautiful China and the implementation of the carbon emission peak and carbon neutralization. This paper systematically reviews the concept, category and quantitative evaluation methods of the co-benefits of air pollution control and GHG reduction, analyzes the sources of the co-benefits from the technical dimension, explores the key areas to achieve co-control from the industry dimension, and summarize four key scientific issues in the comprehensive evaluation from the perspective of management science. The standardization of evaluation process and the combination of key factors in each link are complex, while analyzing the emission and transmission process of GHG and pollutants and their relationship will alleviate the complexity. The diversity of time, space and the selection of assessment objects leads to the uncertainty of the estimation. Strengthening the quantification of the impact of greenhouse gases and pollutants on human health, buildings, agriculture and ecosystems can reduce the uncertainty. Enhancing comparability is the basis for proof and comparison of different results. The way to achieve this is to calculate various indicators from different perspectives. Each level of assessment focus on different aspects. Strengthening the hierarchy of assessment can promote different management departments to carry out more scientific co-control practice.

From trash to treasure：Analyzing the evolutionary behaviors of food waste recovery SC agents under the charging policy

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Abstract:

Food waste charging policy requires food waste generators (FWGs) to pay a gate fee to waste-to-energy companies (WTEs) according to the volume of generation, which is based on the fact that the resource treatment of food waste is a net cost and conveys the message that treatment is not "free." However, in recent years, with the changes in the commercial value of food waste and the emergence of opportunistic behavior, the existing charging policy may no longer be capable of guaranteeing the expected management effect. To address this problem, the current study considers a supply chain consisting of FWGs and WTEs investing in reduction and innovation efforts, respectively. Then, an evolutionary game model is established to observe the interactive behaviors and strategic preferences between the pair. Through sensitivity analysis, several practical approaches are provided to motivate FWGs and WTEs to adopt ideal strategies by adjusting key parameters. Furthermore, we explain the rationale behind the food waste charging policy in management. We conclude that the strategy of merely promoting recovery can contribute to wastefulness, yet a cooperative strategy in which recovery is jointly practiced can counterintuitively encourage further food waste generation.

The impact of environmental policies in various countries on steel industry trade: an empirical study based on major global steel trading countries

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Abstract:

With the development of economic globalization and international trade, the issues of international trade and the ecological environment are receiving increasing attention worldwide. Some researchers believe that the fundamental reason for the conflict between trade and the environment is that the products in trade do not reflect or fully reflect environmental costs, that is, the external negative effects of environmental costs lead to price distortions, making market mechanisms unable to effectively allocate environmental resources, leading to overproduction, excessive use of resources, and increasing deterioration of the ecological environment. The steel industry is an important basic industry of the national economy, and the position of steel trade in international trade is also increasing day by day. This article studies the impact of environmental policies on global steel industry export trade through qualitative and quantitative methods, using relevant theories in environmental policies and international trade.

Emergy analysis of agricultural waste biomass for pellet production: A case study in China

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Abstract:

As energy demand and global environmental concerns increase, the use of biomass pellets as a renewable energy source to replace fossil fuels and meet carbon neutrality targets is becoming relatively ubiquitous. Consequently, evaluating the sustainability of pellet production is necessary for the development of pellet fuels. In this paper, taking corn straw pellet production as a case study, the emergy analysis is carried out for three scenarios: corn single production, corn-pellet co-production, and pellet production. A modified approach to the calculation of the environmental loading rate is proposed in, which takes into account the environmental benefits associated with the replacement of fossil fuels by pellet fuels. The results show that in the case of corn-pellet co-production, the joint transformity and the weighted average of transformity are 7.95E+04 and 1.56E+05, respectively. The emergy yield ratio is 1.21 and 1.20 for corn single production and corn-pellet production, respectively. It indicates that corn-pellet co-production is more efficient than corn single production from an energetic aspect, however, it is opposite from an economic aspect. The emergy sustainability index (ESI) of corn single production and corn-pellet co-production are 3.00 and 3.80, respectively. Corn-pellet co-production is more sustainable than corn single production. Although the pellet production has a high ESI of 25.43, it lacks the use of natural resources with the purchased emergy accounts for 100% of the total input emergy. Sustainability of pellet production decreases as the distance of biomass transport increases or the proportion of renewable electricity decreases. The standardization regression coefficient for the two independent arguments is -0.587 and 0.657, respectively. It illustrates that the proportion of renewable energy has a greater impact on the sustainability of pellet production than the distance of biomass transport. As the rural energy transition evolves, the viability of pellet fuel as a commercial fuel will increase.

The environmental impacts of direct lithium extraction from brine resources in Nevada

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Abstract:

Lithium plays a crucial role as the main component in rechargeable batteries that are widely utilized in portable information technology devices, electric vehicles, and energy storage systems. Approximately 60% of the world's total lithium production is sourced from brines, with the remaining portion primarily derived from pegmatites. The use of evaporitic technology for extracting lithium from brines has been criticized due to its heavy reliance on water, prolonged duration, and limited applicability to continental brines. Direct lithium extraction (DLE) methods have gained popularity in recent years as an alternative to traditional lithium extraction methods from brines, such as solar evaporation and the lime soda process. DLE methods aim to extract lithium directly from brines without requiring a long and costly evaporation process. This study aimed to assess the environmental impacts of Direct Lithium Extraction (DLE) from brine sources in Clayton Valley, Nevada to obtain credible results that can be compared with conventional lithium extraction via evaporation ponds. The study showed that the production of 1 ton of lithium carbonate from brine with the DLE process releases around 17 tons of CO2. This is higher than the CO2 emissions from lithium extraction in Chile's Salar De Atacama, about 3.3 tons; in Argentina, that is 14.5 tons. The primary reason for the CO2 emissions in the Nevada extraction process is the electricity consumption in the pre-treatment stage to increase the temperature of the raw brine from approximately 10 °C to 80 °C. However, in terms of water consumption, all extracted water, including the brine, is recycled and reused in the system, resulting in zero direct water consumption in the DLE process.

Particle geometry of crushed plastics: the randomness of size reduction in three-dimension

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Abstract:

Plastics are widely used as materials in various applications because they are lightweight and have unique and versatile properties. For example, plastics are the materials of choice for packaging, as containers for consumables as well as housings and casings of consumer electronics. To achieve the sustainable development goals, effective separation of mixed plastic wastes into their individual type is required prior to recycling. However, size reduction of plastics generates particles with various shapes that strongly affect plastic-plastic separation. In this study, the effect of crushing on particle geometry—size and shape—of plastics was evaluated. Plastic boards of polyethylene terephthalate (PET) and polyvinyl chloride (PVC) with thicknesses of 1-, 2-, 3-, 4-, and 5-mm were crushed by a cutting mill. The crushed plastics were then screened to obtain four size fractions: +2.0–2.8, +2.8–4.0, +4.0–5.6, and +5.6–8.0 mm. After screening, the length of particles in three dimensions were measured to determine their geometrical shape descriptors like sphericity, aspect ratio, flatness ratio, and elongation ratio. The results showed that for thin plastic boards (i.e., 1-, 2-, and 3-mm), the coarse fraction was dominated by disk-like particles (i.e., low flatness ratio) while those in finer fractions were more spherical (i.e., high flatness ratio). In contrast, a similar flatness ratio with high value (i.e., sphere-like) was found in every size fraction for the thicker plastic boards (i.e., 4- and 5-mm). These results indicate that size reduction via shearing mainly occurred in the intermediate (breadth, I) and long axis (length, L) directions rather than in the short axis (thickness, S) direction. Meanwhile, when the values of S, I, and L are close to each other like in spherical particles, the probability of size reduction in all three dimensions becomes the same.

Industrial symbiosis in clusters around thermoelectric power plants: cases analysis that represent circular economy initiatives

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Abstract:

Industrial symbiosis in clusters of companies can encourage the adoption of circular economy practices through the physical exchange of resources, energy, and information. In the forest-based sector, clusters of companies occur in regions with large areas of cultivated forests, usually with the presence of thermoelectric plants based on forest biomass residues. The aim of this article was to investigate how the industrial symbiosis relationships built around thermoelectric power plants can enable circular economy practices in clusters of forest-based companies. Data were collected in the southern region of Brazil, from a sample of twenty-six companies in a forest-based cluster. The evaluation was conducted within the scope of the meso-analysis considering the formation of linkages and interconnections in two case studies: one related to the use of waste from wood processing industries, and the other related to the use of waste from a pulp and paper industry, either for energetic purposes.

Can carbon tax on food promote low-carbon and healthy food consumption? Evidence from rural China

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Abstract:

Food system is one of the main sources of global anthropogenic greenhouse gas emissions, and has become a constraint on global temperature control targets. The adjustment of dietary structure is considered to be one way to promote carbon reduction and benefit human health. Carbon tax is an effective tool to promote the adjustment of food consumption structure, but its effect on carbon reduction and nutritional change needs to be evaluated. Based on the micro survey data of 100 villages and 891 households in rural China in 2019, three tax scenarios were set up: taxation on all kinds of food (ALL-FOOD), taxation on meat and eggs only (MEAT-EGG), and taxation and subsidy considering the dietary guidelines (INTEGRATED) to explore the multiple effects of carbon tax. Two carbon prices (market price ¥48/kg CO2e and social cost ¥323/kg CO2e) were deployed to examine the effect of taxation rates. The results show that when the carbon price is ¥48/ kg CO2e, the carbon emission reduction rate of the ALL-FOOD, MEAT-EGG, and INTEGRATED scenarios is 0.72%, 0.63% and 0.60%, respectively. When the carbon price increases to ¥323/ kg CO2e, the reduction rate of the three scenarios will increase to 4.83%, 4.21% and 4.05%, respectively. The ALL-FOOD and MEAT-EGG scenarios both slightly reduce the intake of various nutrients, but the INTEGRATED scenario significantly increases the intake of vitamin C, calcium, and other trace elements. The INTEGRATED scenario is the most cost-effective in reducing the carbon footprint. In general, when formulating a carbon tax plan on food system, the impact of taxation on carbon reduction, nutrition, and equality should all be considered in combination with policy objectives.

Tele-connections. driving forces and scenario analysis of agricultural land, water use and carbon emission in China's trade

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Abstract:

Interregional trade can potentially extend the management of scarce resources and induced environmental impacts beyond a region's territory along supply chains. In this study, by combing environmentally extended multi-regional input-output approach and structural decomposition analysis, we analyzed the transfer of agricultural water, land and carbon footprint in inter-provincial trade and explored hidden driving forces in China from 2007 to 2017. We further explored agricultural water-land-carbon nexus from production and consumption perspective in future scenarios. The results showed that the water-starved northern China with abundant agricultural land is the main exporter of virtual agricultural land, water and embodied agricultural carbon emissions. The wealthy coastal regions consumed large amount of land and water resources from less developed regions while producing large amounts of carbon emissions. Resources intensity and economic development are the key factors leading to the virtual resource flow, and their effects show opposite outcomes. Based on the scenarios analysis, economic development will increase the resource and environmental pressure in various regions, especially on the major agricultural production regions in the northern and western China. Improving agricultural water use efficiency and agricultural production carbon efficiency would reduce the flow of virtual water resources and embodied agricultural carbon emissions, especially under the W2LC2 scenario, where provinces face the least resource and environmental pressures. Adjusting the structure and scale of agricultural products, improving regional resources allocation and optimizing cross-regional resources supply and carbon offset mechanism would reduce the pressure on scarce resources utilization and environment. Our findings provide useful information for alleviating the inequality of regional resources and environmental pressure and promoting sustainable development in agriculture in China.

The influence of wear on throughput and energy consumption in the shredding of mixed commercial waste

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Abstract:

Ever stricter legal frameworks such as the European Union's Circular Economy Package include clear recycling targets for municipal waste as well as strongly restrict landfill options. Accordingly, 55 percent by weight of municipal waste must be recycled by as early as 2025. Considering the average recycling rates of the EU-27 countries of 38% by weight reported for 2019, it shows that a significant increase in recycling is needed to meet the target. Increased material to be treated, increased process complexity in recycling, as well as high energy costs are challenges for the waste treatment industry, therefore it must continuously identify and implement optimization potentials.

The process for the mechanical treatment of mixed commercial waste usually includes shredding and various screening and separation stages. Secondary shredding is necessary for the production of solid secondary fuels from the portions of the waste unsuitable for material recycling (EN ISO 21640:2021-05). The shredding process step is of particular importance due to its influence on material quality, throughput and energy consumption and thus worthy of investigation. Khodier et al. 2021 have researched the parameters influencing shredding behavior. In addition to this and building on the findings of the MayRec project, the possible influence of the wear condition of the cutting geometries appears to be particularly relevant, specifically regarding model building for predictive maintenance.

Therefore, a test methodology for investigating the influence was created and comprehensive field tests with different shredding technology were carried out. Initial results show a clear influence of the wear condition, both on throughput, material quality and energy consumption. Further tests to validate the results and model building are planned.

Environmental impact assessment of industrial aquaponics system: a case study in Chongqing, China

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Abstract:

Aquaponics is a sustainable food production system that reduces the adverse effects of conventional food systems on the environment while reducing both nutrient loss and water consumption. However, the environmental impact of industrial aquaponic systems in developing countries is unclear. This study aims to evaluate the environmental impact of a commercial aquaponics system in Chongqing, China, using a life cycle assessment (LCA) approach to improve the environmental performance of Industrial aquaponics system.

The study conducted an LCA analysis on the industrial aquaponics system in Chongqing and obtained the main contributors of environmental impact through sensitivity analysis. The environmental impact of the output unit nutritional value of industrialized aquaponics in Chongqing was compared with the environmental impact of global food production. The energy scenario and the fish food scenario were discussed to further improve the aquaponics system.

The results of the sensitivity analysis show that the main contributors to the environmental impact of the industrial aquaponics system in Chongqing are electricity consumption, fish food in the aquaponics system. The comparison of environmental impact between the nutritional value of aquaponics output and global food production shows that aquaponics has a 27% - 57% lower Greenhouse gas emission. The energy scenario and the fish food scenario discussions show that optimizing the energy mix and changing the kinds of fish food could further improve the environmental performance of the aquaponics system.

This study provides valuable insights into the environmental impact of industrial aquaponics systems and highlights the need for optimizing energy use and reducing the use of fish feed to improve the sustainability of aquaponics. The results of this study illustrate the environmental performance of the Chongqing industrial aquaponics system and provide suggestions and data support for promoting industrial aquaponics systems.

Keywords: Industrial aquaponics system, Life cycle assessment (LCA), environmental performance

Metagenomic profiling of the microbiome and antibiotic resistome in commercial biogas plants operating at hyper-mesophilic temperatures Mac-Anthony Nnorom[1], Lisa Avery[2], Rupert Hough[2], Bing Guo[1]

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Abstract:

Anaerobic digestion (AD) is one of the key cornerstones of sustainable development. This microbial-spearheaded process is used to stabilize, reduce, and most importantly, harness renewable energy from an array of organic waste streams. Following AD, the digestate is typically recycled to agricultural lands as biofertilizers thereby closing the loop in circular economy terms. However, the ubiquity of pathogens and antibiotic resistance genes (ARGs) in organic wastes could undermine the safe recycling of digestate to land especially if the operating conditions adopted during AD do not favour optimal attenuation of these contaminants. In this study, shotgun metagenomic sequencing was used to comparatively characterize the microbiome and antimicrobial resistance trends in feedstock and digestate samples collected from five biogas plants operating at hyper-mesophilic temperatures (41 – 44°C). The sampled sites use either energy crops exclusively as substrate or a combination of energy crops, brewery waste, and animal manure.

The metagenomics data revealed the microbiome and ARGs profile were reflective of the substrate type and operating conditions. In total, 647 ARGs encoding resistance to 26 antibiotic classes were detected across the samples. Resistance genes belonging to macrolide-lincosamide-streptogramin (MLS), aminoglycoside, tetracycline, multidrug, and sulfonamide were the most prevalent. The attenuation efficiency of ARGs ranged between 40 – 87% after primary digestion, with higher efficiency observed at sites operating at higher temperature (44°C). Secondary digestion had very nominal effect on the abundance of ARGs. In terms of microbial community composition, the primary and secondary digester samples were similar at each site. Brachybacterium and Corynebacterium dominated at the genus level and were especially prevalent in the feedstock of sites using manure as a co-substrate.

Collectively, the result demonstrated that the abundance of ARGs was significantly attenuated during AD. However, it should be noted that residual ARGs in digestate may still elicit public health risks if recycled to land.

What does ‘value’ mean in a circular economy? A conceptual framework advancing the operationalization of the circular economy

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Abstract:

The circular economy is a concept that has gained considerable attention in recent years as a pathway to achieve sustainability. Compared to the traditional linear economy, the circular economy is restorative and regenerative by design, and aims to keep products, components, and materials at their highest value at all times. Despite its popularity, operationalizing the circular economy has proven to be challenging due to the ambiguity surrounding the concept, leading to difficulties in developing relevant indicators.

In this context, this abstract proposes a framework centred around value, as the word value is often included in circular economy definitions, but never properly defined. In the framework, a distinction is made between inherent value and created value. Inherent value is defined as value inherently present in resources, materials, components and products, and is linked to the strict definition of the circular economy, i.e., narrowing and closing loops. In a circular economy, inherent value is to be preserved for as long as possible. Created value, on the other hand, is the net sum of handprints and footprints generated throughout the life cycle of a product. It is linked to the broad definition of the circular economy, i.e., pushing the focus to sustainability and the effects circular economy strategies have on the economy, environment, and society. In a circular economy, the generation of created value should be maximized.

To improve the understanding of the framework, the assessment of both types of value and how they are linked is qualitatively illustrated based on the life cycle of a simplified laptop. This shows that the framework allows for a clearer understanding of the circular economy concept, as well as its link with sustainability. Finally, the potential of the framework to serve as a stepstone towards the improved, more structured development of circular economy indicators is highlighted.

Lost in the Shuffle: A Characterization and Categorisation of the Accumulated Resources in Scrap

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Abstract:

Aiming to reach circularity and sustainable production goals and to address resource scarcity, the metal industry is shifting towards the recycling of secondary materials instead of producing them from scratch. This entails an increase in the use of scrap. Scrap is a heterogeneous feedstock handled by many actors whose compositional uncertainty and complexity increase as it advances throughout the value chain. However, for efficiency reasons, the material's chemical structure is only analysed once it is already molten and recycled into a new product. This entails that some accumulated elements end up contaminating and/or being lost in the new material and by-products. Taking an exploratory approach with the use of observation and expert interviews, this study examines the attributes that characterise the scrap pile and influence the resources' recoverability before they become a problem contaminating and dissipating in the recycling process, aiming to answer the question "What are the main attributes that define how the accumulated elements exist in the scrap heap and their potential to be avoided?". Moreover, it classifies these materials into different categories at three consecutive levels, each of which is built after the identified influential attributes. Hence, this paper takes a proactive approach and proposes a categorisation and characterisation model for determining which categories or material types can be prevented from contaminating the final product and getting lost in the process.

Life cycle carbon emissions and environment burdens of cotton textile: a meta-analysis

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Abstract:

The textile industry is an essential basic manufacturing industry, providing human beings with daily necessities while also causing considerable environmental burdens. Cotton textile is the most dominant natural fiber textile. Meanwhile, its production process is accompanied by a large amount of resource inputs, energy consumption, carbon and other pollutant emissions. As the demand for cotton textiles continues to grow, there is an urgent need for a sustainable transformation of the cotton textile industry to reduce resource consumption, carbon emissions, and other pollutions coordinately. Although the literature has focused on the environmental impact of cotton textiles at different production stages, quantitative analysis based on a life-cycle perspective remains to be needed. In this paper, we conduct a meta-analysis to systematically review and quantitatively examine the life cycle environmental impacts of the global cotton textile industry, including carbon emissions, energy consumption, water consumption and other pollutions. The result shows that the carbon emissions and water consumption in the global cotton textile industry vary significantly among countries, but there is still a need for greater efforts to coordinate reduction. This study highlights the importance of applying life cycle assessment to ensure that the environmental impact of each production step is not neglected, especially in the raw material cultivation stage. This study can also provide recommendations and references to achieve carbon neutrality and sustainable development for the cotton textile industry.

Sequential treatment of acid mine drainage using various media in a permeable reactive barrier

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Abstract:

Passive treatment of acid mine drainage (AMD) uses limestone as its most common material due to its abundance and alkaline-generating capacity. However, its treatment capability is severely limited when metal hydroxides precipitate and minimize its dissolution, rendering limestone inert. In this study, laterite mine waste (LMW) and concrete waste were used in sequence with limestone to increase the efficiency and capacity of the treatment system.

A full-factorial batch test was done to determine the optimal sequence of these materials based on the pH increase, and metals and sulfates removal of the AMD. A constant ratio of 0.75 mL AMD/ g media was maintained with a 15-minute retention time in each treatment material. The system with limestone, LMW, and concrete waste present in this sequence achieved the highest treatment efficiency. The sequence increased pH to 8.08 and removed 38.90% Fe, 94.30% Ni, 71.76% Al, and 51.69% sulfates.

A semi-batch test followed to determine the treatment capacity of the optimal sequence. The results show an initial increase in pH from 2.4 to 10.80 which becomes constant around pH 7 starting from the 10th batch of AMD treatment. Calcium levels were well above the initial concentration and stabilized around 700 ppm. A 32.95% reduction in sulfate was initially observed but returned to near initial concentration by the 8th batch of AMD. Iron, aluminum, and copper were consistently lowered to concentration levels well below the standard set by the DENR Administrative Order (DAO) 2016-08, as amended by DAO 2021-19. Using PHREEQC, it was determined that the most common precipitates present in the effluent were Fe and Al minerals. Additionally, only 69% and 66% of Ca and SO4 were present as ions, respectively.

Thus, the use of limestone, LMW, and concrete waste in sequence has the potential to be used as a passive treatment system, or a part thereof, for the removal of Fe, Al, and Cu in AMD.

Enabling the UK's transition to a Circular Economy: A Critical Evaluation of Government Policies on eigenvector approach

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Abstract:

The UK's transition to a more circular economy has both national and international benefits. This is not only because it continues to yield emission reductions, reduces pollution, strengthens the economy, maintains ecosystem services and restores nature, but also because it fulfils the collective ambition of UK nations to be world leaders in responsible environmental stewardship. Stemming from EU Waste legislation in the late 20th century, Circular Economy (CE) policies have evolved to a point where devolved administrations are taking stronger ownership of and adopting a more robust design for their transition journeys.

Existing appraisal studies of CE policy take a siloed approach, focusing on specific themes, sectors, locations, material cycles (biological or technical) or strategies of the circularity ladder. This presentation aims to offer a preliminary answer to the question of how government policies have evolved and shaped the UK's transition to a more CE by dividing CE policies into three 'eras': before 2000, 2000–2015 and 2015 till date. Thematic and content analyses will be applied to policies to identify the most dominant and least dominant themes, sectors, and circular strategies. The presentation will also collate the policy recommendations within academic literature to bring them back to the fore.

Understanding these elements of policies could be instrumental in future policy reviews in the UK and the development of CE policy in other countries. The potential of intensifying efforts to set targets for the less dominant elements, and how these policies address the actors for which they are created, will be explored, and is proposed as a key focus for future research.

Counterproductive effects of alternatives policy of Single-Use Plastics in China

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Abstract:

Single-Use Plastics (SUPs) have been the spotlight of plastics pollution control, and restricting meanwhile turning to other alternatives is widely promoted across countries. As one of the biggest markets, China in 2020 has issued the strictest policy to ban non-biodegradable plastic bags, one of typical SUPs while there is so far no case responding to its scientificity. By combining field investigation, local manufacturing data and delicate transport model, this study comprehensively evaluates the environmental performances of various shopping bags in the condition of China with Life Cycle Assessment. Given regional differences in waste disposal, industrial development and population density within China, provincial-scale analysis armed with multi-indicators is conducted for identifying regional hotspots and prioritized metrics. Results show that overall HDPE plastic bags cause the lowest environmental impacts inducing 6.47 Kt Acidification Potential (AP), 2.38 Mt Global Warming Potential (GWP), 4.20 Kt Chemical Oxygen Demand (COD), 1.03 Kt Eutrophication Potential (EP), 14.8 Mt Fossil Fuel Depletion Potential (CADP) and 23.07 Mt Water Use (WU) over life cycle for one-year national usage. Biodegradable bags show no environmental improvement under current waste treatment structure in China if no plastics leakage occurs, with impact 6.47 times higher. Xinjiang generally has highest average household impacts for using plastic bags due to its long-distance transport and high landfill ratio, and Shanghai ranks as lowest with 53% impacts of Xinjiang. WU are prioritized metrics with greatest changes in both absolute quantity and expansion ratios if implementing substitution with other materials. Additionally, Shanghai which is set as priority place to implement replacement, cause the most significant expansion of impacts, with 10.76, 5.70 and 19.68 times expansion regarding to AP, COD and EP. These can support the amendment of plastic bags ban policy and use as a reference for substitution evaluation of other single-use plastics.

From trash to treasure: Assessing the effectiveness of Green@Community's recycling stores in Hong Kong

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Abstract:

Municipal solid waste (MSW) is a growing problem worldwide, posing environmental and human health risks. In response, the Environmental Protection Department of the Hong Kong Government has established Green@Community, a unified, community-based network for recycling and public environmental education since 2015. However, limited studies have evaluated the effectiveness of the recycling stores of Green@Community since its establishment.

This study aims to evaluate the effectiveness, economic incentives, and public awareness of Green@Community recycling stores in Hong Kong. To achieve that, a questionnaire survey (N = 200) was conducted in March to May 2022 to measure public knowledge and behaviour regarding these recycling stores. Secondary data on the number of recyclables collected at these stores were also analyzed to evaluate their effectiveness.

The number of visitors and collected recyclables at recycling stores showed an increasing trend over time. However, there was still a large gap between the amount of waste generated and the amount of recyclables collected (= 31% of the generated waste). Respondents had weak recognition and awareness on the community recycling network, and also limited recycling behavior.

These findings highlight the need for greater promotion and awareness-raising efforts to encourage participation in community recycling. The study provides baseline data for the government which calls for more efforts in developing and promoting Green@Community network. Overall, this research reveals the challenges facing Hong Kong in managing MSW and contributes to improve local waste management strategies.

The effects of washing laundry parameters on the emission of microplastics

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Abstract:

Microplastics (MPs) are fast becoming a major environmental pollutant that is affecting not only the soil but also the air and many water bodies. The small size, low density, and high hydrophobicity of MPs contribute to their not only ease of spread in the environment but also potential toxicity. MPs have the potential to adsorb toxic organic compounds and hazardous heavy metals, which make them harmful to humans and biota because they can act as carriers of toxic and hazardous substances into organs via ingestion and inhalation. Domestic laundry is well-known as an important source of MPs because textiles used in clothing are composed of synthetic fibers like polyethylene terephthalate or polyester (PET). To investigate the emission of MPs from washing machines, four fabric types—cotton (100%), chief value cotton (70% cotton and 30% polyester), tetron cotton (35% cotton and 65% polyester), and polyester (100%)—were washed in a top loading-type washing machine with varying concentrations of commercial detergent and weight of fabric. After washing, the effluent from each experiment was filtered to collect the MPs. Fourier transform infrared (FTIR) microspectroscopy was used to determine the concentration of MPs, as well as their size and shape. The results indicate that the effluent concentrations of MPs increased with increasing polyester abundance in fabrics as well as the increasing weight of fabric loaded to the washing machine. In addition, it was found that high concentrations of detergent lead to increased emission of MPs.

Combining bioleaching and electrodialysis for recovery of platinum group elements from spent car catalysts

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Abstract:

Platinum-group elements (PGE) are precious metals, some of the scarcest elements in the Earth's crust. They are critical raw materials for applications in catalysts, fuel cells, electronics, cancer therapies, and criminology. Secondary resources of PGE, such as spent car catalysts, contain higher platinum concentrations than primary ores (0.2 to 0.3%, depending on the car's age and fuel burned), so there is a crucial need to recover those resources sustainably.

In our study, we compare the effectiveness of the combination of bioleaching with electrodialysis with each technique by itself. We performed experiments in two-compartment electrodialytic cells using a cation exchange membrane (Membranes International CMI-7000S) as a separator. The experiments lasted 96 h, in triplicate, and were conducted at room temperature (20±0.5°C). In the electrodialytic setups, a low constant current of 5 mA was supplied by a DC power supply (SLS Flowgen PowerPro 3 AMP). In the bioleaching experiments, we used a pure culture of Acidithiobacillus ferooxidans (2 mL of inocula in 48 mL of 882 medium). The catholyte was a 0.01 M NaCl solution and the electrodes were Ti coated (Permascand type PSC101). Voltage, pH, conductivity were measured daily and samples collected for metal analysis in ICP-MS (Thermo-Fisher Scientific iCAP-Q).

Results show an increase in platinum concentrations in the anolyte using bioleaching and electrodialysis 66.7±19.3% higher when compared with electrodialysis, and 92.8±0.9% when compared with bioleaching. A similar pattern was observed for palladium concentrations. When bioleaching and electrodialysis were combined, Pd concentrations were 39.9±12.5% higher than with only electrodialysis and 99.99± 0.01% when compared with bioleaching. These findings demonstrate that the integration of different techniques can enhance PGE recovery from wastes. Further research is needed to optimise the process (liquid to solid ratio, mixing, duration of the experiments) and separate the metals of interest.

Exploring a hybrid model for policymaking toward business-driven circular economy

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Abstract:

Business is often viewed as a primary culprit in ecological problems. Two generic alternatives have historically addressed the problem. First, businesses can volunteer to take action, e.g., by setting and following industry standards to meet ecological expectations, which is often called industry self-regulation. Second, as the arbiter of society's expectations, government may regulate business practices. Nonetheless, occasionally both alternatives fail in delivering the expected outcomes. In this longitudinal process study, I investigate such a case in closing material loops to induct a solution.

This paper is the result of a study started in 2017 about managing hazardous consumer waste in the province of Ontario, Canada. I collected and analyzed enormous qualitative data (e.g., 54 in-depth interviews with key stakeholder leaders) to explore an evolutionary process from 1981 to recent years. Before the 2000s, the government urged the industry to voluntarily manage post-consumer household goods, yet industries never effectively engaged. In 2000s, government responded by imposing policies; however, formal regulation not only failed to spur the innovative solutions that circular economy needs, but also caused unexpected confrontations among the stakeholders. Interestingly, the study explores that in recent years, a new form of industry regulation has evolved that proved more effective. By analyzing this emergence, I propose a "hybrid regulation" model in which both business and government coordinate to close the material loops. Grounded theorizing identifies that the model embodies four constructive tensions which need to be aptly balanced.

The explored model encourages organically shaped competing business solutions for circularity. Such a model can particularly be helpful to transition to business-driven circular economy when, on the one hand, sustainable practices incur high costs to business, resulting in minimal business motivation for involvement, and on the other hand, no available regulatory solution exists to help government regulate business.

Sustainable Conservation Strategies for Rivers and Watersheds: Restoration and Rewilding in a Changing World

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Abstract:

River and watershed management and ecosystem conservation are associated with dynamically migrating river channels and changing floodplain habitats. For the pursuit of the sustainable development, direct occupation and modification of river channels and corridors linking with floodplains have greatly damaged habitat diversity, degraded river ecosystems and caused biodiversity loss. River hydrogeomorphology restoration is crucial to restore the degraded lotic habitats. Meanwhile, watershed rewilding is an efficient approach of Nature-Based Solutions to restore and recover native biodiversity. This study illustrates the importance of the three attributes of geomorphology for river and watershed ecosystems: spatial complexity, connectivity, and dynamism. Four sustainable, adaptive strategies to restore river geomorphology and to rewild watershed landscape by reducing anthropogenic disturbance impact are based on: (1) nature-based design, (2) multi-dimensional space design, (3) flexible riparian/watershed design, and (4) multifunctional habitat restoration/rewilding. Along with these adaptive strategies, the additional approach allowing the river channels, floodplains, and watersheds to “ecologically heal themselves” through setting aside a river channel migration zone (geo-morphologically erodible area) can be one of the most efficient, low cost-benefit ratio, and sustainable strategies for ecological restoration, when the rivers have sufficient stream power and sediment load to reestablish channel complexity. Physical and ecological restoration at a local scale and rewilding at a basin scale to recover fluvial morphology and floodplain reconnection contribute to the improvement of ecosystem health and self-sustainability of river ecosystems and watershed landscape. River ecosystem restoration and large-scale watershed rewilding should combine aquatic and terrestrial ecology, biodiversity conservation, geomorphology, hydrology, hydrogeology, and habitat heterogeneity with landscape architecture attributes. Such holistic conservation strategies for rivers and watersheds can enhance catchment resilience, and improve the ecosystem services supported by the riverscape of river channels, floodplains, and watersheds, by providing multiple, healthy ecosystem processes, and supporting aquatic biodiversity recovery.

From zero to leadership: A longitudinal case study of the municipal solid waste infrastructure system in Almere, the Netherlands (1976–2022) Zhaowen Liu[1], Daan Schraven[1], Martin de Jong[2], Marcel Hertogh[1]

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Abstract:

Climate change and environmental degradation have brought unprecedented transformational pressure on human society. Cities are struggling not only to meet the production and consumption needs of expanding populations but also to deal with the growing and complex residential waste. Under this circumstance, an integrated Municipal Solid Waste Infrastructure System (MSWIS) is needed to serve the circular economy and sustainable development goals. In this study, we gained insights from Mission-oriented Innovation System (MIS) and Strategic Niche Management (SNM) to frame how niche innovations are created, scaled up, and institutionalized by the network of actors in developing a mission-oriented MSWIS. With this conceptual framework, we conducted an in-depth longitudinal case study of MSWIS development in Almere, the Netherlands (1976–2022). As a young reclamation city and a pioneer in Europe in the pursuit of zero-waste, Almere's MSWIS has grown from zero to a highly developed level. The case reveals that in the development of MSWIS: (1) the interpretation of a mission (sustainable waste management) is adapted to the context and perception of the times (from "landfill less" in the 1980s to "incineration-energy" in the 1990s to "recycling and upcycle" after the 2000s); (2) knowledge sharing among actors (e.g., municipalities, communities, social organizations, and business associations) is central to moving the innovation from pilot to universal; and (3) MSWIS is a very local, but also (potentially) cross-regional assemblage, where the realization of one mission is increasingly dependent on the support of the surrounding area and multi-mission thinking (e.g., integrated waste-energy-food missions). We concluded by discussing how policymakers and social organizations can engage inclusively in defining and achieving a future-oriented, people-centered MSWIS.

Disentangling the effects of air pollutants on the COVID-19 pandemic with many instruments—A global perspective

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Abstract:

We study the impact of short-term exposure to five components of PM2.5 and SO2 on the COVID-19 morbidity and mortality worldwide. Pandemic information on country-level or province-level are combined with regional social and economic data. Following Godzinski and Castillo(2021), we select optimal instruments from a large set of atmospheric weather instrumental variables via LASSO method to instrument short-term variation of air pollution. We confirm the influence of PM2.5 on the local severeness of the pandemic in the previous literature and find a one μg/m3 in ambient OC concentration increases the number of same-day confirmed cases by 4.8% from the mean case incidence, as well as with 2.9% incidence increase from SO2 concentration increase. These effects are robust to a collection of sensitivity tests. When analyzing health effects among different areas, we find stronger impact in China, for its higher local air pollution concentration, as opposed to United States. Our findings shed light on the import key role of PM2.5 composition in aggravating the severity of respiratory syndromes, manifesting the effect of higher OC exposure compared with other components.

On-site validation of nutrient recovery from pig slurry liquid fraction using membrane technologies at pilot scale

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Abstract:

In Europe, farms' livestock population produces around 1400 Mt of manure annually. Among EU27 countries, Spain is one of the main pork producers and Catalonia is the region with the highest yield of pig-intensive farming. More than 90% of the produced manure is returned untreated to agricultural fields, which is inefficient and leads to some environmental problems such as nutrient leaching or pollutants persistence in soil. However, livestock slurry has been reported to be a potential secondary raw material for fertilizer production since it contains macronutrients (NPK) helping to close the nutrients' loop. This work assesses the recovery of nutrients from pig slurry liquid fraction (SLF) through membrane technologies for their use as fertilizer. SLF samples, pre-treated via a solid-liquid separator with a 280 µm mesh, were obtained from a pig fattening farm in Catalonia. Afterwards, the SLF was treated using first a microfiltration membrane with a 4.5 µm pore diameter for removing suspended solids while recovering phosphorous salts. Then, microfiltration's permeate was further treated for nitrogen recovery by membrane-enhanced liquid-liquid extraction using sulphuric acid, obtaining ammonia sulphate. The effluent was finally sent to reverse osmosis, where regenerated water was obtained, as well as a concentrated effluent rich in potassium. System's operational feasibility was assessed along seasonal variations during two operational years at an on-farm pilot plant. During warmer seasons, ammonia losses increase before and during microfiltration due to volatilisation, however higher ammonia release leads to higher efficiency during the stripping process. On the opposite side, pigs' water intake is reduced during colder seasons, increasing slurry's viscosity and hindering its treatment. Finally, pH modifications in SLF reported promising results for improving macronutrient recovery at lab scale. Therefore, further research and optimization at bench scale are needed for boosting technology uptake in the farming sector.

Mission CE? The role of public policy in driving circular innovation

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Abstract:

Circular economy is increasingly positioned in UK policy and strategy documents as a means through which decarbonisation targets can be met while maintaining economic growth. A recent example of this is the Independent Review of Net Zero, which recommends the adoption of circularity principles across departments and policy mixes to accelerate progress towards a net zero economy. However, the Government's formal response to the Review refers to the circular economy sparingly, and advanced recommendations such as a 'circular economy mission' are left out entirely. In a global policy context where circularity is increasingly embedded—i.e. EU's circular economy action plan and the US Inflation Reduction Act—this presentation seeks to answer why this is not the case in the UK.

This presentation addresses this disconnect by exploring why CE has been difficult to embed in the UK at the level of national public policy. Drawing on mission-oriented innovation policy, this presentation will develop several lines of thought, including: 1) An analysis of the challenges facing the implementation of CE in the UK at the national level 2) An exploration of the mission-oriented approach and how it can be used to develop CE policy. This approach emphasises setting ambitious goals, aligning stakeholders, and creating the necessary conditions for innovation and systemic change, and 3) A discussion of how public policy can be used to drive innovation and the creation of circular markets in the UK, while implementing positive directionality within the economy in social and ecological terms while creating opportunities for growth under a new social contract.

Through a combination of theoretical analysis and practical examples, this presentation will offer insights into how CE can be effectively integrated into UK public policy, with relevance for policymakers, academics, and practitioners interested in pursuing responsible innovation and a renewed sense of purpose in public policy.

Multiscale greenness supporting people’s mental health

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Abstract:

Natural environments can promote human health, particularly mental health. Rapid global changes have significantly impacted natural ecosystems and affected people's mental health. 14% of the global burden of disease was attributed to neuropsychiatric disorders, which is a combination of neurology and psychiatry to deal with mental disorders. Green landscapes provide health resources that benefit human physical and mental health. However, the mental health benefits of nature greenness exposure at different scales are dynamic and poorly understood. This review systematically synthesized the evidence to assess trends in the relationship between greenness exposure at various scales and mental health. We did a comprehensive keyword search in databases of PubMwd, Web of Science, Science Direct, Google Scholar, WHO, CNKI. Keywords include mental health, psychological health, green landscape, green space, community green space, home garden, or informal green space. We conducted a scoping review of related literature on associations with those topic words. A total of 1537 relevant papers were initially identified and through screening 244 were included in the review. Studies found that greenness with different habitats can improve human mental health by enhancing cognitive function and emotional well-being, reducing air pollution, noises, and the heat island effect, which can trigger depression, anxiety, and bipolar symptoms. Green environments contribute to urban habitat diversity supporting fauna and flora communities across multiple scales from the family and community to entire urban areas, which can benefit people’s outdoor physical activities and improve mental health through three interactive approaches: physiological, psychological, and social behaviors. Green habitat diversity at multiple scales increases human-nature connections by offering more outdoor physical activities and providing an increased aesthetic tendency to appreciate greenness with native niches inhabiting abundant species, thereby eliciting more positive psychological responses and experiences that benefit mental health.

Self-driven enhanced electrochemical leaching of spent lithium-ion battery cathode and anode

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Abstract:

The rapid development of electric vehicles and the energy storage industry in recent decades had produced a large number of spent lithium-ion batteries (LIBs). Traditional hydrometallurgical recycling of spent LIBs cathodes generally adopts complex pretreatment processes to separate cathode active materials from the current collector (Al foil), binder, and conductive agent with a scope to facilitate faster leaching kinetics. However, unexpected enhanced leaching of spent LIBs was observed at the initial stage with the cathode sheet rather than the cathode powder. The self-driven enhanced leaching mechanism was revealed with delicately designed electrochemical experiments as shown in Fig. 1. Four different electron exchange reactions could participate in the leaching process. When the cathode sheet was first introduced into the solution, Al foil, which is in direct contact with LiCoO2, was oxidized in the acidic solution, providing electrons to both Co3+ at the spent LIBs cathode and H+ at the spent LIBs anode, during this period the leaching of valuable metals was driven by the oxidization of Al. After Al is completely dissolved, the LiCoO2 acquires electrons from the Cu in the spent LIBs anode. Finally, all active materials were leached completely with the enhanced self-driven electrochemical leaching, the residual only contained the PVDF binder and conductive carbon. Based on the self-driven enhanced leaching mechanism, a galvanic cell system was built to leach valuable metals from spent LIBs cathodes and anodes efficiently. This research sheds light on the innovative recycling of spent LIBs without chemical reducing agents and enables the recycling of both spent LIBs cathodes and anodes simultaneously without complex pre-treatment processes.

Predicting whole-life carbon emissions for buildings using different machine learning algorithms: a case study on typical residential properties in the UK

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Abstract:

Whole-life carbon emissions (WLCE) studies have emerged as critical studies to assess a building's carbon emissions from construction to demolition. However, existing methods of predicting WLCE can be time-consuming and data-intensive, limiting their effectiveness in the early building design stage. Machine learning algorithms are powerful data-driven techniques, particularly when it comes to predictive analytics. Nevertheless, their applications in building WLCE studies have not been extensively researched and comparatively evaluated, especially the lack of use of the features related to the building descriptors to make predictions. To address this gap, this paper aims to provide an overview of benchmark machine learning algorithms and their suitability for developing prediction models for WLCE and WLCE intensity (WLCE normalized by floor area) of buildings, by conducting an experiment that uses ten machine learning algorithms to predict WLCE and WLCE intensity of buildings. The models were trained on detailed WLCE calculation results of 150 typical residential properties in the UK and 28 high-level correlated features of buildings' attributes and their occupants' characteristics from a comprehensive survey, such as floor area, heating type, and the number of occupants. Ten different algorithms such as Multiple linear regression, Decision Tree, and Random Forest, were used to build the prediction model. The results show that machine learning algorithms can predict WLCE and WLCE intensity accurately and efficiently, with most benchmarking models outperforming the linear regression model. The Random Forest model performed the best for the prediction of WLCE and WLCE intensity, respectively. These results indicate that machine learning models can provide reliable and efficient predictions of WLCE and WLCE intensity, which can support data-driven decision-making in sustainable building design at an early stage.

Fabrication of lime mud based cementless binder : an environment friendly approach to mitigate climate change

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Abstract:

The objective of this study is to utilize and study the reactivity and hydration behavior of alkali-activated Lime mud (LM) for the fabrication of cementless binders. The alkali treatment of as-received LM was performed to dissolve the calcium carbonate by using 2 M NaOH in the proportion of 80% LM and 20% NaOH. The reactivity of the activated LM was significantly improved, as corroborated by X-ray diffraction (XRD) analysis, Thermogravimetric analysis (TGA), and Fourier transform Infrared spectroscopy (FTIR) analysis. Different blends were prepared by applying up to 50%of activated LM with ground granulated blast furnace slag (GGBFS) in cementless mortar. Activated LM was found to be effective in enhancing the reactivity of binder pastes for all replacement proportions and developed more compressive strength in comparison to the blends without activated lime mud. Mineralogical analysis exhibited the presence of less calcite and more hydration products in the case of activated LM-based paste than in as-received LM-based paste samples. Using lifecycle analysis software, the application of the 50% activated LM-based paste sample resulted in 95% fewer carbon dioxide emissions.

A systems approach to policy making for a circular economy: a comparative analysis UK and devolved administration's policies and governance approaches (case study cement and concrete)

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Abstract:

It is often argued that a transition to a circular economy will require a systems approach if the interconnections across the economic, political, legal, social, and ecological landscape are to be addressed in an integrated manner by policy makers. The ability and capacity to pursue a system thinking approach by policy makers within government is as such key to achieving an integrated, coherent sustainable transition to a circular economy. Delivering an integrated systems wide move to a circular economy faces numerous challenges. A significant issue is working within existing public administrative and regulatory structures that underpin the current policy making and governance system of the linear economy. These vary across and between different economic sectors. This paper will focus on construction, especially mineral based materials of cement and concrete.

This paper analyses the circular economy narrative that the UK government and devolved administrations have used in their policy related literature. It explores how the UK government and devolved administrations are proposing to advance the circular economy. The paper situates itself within wider research on transition discourse and governance. The paper will highlight the differences in approach between the UK government and devolved administrations and focus on the implications these have specifically for increasing circularity for mineral based construction materials cement and concrete. The paper concludes that the devolved administrations are leading the way already in responding to creating a more integrated systemic governance approach to further the circular economy alongside goals for achieving net zero. Yet there remain constitutional obstacles to a fully systemic approach that have not do date been fully examined. Going forward if the UK collectively is to create an integrated systems based circular economy transformation Westminster/England needs to be lessons learnt by the devolved administrations. This will require cooperation and further reconfiguration of administrative governance.

Profitability and policy instruments for plastic recycling: A comparative study across countries with different economic, demographic and policy characteristics

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Abstract:

Recycling of plastics is widely recognized as an environmentally beneficial but not always profitable economic activity. Therefore, recycling rates are still very low, especially in countries were there are no policy incentives to do so. The profitability of recycling technologies and circular activities is affected by a variety of factors, such as capital costs, labor costs, recycling incentive policies, corporate taxes, urbanization levels, and population density. The objective of this paper is to examine the profitability of circular economy activities related to plastics recycling and the best policy instruments to promote them in countries with different economic, policy, and demographic characteristics and identifies.

To accomplish this, data were collected from several countries and a representative country was selected from each cluster. The profitability of each plastic recycling technology was calculated using a techno-economic assessment. Policy instruments were then proposed for each cluster of countries, taking into account their unique economic, policy, and demographic characteristics.

The study shows that in regions with lower labor costs, lower urbanization rates and population density, mechanical recycling is generally profitable. On the other hand, high-end technologies like chemical recycling tend to be more profitable in highly urbanized countries with lower capital costs. Moreover, policies that increase the collection and recycling of waste, such as extended responsibility schemes, and policies that increase the demand of recycled products such as recycling content standards are necessary and complementary tools for promoting circular economy activities. The results provide valuable insights into the cost structure of circular economy activities and the policy instruments required to promote them effectively in different regions. The findings can help policymakers to develop more effective strategies for promoting circular economy activities and achieving sustainable development goals.

Highly defective composite oxides derived from spent lithium-ion batteries for catalytic oxidation of volatile organic compounds

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Abstract:

Considering the environmental pollution and consumption of metal resources in spent lithium-ion batteries (LIBs), it is a green pathway to recycle waste LIBs to prepare composite oxides as combustion catalysts of volatile organic compounds (VOCs). Herein, a feasible strategy was reported to reuse the spent lithium-ion batteries (LIBs) as precursors to develop efficient CoMnNiOx catalysts for propane oxidation. Interestingly, the T90 value of the highly defective CoMnNiOx catalyst for propane oxidation was only 200 °C. The de-aluminum and de-lithium processes generated by the alkaline etching promoted the increase of oxygen vacancy defects, which was confirmed by ICP-OES, XPS, EPR, and DFT calculations. At the atomic level, the oxygen vacancies near the aluminum and lithium vacancies (NiO-Alv-Ov and NiO-Liv-Ov) were more likely to promote the activation of oxygen molecules. Furthermore, it was observed that the reducibility, acidity, and lattice oxygen mobility of the defective CoMnNiOx catalyst were boosted by abundant oxygen vacancy defects, and thus enhancing the catalytic activity. Remarkably, the TLIBs recycling and defect enhancement engineering are conducive to developing green and efficient catalysts for the catalytic oxidation of VOCs.

Factory-scale fired clay bricks with synergistic incorporation of fly ash and chrome plating sludge: Mechanical, microstructural, and leaching characteristics with life cycle assessment

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Abstract:

Hazardous nickel-chromium plating sludge (NCPS) is generated during the production of chrome-electroplated steel. Metal recovery from NCPS yields even more toxic solid wastes of similar volume. Thus conventionally, NCPS is immobilized with cementitious binders in landfills- an alternative that is risky, carbon-intensive, and expensive. This work reports a pioneering development of fired clay bricks with a synergistic co-valorization of NCPS and fly ash (FA). The best-performing bricks have the proportion of clay: FA: NCPS as 50:37.5:12.5. Green sludge bricks were fired together with conventional clay bricks (CCBs) in a Fixed Chimney Bulls Trench Kiln with conventional firing parameters, thus confirming the feasibility of immediate industrial upscaling. Fly ash has a similar chemical composition as clay, thus facilitating the high-volume substitution of clay. Iron- and alkali oxides in the fly ash acted as fluxing agents, causing better sintering at lower firing temperatures, thus leading to higher compressive strength, reduced porosity, and water absorption. NCPS, with its high calorific value of 960 kcal/kg, caused the internal firing of bricks and the creation of micro-pores, which improved their thermal characteristics. Leaching analysis confirmed the successful immobilization of the nickel and chromium. XRD analysis revealed immobilization of heavy metals in the stable spinel structures formed at elevated temperatures. Muffle furnace-based firing of the bricks confirmed the estimated 55% energy savings in kiln firing of bricks. ReCiPe-2016-based comparative life cycle assessment of the CCBs and sludge bricks revealed significant improvement across all midpoint and endpoint damage categories. Finally, sensitivity analysis revealed the limiting transportation distances of industrial wastes (sludge and FA) from their generation points to keep the carbon emissions of sludge bricks lesser than CCBs.

Embracing complexity in public policy: A Circular Economy perspective

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Abstract:

Policies are events in complex systems. These systems are non-linear, far from equilibrium, co-evolving (with their environment), unpredictable, and dispositional (cause and effect relations are very difficult to pin down). Therefore, using linear systems-based approaches in/for policy making in complex systems normally fails or leads to catastrophic unintended consequences. The science of public policy, as a result, has started to embrace complexity perspective over the last two decades. Complexity-informed policy-making is pragmatic and does not put too much emphasis on scientific evidence hierarchies (i.e. evidence-based policy making which belongs to a linear, mechanistic view on cause and effect relations). Pragmatic complexity befriends the uncertainty of complex systems and promotes experimental, safe-to-fail, and democratic deliberations, allowing to test of several policy options at smaller scales using both scientific and practical evidence and knowledge in context. Policy options are also adaptive and anticipatory, evolving with the evolution of complex systems. In this paper, we use the pragmatic complexity approach to illustrate a case example of policy-making in the circular economy in the UK. This takes us to the origins of a circular approach to the economy that goes back to the first wave of cybernetics in mid 20th century. Interestingly, cybernetics was known as the science of complex systems studies, but the circular economy has forgotten its roots and has landed on the linear systems camp where people look for the one-size-fits-all type of evidence for the implementation of circular policies. We provide examples of the failure of such linear approaches in other areas and finally liaise the increasing concern with rebound effects of circular transitions with such linear outlooks to evidence and effectiveness indicators in the current circular economy literature. We hope this can lead to better policy-making around the circular economy in the UK and elsewhere.

Financial aspects of the circular economy: a systematic literature review

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Abstract:

This paper presents a systematic literature review examining the financial aspects associated with the circular economy (CE), with a specific focus on firm-level analysis. While there is a growing body of literature review on CE, there has been a notable neglect of pertinent financial topics in the field. To fill this gap, the paper has two primary aims: (1) to provide a taxonomy of financial topics on CE and (2) to identify a research agenda for future investigations. The study clarifies four distinct research areas within the financial domain of the CE and identifies eleven specific topics. These areas encompass financial performance and CE practices, financial decision-making, financing resources and impact, and financial models. By synthesizing existing literature and highlighting research gaps, this review enhances the understanding of the financial implications of CE practices and provides valuable insights for policymakers, managers, and investors. Additionally, the identification of future research directions serves as a guide for further advancements in this area.

Supply of critical metals: a quantitative and dynamic framework to forecast material stocks and flows in the economy

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Abstract:

The supply of critical metals and minerals is increasingly at risk due to the general decline in ore grades, the increasing demand from decarbonisation technologies and geopolitical instability. This presents a challenge for government policy-makers and industries in all sections of metal supply chains. To manage supply and price movements, all stakeholders require a deeper understanding of the complex system they are a part of. New modelling and simulation efforts towards dynamically predicting the evolution of the stocks and flows of material in the economy have the potential of bringing about a more quantitative appreciation of the interactions between the environment, industry and the commodity markets. We here present a prospective, dynamic material flow analysis (MFA) model fully based on ordinary and delay differential equations (ODEs and DDEs). An explicit link is made between market dynamics (price, supply and demand) and the movements of material through the anthroposphere – from extraction, through manufacturing and use and finally to disposal. Simplified anthropogenic material cycles are simulated with a system of linear ODEs in normal form. Two flows, extraction and recycling, are governed by DDEs which represent market conditions and build on the cobweb economic theory. To ensure conservation of mass, recycling is further constrained by the availability of scrap metal in the material cycle. We showcase an application of the model to the copper cycle and market to exemplify the dynamic behaviour the model is able to generate as well as its sensitivity to the various parameters introduced. Numerical simulations in the form of initial value problems illustrate broad reconstructions of the commodity cycles exhibited in price and supply fluctuations from 1961, whilst keeping with the magnitudes of anthropogenic stocks and flows observed in retrospective MFA studies. Forecasts of the system based on different economic growth scenarios are also discussed.

Identifying current trends in the environmental impacts linked to fishmeal production in Peru

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Abstract:

The anchoveta fishery in Peru, which is almost entirely devoted to the production of fishmeal and fish oil, is one of the largest fisheries in the world. It is volatile in terms of fishing stock availability, and the fishmeal industry has been subject to technological changes to upgrade its efficiency and reduce costs to maintain its competitiveness. Hence, the objective of this study is to analyze the environmental impacts using Life Cycle Assessment of the production and export of fishmeal and fish oil products to importing nations of a relevant local producer in Peru, representing 10% of national production. A set of 169 vessels targeting anchoveta were inventoried, 88% of which are owned by third parties, and two factories belonging to the company were assessed in the towns of Chimbote and Chancay for the year 2021. Ecoinvent and SimaPro were the selected database and software, respectively, to undergo the computational framework. Results showed that greenhouse gas (GHG) emissions related to the production of fishmeal ready for distribution resulted in 330 and 338 kg CO2eq per t, for Chancay and Chimbote, respectively, when applying energy allocation. The fishery accounted for ca. 45% of emissions, indicating a greater influence of the fishing stage than in previous studies. The reasons behind are linked to the combined influence of improvements in the energy matrix of the plants and slightly higher fuel use intensity of the purse seining fleet. If maritime transport of the final product is included in the system boundary, GHG emissions increase to a range of 442-577 kg CO2eq, depending on the destination. Regarding marine plastic impacts, approximately 1.6 kg of abandoned, lost or discarded fishing gear were generated per t of fishmeal; and roughly 3.3 g of microplastic were emitted to the ocean per t due to antifouling weathering on vessels.

Investigating the potential of calcium oxide incorporating high-volume silica fume as a cementitious binder for pavement application

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Abstract:

It is well-known that producing calcium oxide (CaO) from limestone requires a much lower calcination temperature than that required to produce Ordinary Portland cement (OPC). Also, silica fume is a waste by-product of the silicon and ferro-silicon industries that can improve the properties of cementitious systems. This work proposes a novel calcium oxide-activated high-volume silica fume mixture as a cementitious binder for pavement application. Calcium oxide (CaO) was mixed with silica fume to obtain pastes with different CaO/silica fume ratios. The mechanical and microstructural properties of the different CaO-silica fume mixtures were studied at 7, 28 and 90 days of curing. These properties were compared with those of corresponding OPC-silica fume mixtures in the same OPC/silica fume ratios. The results showed that even by using a small fraction of calcium oxide as the primary cementitious material, it is possible to obtain acceptable strengths, while OPC is unable to provide similar strengths at such low dosage. Also, the mix having CaO content 30% of the silica fume content shows the highest compressive and flexural strengths, sufficient for pavement application. From the microstructural results, it was seen that the calcium oxide system develops strength due to formation of both calcite and calcium silicate hydrate. Finally, a comparative life-cycle analysis revealed the cost and environmental benefits of using calcium oxide over OPC as a cementitious binder in pavements. Based on the mechanical, microstructural, and life-cycle analysis results, it was concluded that CaO-silica fume is a viable alternative cementitious binder for pavement application.

How to reconsider circular economy strategies into science-based targets for carbon emission reduction? A critical methodological evaluation on how to incorporate circular economy carbon performance into science-based targets of manufacturing companies

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Abstract:

Following the Paris Agreement, renewed carbon mitigation efforts have been advanced to engage the global corporate sector towards active leadership to stabilize global atmospheric temperatures. The Science-Based Targets initiative (SBTi) organizational partnership is now recognized as a central vector to promote absolute or Science-Based (SB) Paris-aligned emission targets for the corporate sector. By establishing specific SB targets that each individual company or sector can achieve, SBTi allows them to voluntarily engage and recognize carbon reduction efforts.

Following the SBTi procedure, companies shall account for their carbon emissions according to a base year and set up ambitious SB targets (in coordination with SBTi) to reduce their emission over time. Until now, SBTi has attracted nearly 5000 companies in more than 50 sectors accounting for a volume of 53 million tons of CO2e reduction commitments and is further attracting many more companies. However, there is now an urgent research need to understand how and in which modalities companies can realistically and credibly achieve their SBTi targets.

Implementing circular economy (CE) strategies, such as recirculation of products/parts (e.g. reuse, repair, remanufacture) via long-life products or new business models, or recycling measures are highly promising to achieve the SBTi targets. Nevertheless, current approaches for calculating CE carbon reduction potentials and accounting for their performance along companies' SBTi journey are not comprehensively represented.

This paper provides a critical evaluation of the approaches for calculating carbon reduction performances for CE strategies to investigate the existence of a viable method for manufacturing companies to account for their CE strategies' performance to achieve SBTi targets. Our results show that while the GHG Protocol provides several methodologies, many CE strategies remain uncovered. We provide several robust argumentations for the present need to better incorporate CE into the methodological layout for manufacturing companies engaged in SBTi.

Bioleaching and bio-recovery of PGE from anthropogenic matrices

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Abstract:

The metals supply market is facing a critical period because of the high demand for primary raw materials. In search for alternative sources of technology-critical metals, spent automotive catalytic converters (SAC) represent a diversified source of supply of Platinum Group Elements (PGE) which are used in many applications without substitutes, and result an increasing category of waste potentially ecotoxic. Using traditional methods from Solid Earth Sciences (ICP-MS, SEM, XRD, etc.) combined with marine biotechnology, we aim to develop a bio-hydrometallurgical process identifying extremophile marine bacteria suitable for the treatment of SAC and recovery of precious metals including PGE. The bacteria were isolated from marine sediments marked by geochemical anomalies through different enrichment methods: i) enrichment with SAC powder, ii) enrichment with SAC leachate. This experimental design favoured the selection of matrix-tolerant strains. Therefore, mineralogical and chemical analyses informed the first set of bioleaching and bio-recovery experiments to assess the capability of the selected microorganisms to sustain leaching performances. Primary bioleaching was conducted by mixing the bacteria directly on SAC powder in a minimum growth medium and analysing by ICP-MS three components: biomass, SAC powder, and leachate. The bacterial bio-recovery potential of aqueous Pt(II) was investigated by analysing the residual Pt concentrations of the aqueous phase with and w/o bacteria. The strains selected for the experiments were the best candidates resulted from pH and Pt (II) tolerance assays, showing growth in a range of pH from 7 to 3, and a Maximum Tolerance Concentration (MTC) of 0,5 mM (~ 211ppm K2PtCl4, ~ 100 ppm of Pt) to K2PtCl4. Interestingly, one strain showed an MTC of 4 mM (~ 1600 ppm K2PtCl4, ~ 768 ppm of Pt). These preliminary results emphasise the potential application of new eco-technological solutions to recover Pt and other critical elements from SAC using adaptable, matrix-tolerant strains.

The water resource use efficiency impact of water rights trading: evidence from China's water rights trading pilots

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Abstract:

With the increasing conflict between the supply and demand of water resources, improving water resource use efficiency has gradually become a focus of attention. As a new way to manage water resources, the water rights trading pilot has been basically completed in China. It is of some significance to explore the impact of water rights trading on regional water resource use efficiency and possible impact paths. This paper uses a global non-radial directional distance function (GNDDF) model to measure water resource use efficiency, which is more scientific and realistic. To investigate the effect of China's water rights trading pilot policy on improving regional water resource use efficiency, we apply the regression control method (RCM) for counterfactual analysis and test the possible pathways through which the water rights trading policy affects water resource use efficiency. This article draws the following main conclusions. (i) The overall average level of water resource use in China over the past decade or so is not high, and the water resource use efficiency varies greatly from region to region. (ii) The water rights trading policy has the significant effect of improving the water resource use efficiency in the pilot provinces, and the effect has regional differences, which may be related to the level of water resource use in the pilot provinces and the specific form of water rights trading undertaken. (iii) The water rights trading policy can improve water resource use efficiency by incentivizing water conservation, improving medium water reuse and promoting water use restructuring.

Content analysis methodologies and metadata on resources of sustainable smart cities, sustainable digital transformation, and sustainable city management: A review from 2010 to 2023

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Abstract:

This article performs a metadata and content analysis of the effects of sustainable smart cities and sustainable digital transformation on sustainable city management, finding gaps to be studied according to the literature review published on the topics between 2010 and 2023 and presenting insights and directions for future research. The survey collects data from Scopus, objectively selects 463 articles and performs metadata and content analysis. Two hundred and forty-three articles are analyzed to present the insights and rankings of the literature based on content reviews that include conceptual development, collaboration with smart city partners, resource optimization, evaluation of sustainable practices and sustainable performance of smart cities. The research reveals the research trend in sustainable smart cities, sustainable digital transformation and sustainable city management. The survey finds consistent growth in resource assessment for sustainable smart cities, sustainable digital transformation and sustainable urban management. The concept of sustainable smart cities started to gain popularity among academics in the early 21st century. This research finds a sharp growth in publications from 2017 to date. This survey identifies influential authors, top journals, top contributing countries, top contributing institutions, and contributions by discipline. This research presents a comprehensive but straightforward preliminary conceptual framework of sustainable smart cities, sustainable digital transformation and sustainable urban management. The research results and future research directions offer a new avenue for further exploration and contribution to this topic.

Keywords: Smart Cities, Digital Transformation, City management, Sustainable Smart Cities, Metadata and Content Analysis

Analysis of the building envelope energy efficiency in accordance to the Spain regulations.

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Abstract:

The natural resources depletion is a huge concern of the mankind. Therefore, strategies to overcome this issue are required because the energy consumption of the world is increasing continuously. In this sense, residential sector plays an important role since it is responsible of the 20% of the total energy consumption in the developed countries. Consequently, the development of more sustainable building could be considered as a relevant task to reduce the energy consumption and hence to achieve a better use of natural resources. However, as there is a huge number of buildings built in accordance with different regulations along the time, a complete survey is necessary as starting point to evaluate and improve the energy efficiency of the buildings envelope in this sector. Thus, this work presents a thorough analysis of the current state of the building sector in Catalunya in terms of energy efficiency based on the different regulations in Spain.

Peer effect on low-carbon activities of firms along the value chain: Evidence from China

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Abstract:

In recent decades, peer effects have become a subject of considerable interest not only in individuals' behavior, but also in business behavior. A significant number of papers have found that firms' behavior and actions are also directly related to their peers and surrounding conditions. However, the spillover effects in low-carbon activities, especially the mimicry of firms on low-carbon activities from their peers of upstream and downstream firms along the value chain are barely discussed in the literature. In this paper, we extend the research on peer effect to the convergence of low-carbon activities of firms along their value chain at the firm level, and explore the spillover effects and mechanism of the low-carbon activities among peer firms along entire value chain.

To conduct the empirical model, we combined two large databases -- the Annual Survey of Industrial Enterprises (ASIE) for the period 1999 to 2009 released by China's National Bureau of Statistics and the China Environmental Survey Database (CESD) released by the Ministry of Ecology and Environment, and obtained firm-level data with nearly 360,000 observations of Chinese industrial firms from 1998 to 2010. We also employed the inter-industry linkage shown in city-level input-output tables of China to weight the spillover along value chain.

Our results suggest that there is a significant peer effect on low-carbon activities at the firm level. The carbon emission intensities of the target firms are not only influenced by the carbon emissions intensities of their peers in the same industry, but also by the activities of their peer firms in the backward and forward industries. We also conduct heterogeneity analysis among different types of firms, city groups, and industry groups. All the results are very robust. The results provide important implications for the government to better understand and promote low-carbon activities of firms.

Recovery of copper from municipal solid waste incineration bottom ash by flotation

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Abstract:

The fine fractions of municipal solid waste incineration bottom ash can have copper concentrations that are comparable to those of ores from primary raw material extraction. While the processing of the coarse fraction (>2 mm) is state of the art in Central Europe, the fine fraction is often landfilled. This results in high costs and valuable materials are withdrawn from the cycle. A possible approach to recover the copper could be flotation, which is the standard process in the primary raw materials industry today.

First, a mineralogical characterization of the ashes was performed. The spatially resolved phase analysis shows that the material contains a very heterogeneous mixture of naturally occurring compounds as well as particles of alloys, metals, (artificial) oxides and sulfides. Copper can occur in the form of alloys, simple sulfides and oxides. During the combustion process, new phases are formed that are different from the naturally occurring phases. Besides glass and quartz, mineral compounds can be identified as the main phases of the matrix, originating in building materials such as cement and gypsum.

Based on these results, copper oxides and sulfide can be identified as the most important minerals for a possible recovery. Due to the high complexity and high pH of the ashes, the investigations focused on selective flotation using thiourea, thiophosphate and thiocarbamate based collectors. Flotation tests on single minerals show a high hydrophobicity of these collectors on both the copper oxides and the sulfide. By measuring the contact angle on both the main matrix phases and metal oxides, the selectivity of the collectors was investigated.

Investigations with generic mixtures consisting of copper oxide and the individual main phases show, with the phases introduced by cement, reduced yield of the copper. By using organic depressants, such as alginic acid, the copper yield could be improved.

Estimating material dissipative losses in thermal spray

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Abstract:

Thermal spray technologies are necessary for various components to meet technical functionalities under harsh environmental conditions. Those technologies come at the expense of dissipative losses of coating materials throughout the life cycle of components. Some of those materials are considered critical due to their high economic importance, limited availability of viable substitutes, and supply risk. Measuring these material life-cycle losses has so far retained little attention in the field, despite an abundance of parameters and characteristics of thermal spraying processes based on lab results. Accordingly, having a structured way to estimate the dissipative losses is needed. Our research provides a framework to estimate material dissipative losses in surface engineering applications based on some parameters, mainly deposition efficiencies. We then apply substance flow analysis for the main metals used in thermal spray (Cr, Co, Mo, Ni, Si, W, Y and Zr) to quantify their life cycle dissipative losses. The investigated sectors are transportation and energy generation, where thermal spray is highly utilized. Due to the scarcity of primary data, we strongly relied on experts' knowledge to balance mass flows of coating materials over the components' life cycle. This is complemented with an uncertainty range to account for the variability. Building on those results, material efficiency strategies specific to thermal spray applications are recommended. Results show that the life cycle stage responsible for most of the dissipative losses is the coating itself, where real deposition efficiencies communicated by experts were much lower than what is usually reported in literature. Significant dissipative losses also occur at the end-of-life, where most coating materials are melted with the substrate (non-functional recycling) and not separated beforehand. Improving the deposition efficiency, recovering the unstuck coating and de-coating the components at their end-of-life were found to be key areas of intervention to reduce the critical material losses.

Labour market effects of the circular economy in Belgium: modelling the recycling and waste sectors using a general equilibrium model

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Abstract:

The last decennia, management of waste and secondary materials has created economic value and jobs in Belgium. Furthermore, increasing the waste and recycling activities is one of the building blocks of the circular economy (CE). In this research, we first introduce a methodology to map the Belgian waste and recycling sector. Second, this paper includes the modelling in a general equilibrium model of three policy measures from the Circular Economy Action Plan of the European Commission and an analysis of the results in the current policy context. These policy measures are: increasing the minimum recycled input used in the production of goods, facilitating high quality recycling, and a tax on the export of waste. Third, we perform several sensitivity analyses for an increased energy price and an increased elasticity of substitution between recycled input and conventional input. Lastly, we translate the results in a skills extension tool which allows us to analyse the changes in the necessary jobs and skills in the waste and recycling sector and in other sectors. The results show that an increased uptake of recycled input causes reduced output for the manufacturing industry as this industry is forced to shift to secondary materials. The second policy measure, enabling high quality recycling, results in increased economic activity as well as increased household consumption and GDP. The third policy measure of addressing waste exports causes a reduction in W&R activities, however, the remaining waste production will not be processed domestically but will rather be incinerated. This research is the first to disaggregate the waste and recycling sector in a general equilibrium model and to analyse the link with skills and jobs.

Decarbonising Urban Form: Opportunities and Benefits in Reducing the Use of Concrete and Cement in Chinese Cities

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Abstract:

In view of the various negative effects caused by the massive use of concrete and cement in the construction industry, it is necessary to redefine the construction mode in order to reduce the direct use of concrete and cement. This paper puts forward two main solutions in case-based analysis: one is to create recycled materials to be put into the construction process by recycling the waste concrete and cement in construction waste, thus reducing the over-production and use of raw materials; the other is to promote the development of Mass Timber Construction (MTC), using wood as a substitute for concrete and cement.

Specifically, recycling concrete and cement has many benefits. In the most direct sense, it can accomplish a considerable amount of CO2 emission reduction tasks, by replacing natural aggregate concrete and other mixtures with recycled concrete and recycled inorganic materials. In addition, vigorously promoting the recycling of concrete and cement actually promotes the development of construction waste treatment plants and create a considerable number of employment opportunities in transportation, processing, treatment and other links, and at the same time alleviate the phenomenon of garbage siege to a certain extent for people's better livelihood.

Mass Timber Construction (MTC) is a good substitute for concrete and cement both in terms of cost and natural capacity. Its most intuitive benefit is that it brings direct CO2 emission reduction, the comparison between a mass timber structure and a concrete structure shows that a timber building has a 22% lower impact on GHG emission. Moreover, the characteristics of wood make it possible to realize carbon sequestration in long-term.

In short, recycling concrete and cement and using wood as substitute materials are two feasible and effective methods where the government should also take corresponding measures in regulations, finance, education and other fields.

Recycling treatment of waste activated sludge lysate based on bioelectrochemical systems: carbon and nitrogen separation, recovery of ammonia nitrogen

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Abstract:

Sludge lysate is unavoidable and high-organic liquid rich in ammonia nitrogen and short chain fatty acids (SCFAs) produced from the waste activated sludge hydrothermal pyrolysis, the treatment of which is usually discharged directly into wastewater treatment plants (WWTPs). Here, bioelectrochemical systems (BESs) integrated with transmembrane chemisorption (TMCS) unit were investigated to achieve carbon and nitrogen separation and ammonia nitrogen recovery of sludge lysate, so that to maximizing resources recovery of sludge lysate and reducing nitrogen removal burden of receiving WWTPs. Under the driving voltage 1.1 v and nitrogen loading rate 10.45±0.017 g N/(m2·d), microbial electrolysis cell (MEC) and anaerobic sludge microbial electrolytic cell (AS-MEC) obtained 78.83% and 93.25% ammonium recovery efficiencies respectively. MEC recovered ammonium with less carbon source consumed (△C/△N was 2.29), and left more SCFAs (50.11%). When MEC effluent was added to low carbon nitrogen ratio (3.5) influent SBR, it could act as denitrification carbon source and reduce SBR effluent total nitrogen by 41.12%, however raw sludge lysate increased by 38.25%. Alternatively, AS-MEC generated more electricity and obtained higher ammonium recovery efficiency because of complex microbial community collaboration and stronger impact resistance, but consuming more carbon source (△C/△N was 3.24). When AS-MEC effluent was added to normal carbon nitrogen ratio (9.4) influent SBR, it could reduce effluent total nitrogen by 26.32% compared to raw sludge lysate. In particular, we found limited electricity generation affected the system handing load of sludge lysate most in the different load experiments. We also evaluated the economic benefits of the concept and found 1.37 million dollars could be saved per year for a WWTP processing 0.1million tons waste water daily. This concept is worthy to be developed in WWTPs for sludge lysate treatment with considerable resources recovery and capital saving.

Managing water resources under conditions of scarcity: A contingent valuation of smallholder farmers' willingness to pay for improved irrigation water supply in Egypt

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Abstract:

The agriculture sector in Egypt is heavily dependent on the Nile River's irrigation water due to the country's arid and desert climate. However, recent water scarcity challenges have increasingly affected crop yields, farmers' income, food security, and the environment. To address these issues, recent irrigation projects require farmers to contribute financially to enhance the financial sustainability of the projects, improve water management practices, distribute the benefits more equitably, and increase the efficiency of water use. This study has, for the first time, examined the willingness to pay (WTP) of smallholder Egyptian farmers for improved irrigation services. A survey of 313 Egyptian smallholder farmers was conducted in 2022 to elicit WTP using a double-bounded dichotomous choice contingent valuation experiment in the Nile Delta region's Fayoum province. Probit and bivariate probit models tested the WTP estimates and explanatory factors for robustness. In addition, a two-step Heckman correction was estimated to control for protest responses' selection bias. The results indicated that farmers are willing to pay a significant amount of around 1300 Egyptian pounds per feddan (roughly 0.42 hectares) for improved irrigation services, or around 5 % of the average annual income per feddan in the region. Attitudes and perceptions about irrigation water quality and availability, type of irrigation water, average income from agriculture, and farm size and location on the irrigation canal have a positive significant influence on WTP. On the contrary, psychological distance and access to credit have negative significant impacts on WTP. Our results provide better understanding of the behavior and decision-making process of smallholder farmers, who play significant role in water use and agricultural production in Egypt. Furthermore, the findings can inform the optimal design of tariff on water use that take farmers' preferences into account to improve water management and irrigation services in Egypt.

Solely economic mitigation strategy suggests upward revision of nationally determined contributions

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Abstract:

The use of equity principles to review the nationally determined contributions (NDCs) is critical to facilitating more ambitious climate actions. However, disagreement over the equity principles persists. We instead treat emission reduction as a solely economic behavior motivated by avoiding future economic damage from climate change. Assuming no international cooperation, we provide a solely economic mitigation pathway to review national climate pledges until 2100. Using the value in 2030 to review the NDCs, we find that the NDCs of China, the USA, and the EU are 1.5, 1.4, and 0.9 respective GtCO2eq lower than their solely economic emission levels, whereas India commits 3.8 GtCO2eq more than its solely economic emission level. We also propose an equal-effort cooperation scenario toward 2°C where each country reduces emissions by 28% of their solely economic levels in 2030. Through exploration of the economic trade-offs, our results suggest that more ambitious NDCs are urgently needed.

Consumer Perceptions and Adoption of a Circular Chemical Economy Ruini Qu[1], Kaiwen Chang[1], Umit Bititci[1], Jin Xuan[2], Bing Xu[1]

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Abstract:

Despite the chemical sector playing a vital role in the UK economy, it heavily relies on fossil fuels and stands as the second-largest CO2 emitter. The concept of a circular chemical economy has emerged as a viable solution to transition from the current linear chemical sector. However, limited attention has been given to how consumers perceive and respond to products made from circular materials. Consumer perceptions of sustainability and environmental responsibility shape the behaviour of our society and drive market demand. Neglecting the social context of sustainable chemicals can hinder their widespread market development, deployment, and adoption. To address this research gap, we conducted a survey on everyday chemical products among UK citizens (N=2,620). The aim of the study is to gain a better understanding of the consumers' mindset toward the use of circular chemical products, as well as their behaviour when purchasing, using, and disposing of such products. Our findings shed light on consumers' willingness to pay for circular chemical products and reveal the barriers to their adoption. These insights can guide the design and implementation of policies and regulations aimed at promoting a circular chemical economy. Although our results are based on a large set of unique UK-based data, they may provide valuable insights for countries with similar socio-economic characteristics.

Keywords: Circular economy, Chemical industry, Consumer perceptions, Willingness to pay

Exploring adaptive strategies for the black soil region to guarantee China's food security under various uncertainties

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Abstract:

The black soil region of Northeast China is an important national food production base, where grain production accounts for about a quarter of the country's total. Due to long-term high-intensity development and utilization, coupled with wind and water erosion and other impacts, the thickness of the black soil layer and organic content declined, which posed a certain risk to food security in the northeast and even the country. In the national grain supply and demand balance process, there is still a lack of comprehensive research on the contribution capacity of key crop supply in key grain-producing areas. The study uses a panel regression model to identify the key paths of action to ensure the balance of grain supply and demand in China. the number of provinces in a grain supply and demand surplus nationwide is increasing from 2000 to 2020. In addition, with the expansion of rice cultivation in the northeast in recent years, Heilongjiang had the largest increase in its contribution to rice (58.9%). Heilongjiang and Jilin have absolute dominance (90%) in the domestic soybean supply. Overall, the black soil area contributes more than 40% to the national food security guarantee and is the most advantageous main grain-producing area in the country, which provides strong support to improve the uneven spatial distribution of grain production and consumption structure in China, guarantee the balance of domestic grain supply and demand, and meet the growing dietary nutrition needs of residents. It is important to develop adaptive strategies for China's black soil areas to cope with the impact of uncertainties such as climate change and international conflicts to ensure national food security.

Ammonium recovery driven by benzonic acid removal in two-chambered bioelectrochemical system

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Abstract:

Nitrogen is one of the key nutrients and contaminates in diverse wastewater, a focus on reducing the environmental footprint that is part of classical ammonium removal. Compared to the traditional techniques for ammonia removal, electrical energy generated with the help of electroactive microorganisms can be directly drive the ammonium recovery in bioelectrochemical system (BES). Benzoic acid was found as the main contaminant of industrial wastewate in Tianjin wastewater treatment plant. In order to face the needs of actual applicatio, BES-ammonia recovery system was proposed to enhance BA removal, and even effectively recover inorganic pollutants-ammonia nitrogen by the generated current from benzoic acid degradation. Ammonium recovery efficiency driven by benzonic acid removal were studied on the basis of determining optimal anode potential as -0.2 V. The BES coupled ammonia recovery system was operated in a continuous-flow mode, and the hydraulic retention time was set as 8 h. The removal rate of benzoic acid was more than 75%, and benzoic acid were proved to achieve complete mineralization based on the comparation of measured COD and calculated COD. The pH value of the cathoyte was 11.8±0.2, result in most ammonia nitrogen transferred from the anode chamber to the cathode chamber, and then absorbed by sulfuric acid in the form of free ammonia. Total ammonia nitrogen recovered in the absorption solution accounted for 81% of the total NH4+-N of influent, and 91.3% of the removed NH4+-N. In this proof-of-concept work, the proposed BES ammonia recovery system opens an opportunity to treat the refractory organic compound wastewater in a more compact and sustainable manner, and simutanously driven nitrogen resource recovery.

Global material demand and associated climate impact for servers and storage of data centers and mitigation strategies to 2050

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Abstract:

With the increasing demand for digital services, such as cloud computing, artificial intelligence, and the Internet of Things, data centers have rapidly expanded worldwide in the past decade and are projected to continue to grow in the coming years. These energy-intensive facilities entail significant energy consumption and carbon emissions throughout their entire life cycle. Notably, recent improvements in energy efficiency and the proportion of renewable energy use during the operational phase have reduced the proportion and potential for carbon emission reduction in that stage, while the potential for emission reduction in the manufacturing of relevant equipment has increased. While previous research has explored the environmental impact of data centers, the majority has focused solely on the operational stage, neglecting the life cycle as a whole. Thus, it is essential to investigate the environmental impacts and potential emission reduction strategies for constructing data centers.

In this study, we develop a comprehensive model that integrates a dynamic material analysis (MFA) and a prospective life cycle assessment (LCA) method to estimate the future material demand of IT infrastructure contained within data centers and quantify the associated emissions from relevant material production on a global scale. Specifically, we examine the two most critical components of data centers, servers, and storage systems, and investigate the material resource demands for 22 types of materials embodied in these devices. Moreover, we estimate the greenhouse gas (GHG) emissions resulting from this material production by 2050. Finally, we evaluate the potential impact of material efficiency strategies (e.g., recycling, reused and lifetime expansion) in mitigating GHG emissions along the life cycle of data centers.

Our research provides insights into realizing net-zero data centers across their life cycle, aiding relevant stakeholders and policymakers in gaining a deeper understanding of the relationship between material resources, climate change, and the circular economy.

Motivations and Barriers to Surplus Food Redistribution from Consumer and Business Perspectives: a Case Study of a Surplus Food Mobile Application

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Abstract:

Redistributing surplus food through mobile applications has become increasingly popular in promoting food sustainability. The main purpose of this study was to explore the motivations and barriers of 'food savers' from different stakeholders' perspectives, including a surplus food mobile application's founder, food service providers, and consumers using the application (app). This study employed a qualitative case study research approach. "Tasteme", the first and the only surplus food mobile application in Taiwan, was selected as a case in this study. The Social Identity Model of Collective Action (SIMCA) was adopted to guide this study. Three focus group interviews with customers and nine semi-structured in-depth interviews were conducted with food service providers and the app founder were conducted. The findings unveiled that the main motivations of the app founder were emotions regarding discarding food, the significance of group identity, and instrumentality. Financial effectiveness and emotional attachment to food were the primary motivations for food service providers, while time-consuming was a key barrier for them. Social influence from peer groups and achieving desired outcomes of cherishing food and saving money were powerful motivations for customers. However, customers faced several barriers, including limited food options, time costs, financial risks, and food safety risks. This study suggests designing food apps with flexible payment options and an instant message system, partnering with various food vendors, and promoting education on food sustainability to prolong food lifespan and encourage surplus food consumption.

Keywords: surplus food redistribution, mobile application, food sustainability, motivation, barrier, Tasteme

The role of lithium in the low-carbon and circular transition in China's lithium-ion battery sector

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Abstract:

With the quick development of China's lithium-ion batteries (LIBs) industry, concerns have been raised around lithium scarcity which may compromise the low-energy transition. A dynamic bottom-up material flow analysis (MFA) model was developed, combining the Weibull distribution model and the 'Apparent Domestic Consumption' (ADC) metric, to explore current and future lithium flows and stocks in China's LIBs system. Five different future scenarios have been developed to reflect different possible pathways to 2050. Results show lithium flows in 2050 are projected to be 5-7 times larger than in 2018, as electronic vehicles (EVs) become the major consumer of lithium in China. The study also shows how different interventions can have major impacts on reducing primary Li consumption. New battery chemistry innovation and improved LIBs waste management are the two most impactful strategies to secure a more sustainable and circular lithium supply. Policy recommendations are proposed for the transition towards circular Li flows in China.

Multi-agent based for the driving mechanism and policy simulation of residents' garbage classification behavior: Take Chongqing’s garbage classification as an example

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Abstract:

With the economic and social development and the substantial improvement of material consumption level, the amount of garbage generated is growing rapidly in China. The "garbage siege" has become the city's pain. The effective implementation of garbage classification is vital to the sustainable development of cities. However, the current household garbage classification and recycling management is inefficient. Cultivating residents' habits and increasing participation is a critical issue to be addressed in garbage classification. In order to explore residents' garbage classification behavior and formulate efficient policies scientifically, this paper analyzes the factors and mechanisms affecting residents' garbage classification from a microscopic perspective. This paper constructs a multi-subject model and designs 12 scenarios to simulate the dynamic evolution of residents' garbage classification behaviors based on three types of policy scenario indicators: policy regulations, public education and incentives, from different policy measure strengths, different policy measure types, and different policy measure combinations. The results show that for the same policy, the higher the intensity, the higher the growth value of the promotion effect on the classification rate. For different policies, Policy Regulations > Public Education > Incentives. For different policy combinations, Public Education & Policy Regulations > Policy Regulations & Incentives > Public Education & Incentives. By comparing single policy with multiple policies, the effect of multiple policy combinations is better than that single policy, and the policy combination can achieve the complementary disadvantages of different policy measures. This study provides a behavioral decision-making perspective of individuals, analyzes the behavioral characteristics and preferences of garbage classification resulting from behavioral heterogeneity of residents, and quantifies policy effects at the macro level, providing a common research method and paradigm for behavioral research and policy formulation.

Data collection needs for the simulation of LIB recycling processes

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Abstract:

Lithium-ion batteries (LIBs) are essential to achieve the ongoing decarbonisation efforts as they are the preferred energy storage technology in electric cars, renewable energy, and portable electronics. The composition of LIBs is variable, but they generally contain Li, Co, Mn, Ni, Cu, Al, and graphite which are largely obtained from primary mineral resources. Recycling spent LIBs is crucial to provide sufficient raw materials as their demand continuously grows. Modelling and simulation are essential engineering tools that can predict the outcomes of existing and novel concepts. In the case of recycling, they aid in the prediction of recovery rates of processes and the forecast of their environmental impact. Still, data on LIB recycling processes produced from laboratory and pilot scales has a high degree of heterogeneity and information gaps. This study aims to define a framework for the systematic data collection for recycling processes. We reviewed the current state of the literature regarding engineering models for processes and operations reported for LIB recycling including direct recycling, hydro- and pyrometallurgical routes. Accordingly, the data published in the literature was crossed referenced to identify parameters or operating conditions most commonly missing. The outcome of this study is a guideline about what data should be reported to generate useful simulations.

Industrial symbiosis in India - an exploration of an Indian industrial estate

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Abstract:

This study investigates challenges and opportunities for industrial symbiosis within Indian industrial estates, focusing on material flow, resource efficiency, and sustainability. The primary barrier to establishing closed-loop systems is the lack of trust and cooperation among companies. However, early industrial symbiosis instances and a thriving informal waste management system provide potential for future development. Interactions between company managers on environmental concerns, infrastructure, and waste management present opportunities for environmentally favorable waste material utilization decisions.

Local waste dealers play a crucial role, capturing 78% of waste materials from manufacturing companies in the Naroda industrial estate. The study emphasizes the need for partnerships with informal waste markets to foster economic and environmental benefits for disadvantaged communities. Enhancing industrial symbiosis in India would contribute to resource efficiency, profitability, environmental protection, improved public health, and the achievement of Sustainable Development Goals (SDGs) 8, 9, and 12. The connection between industrial symbiosis and these goals is demonstrated through various cases in India and globally.

The governance mechanism of household waste sorting in residential communities: Insights from Changsha, China

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Abstract:

Recent policy developments in China have recognized waste sorting behavior as an important issue. The Implementation Plan for the Household Waste Sorting System, issued by the State Council in 2017, aims to promote a fundamental change in the way waste is managed, moving from a "waste to resource" transformation. This mixed-methods research seeks to explore a sustainable collaborative governance model for waste sorting in residential communities in Changsha. A questionnaire survey was conducted from December 2020 to January 2021 to investigate residents' attitudes and behaviors related to household waste sorting, and 437 responses were received.

The results show that gender does not significantly affect residents' willingness to participate in waste sorting activities, although age group and education level do have a significant impact. Younger residents are more likely to participate in waste sorting publicity activities than elderly residents, and there is a positive correlation between residents' education level and their willingness to accept a charging system. In addition to quantitative data, in-depth semi-structured interviews were conducted with eight stakeholders, including cleaners, residents, NGOs, and local community committees, in March and April 2023. The research team found that poor execution, hierarchy between different stakeholders, and unsolid cooperation systems are the key factors hindering the promotion of household waste sorting movements.

Using the data collected, this research formulates a co-governance network connecting different stakeholders to maximize the common interest and rebuild social capital. It also provides potential strategies based on contextual identification and field investigation. Future research should focus on identifying potential indicators to accurately evaluate the outcome of waste sorting practices and expanding the scope and stakeholder involvement in the investigation.

Drivers and barriers for the advancement of a circular blue bioeconomy in Iceland and Norway

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Abstract:

A circular bioeconomy can reduce dependence on non-renewable resources, promote sustainable resource use, and support the development of innovative bio-based products and services. The blue bioeconomy (i.e. aquatic resources) is an underresearched but integral part of the bioeconomy especially in nations such as Iceland and Norway with economically significant blue industries (e.g., fisheries and aquaculture). The circular economy paradigm calls for the redesign of the linear economic system whereby the environmental and social costs of products are externalized, to a circular system based on closed-loop resource flows that can preserve the embedded environmental and economic value in products over time. In-depth interviews and focus groups with key stakeholders - high level managers, industry (primary, secondary and supporting), and government and industry experts - were conducted in Iceland and Norway to investigate the major institutional factors for the advancement of a more circular and sustainable blue bioeconomy. The analysis was supplemented and triangulized by review of regional and national policy and strategy documents. The findings show that realising the potential of a more circular blue bioeconomy requires the development of target-based overarching strategies and the implementation of a systemic approach cutting across different sectors (e.g., agriculture, tourism, transport and energy sector). Companies need to reconsider their value creation and adopt strategies that promote circular economy objectives for the biobased sector including increased collaboration through clusters and public-private partnerships. Overcoming barriers such as the lack of institutional and infrastructural capacity requires the attention of policymakers and investors. Advancing a more circular blue bioeconomy has the potential to improve the efficient use of aquatic resources but also to contribute to the bioeconomy and the circular economy at large as improvements can have cascading effects on other major industries. The study proposes targeted recommendations for improved policy and strategy options.

Environmental extended input-output analysis in sustainable supply chain management: greenhouse gas emission inventories of regional level in Taiwan

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Abstract:

Global warming is one of the sensitive and distressing issues at the present time. The incalculable consequences in terms of aspects that global warning also climate change causes not only influenced the environment but also impinged human health. The main cause of the global warming effect is greenhouse gas emission, therefore calculating GHG is essential to understand the extent of human impact and inform policy decisions at local, national, and international levels. Furthermore, GHG emissions data can be used to monitor progress towards emissions reduction targets. By tracking emissions over time, we can assess whether our actions are leading to reductions in emissions and adjust our strategies accordingly. Supply chain, one of the main industries in the national economy, contributes a huge part to GDP, GHG emissions in supply chains can account for a significant portion of a company's overall emissions, especially for companies with complex and global supply chains. Therefore, GHG emissions in supply chains are important to consider. The overall global goal is defined as the reduction of GHG emissions, the worldwide target to be achieved to contain global warming since the IPCC first assessment report was released in 1990. Therefore, this paper conducts review and a micro-level supply chain analysis focusing on the carbon footprint of the supply chain industry. In particularly, this article which is an analysis of the application of the Input-Output of carbon footprint in Taiwan by model with a specific example of applying model to 63 sectors in Taiwan in the period from 1990 - 2020 based on data of Taiwan EPA also Statistical tables (I/O tables) of National Statistic R.O.C (Taiwan) in a one step at a time effort towards sustainable supply chain management in Taiwan, and further meet future goals related to Carbon Border Adjustment Tax (CBAM).

The chemical recycling of waste plastics using a bio-based solvent dimethyl isosorbide

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Abstract:

The excessive use of single-use plastics for packaging nowadays and for personal protective equipment (PPE) during the COVID-19 pandemic results in large quantities of plastics whose disposal poses risks to the ecosystem and human health. In addition to mechanical recycling, solvent-based dissolution-regeneration is a promising chemical approach that preserves the properties of plastics. However, most traditional solvents are fossil-based and toxic. Herein, we have screened a bio-based solvent via Hansen Solubility Parameters (HSP), dimethyl isosorbide (DMI), and applied it to different plastics (PET, PLA, PS and PVC). DMI shows a high dissolution performance at 180°C in a short time (<6 min). FTIR and XRD analysis showed that the hydrogen bonding interaction between PET and DMI molecules could be responsible for the significant solubility of PET in DMI. The PET obtained after precipitation using water as anti-solvent retains properties similar to virgin PET with minimal degradation (~2.2%) and negligible thermal performance loss. Furthermore, we have hydrolysed the regenerated plastic under alkaline conditions to monomers within 10 min, thanks to the reconstruction of the PET hydrogen bond by DMI. This work provides an environmentally friendly, energy-efficient and rapid solvent-based technology to recycle waste plastic to its polymer or monomer form, thus achieving a closed-loop approach.

Total material requirement (TMR) of China's automotive industry in the context of green and low-carbon transition

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Abstract:

In green and low-carbon transition, the electrification and lightweighting of vehicles increase the demand for mineral resources. China is the largest automobile market worldwide, severe environmental impacts have been caused on the mining location for China's vehicle production within the global trade network, including the indirect flows such as mine waste left on the ground. Howover, such environmental impact caused by Chinese automotive electrification and lightweighting has not been quantified yet.

Total material requirement (TMR) is an indicator to reflect the total mass of primary materials extracted from nature, including hidden flows such as mine waste. This study aims to quantify the total material requirement for China's automobile production within the global trade network. The trade-linked MFA model was applied to simulate vehicle production resource flows, and LCA was used to estimate the resource input for each process.Five key life cycle stages of vehicles and three kinds of flows of resources (domestic, international trade, and other regions') are defined.

A Chinese TMR database that contains 10 metal resources (Fe, Al, Cu, Ni, Li, Mg, PGMs, Pb, Co, REEs) and 3 energy resources (coal, oil, natural gas) relevant to China's vehicle production was established in this study. The mine wastes from more than 2000 mine sites were calculated. According to results, bauxite and cathode Cu have the largest TMR coefficient among those ores and semi-products used in China's vehicle production, respectively. For example, 7.4 t of solid materials would be extracted around the world to produce 1 t of bauxite used in China. The results suggested noticing the embodied and increasing environmental impacts from the more complex global trade networks and the increasing demand for Al, Cu, and Ni because of their high TMR coefficient.

Redesigned urban sanitation can arrest environmental degradation and improve food security

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Abstract:

As urbanization stabilizes during this century, 85 % or some 8.5 billion people, will reside in urban areas. These areas become hotspots for the demand of water and food, while disposing vast voulmes of wastewater and organic waste including human excreta. Today, agriculture is a major contributor to global environmental degradation and occupies half of the earth´s inhabitable area. Global resources limits/boundaries for provision of food and water together with serious degradation of the environmental conditions will put the recycling issue on the global agenda.

Global data on resources and causes of pollution are forthcoming, making it possible to conjure future resources restrictions and imbalances of nutrients and water. Also, emerging infrastructure and technologies will make it possible to reduce household demand for water by at least half and a return to more plant-based diets, intensified food production, and food production in ”food factories” using recycled nutrients will free presently used land areas.

The geographical concentration of disposal of resources from urban areas will facilitate recycling of water and nutrients after use. But such progress can only be achieved with new sanitation arrangements and a reduction of household usage of harmful chemical products. Thus, the demands of water and nutrients for food production can be substantially reduced, while global degradation of the environment (GHG emissions, eutrohication, land use, biodiversity loss, etc.) is reversed and vast stretches of agricultural land can be returned to Nature.

Such favourable conditions can be achieved through reconnecting urban and rural resouce flows by recycling arrangement. A combination of functionally improved installations in households, return to more plant-based diets, redesing of infrastructural, etc. is likely to guide the next generation of urban planning and resouce flows.

Opportunities and challenges for circular economy in Maldives: a stakeholder analysis of the informal sector in e-waste management in the Greater Male' Region

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Abstract:

The contributions of informal e-waste recycling and recovery in Maldives are considerable, particularly at the time of the formalization under discussion, but have been little studied. This study aimed to explore the opportunities and challenges for circular economy in e-waste management in the Greater Male' Region of Maldives by focusing on the role and perceptions of the informal sector and the other major stakeholders (i.e., government and consumers). Data were collected from respondents in the formal sector (n = 5), informal sector (n = 11), and consumers (n=202) through semi-structured interviews and structured questionnaires in September 2022. Data were analyzed based on thematic analysis, correlation analysis, and t-test to examine differences in opinions about e-waste management between the stakeholders and consumers. The consumer respondents' willingness to interact with the informal sector is higher with government intervention than without. The formal sector respondents have higher positive perceptions towards the formalization of the informal sector than the informal sector respondents regarding the economic and environmental impacts. Furthermore, nine leading themes were identified from informal and formal sector interviews, including the role of the informal sector, challenges in recovery works, and formalization. Results indicate a consumer base for the informal sector with government involvement in regulating the informal sector. The opportunities for an e-waste-related circular economy in Maldives include higher e-product consumption and e-waste generation and an active informal workforce. The challenges include a need for policies for e-waste recovery and a lack of research and development in the field. Furthermore, the lack of government helps for the informal sector, a lack of space to store used e-products or conduct repair and recycling operations, and consumers' stereotype of informal workers add up as an obstacle to executing the circular economy in Maldives.

Keywords: E-waste, circular economy, informal sector, formalization, sustainable production, and consumption

Unlocking carbon visibility from micro-scope of power systems

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Abstract:

The transition to a net zero energy system requires a deep understanding of carbon emissions at various scales, from national-level utility grids to community-level local energy systems. While significant progress has been made in measuring and reporting carbon emissions from large-scale power plants, such as carbon flow tracing and carbon intensity assessment, there is a lack of understanding of the carbon footprint from micro-scope of power networks, i.e., local energy systems. Unlocking carbon visibility from such perspective involves developing new methods and tools for measuring, monitoring, and reporting carbon emissions. The digitalisation and digital twin of local energy systems are able to collectively incorporate the emission related data, registration of system assets, intensities of various emission sources, and intelligent analytic algorithms, to improve the efficacy, interoperability, responsiveness, and automation of carbon accounting. In addition, the standardisation for reporting carbon emissions is crucial for comparing emissions across various spatial and temporal scales of energy systems, which is particularly essential to fairly allocate emission responsibility between upstream transmission networks and downstream distribution networks. The distributed ledger technology, e.g., Blockchain, can solve this challenge by establishing a standardised, decentralised, and autonomous framework for reporting emissions from local energy systems, analogous to the Greenhouse Gas Protocol for reporting emissions from large-scale power plants. Therefore, this paper aims to understand the carbon footprint of local energy systems and develop standardised methods for reporting emissions through using digital technologies and distributed ledger technologies. The outcomes of this work would identify opportunities for accelerating net zero energy transitions and inform decisions of policy makers and practitioners

Are reuses growing in industrial metabolism: Analyses from a perspective of the diversity of byproducts and companies

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Abstract:

Industrial metabolism has significantly increased waste streams and associated environmental impacts in developed and developing countries. Facing this issue, several industrial systems have developed multiple resource recovery and reuse modes that can eliminate industrial waste and reduce the cost of materials. A few industrial symbiosis studies have explored the byproduct synergies in different industrial parks or regions in a year. However, few studies analyzed how the growing industrial byproduct reuses in quantities and categories supports a transition toward a more resource-efficient system. This study aims to observe the trend of industrial symbiosis in an economy and unveil the emerging modes of byproduct recovery and reuse that are increasing the reuses in quantities and categories.

This study employed exploratory data analysis (EDA) on the industrial waste datasets of Taiwan, which is highly resolved in waste classification (323 waste categories). After cleaning, classification, and grouping, the datasets of companies' waste generation and byproduct inputs were analyzed from 2012 to 2022.

In a series of EDA, we first explored the trends of total secondary material reuses and the growing numbers of reusing companies. Second, several wastes reused most by the industries in Taiwan were explored by a stacked area chart. Third, we analyzed industrial metabolism by calculating the portions of major industrial wastes that were used by industry. Also, the shares of the reusing companies among all companies were calculated. After observing the secondary materials of significant reuses in Taiwan, we further explored the by-products showing substantial rises in industries' consumptions with sub-group regression. These industrial wastes can be regarded as emerging byproducts. We also estimated the circularity gap by capturing regional potential to exchange more between other companies. Finally, Sankey diagrams were used to map these potential regional flows. These diagrams may inspire companies to join the existing eco-industrial network.

Synergetic treatment of rural different waste flows for improved resource recovery in arid and cold regions of China

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Abstract:

In rural areas, there are different waste flows such as wastewater, blackwater, greywater, yellow water, kitchen waste, straw waste, manure etc. In past, treatment processes focus on individual waste flow in order to meet the requirements of environmental protection standards. If such processes are assessed in terms of resource recovery, low carbon emission, or energy consumption, cost efficiency, etc., all the processes should be re-evaluated with more reasonable criterion system, and new treatment technologies may be necessary to be developed. In this study, characteristics of different waste flows will be analyzed and compared, and synergetic treatment processes considering waste flows similarity and complementary characters are discussed and proposed to realize maximized resource recovery efficiencies. In arid and cold regions of China, each farm has relatively large farmland areas, and the water supply may be limited, also liquid transportation in winter is a challenge. For such situation, recovered resources have more possibility to be used onsite, which provide a good condition to treat waste flows and recycle the recovered resources with low carbon emission and cost positive methods.

For technology development, treating rural wastewater and solid waste in arid and cold climates also presents many challenges. Co-digestion of blackwater and kitchen/animal manure or straw waste, greenhouse-structured wetland treatment, ice-blocked wastewater treatment, and other low-carbon natural systems as well as renewable energy utilization may provide some possible ways for improving resource recovery in these areas more efficiently. In addition, emerging contaminants such as pharmaceuticals, hormones, and microplastics still need to be considered during resource recovery and effluent reuse in arid and cold rural regions to avoid secondary contamination.

Efficient lithium extraction from brines with porous and hydrophilic LiMn2O4 membrane electrode

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Abstract:

The rapid development of electric vehicles enhances the demand for lithium, and lithium extraction from the salt-lake brines, which accounts for 70 % of the global lithium reserves, has sparked considerable interest. The diffusion resistance inside the membrane electrode hindered the fast deintercalation/intercalation process causing the electrode polarization. A novel electrochemical deintercalation/intercalation system based on a "rocking-chair" electrode system of LiMn2O4/*λ*-MnO2 with high hydrophilicity and permeability was proposed. To decrease the diffusion resistance, surface modification and pore-making were adopted. The resulting membrane electrode shows strong hydrophilicity (the contact angle of the electrode decreases from 118◦ to 28◦) and porous structure. Compared with the unmodified electrode, the lithium extraction speed is increased considerably. Moreover, the capacity of the LiMn2O4 can be maintained at about 30mg (Li) g-1 (LiMn2O4) for 100 cycles with great lithium selectivity and high current density. Therefore, the proposed hydrophilic and polyporous electrode has great potential for extracting lithium from salt-lake brine in an energy-saving and efficient manner.

The assessment of nutrient recovery systems for sustainable wastewater management and protecting water quality in lakes using the case study of Laguna de Bay, Philippines

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Abstract:

Population growth and rapid urbanisation increase the consumption of resources such as phosphorus, as fertiliser for agriculture and food (agri-food) systems; and increase the adverse environmental impacts especially eutrophication on water resources such as lakes. Nutrient recovery from wastewater has been explored to address these increasing challenges through the concept of a sustainable circular phosphorus economy. However, the environmental benefits and costs are needed to be evaluated especially in developing countries for the sustainable technology integration and policy development. For this study, a life cycle assessment (LCA) integrated with a lake model was done to holistically assess the impacts of integrating a nutrient recovery system on wastewater and water resource management using Laguna de Bay, largest lake in the Philippines, as a case study. The life cycle inventory was developed based on the data from a pilot-scale reactor integrated in an onsite sanitation system, i.e. septic tank, at a local farm in the Philippines. The nutrient recovery reactor processed septage to recover an alternative fertiliser that was used for crop production, while simultaneously treating the wastewater for water reuse and safe discharge. The system boundary was extended to the application of the recovered fertiliser to agriculture and discharge to nearby water resources including Laguna de Bay. The functional unit is the recovery of 1 kg of phosphorus fertiliser. The LCA was developed using SimaPro, integrated with the lake model using Water Quality Analysis Simulation Program (WASP) tool, and the environmental impacts were evaluated using the IMPACT World+. This study provides quantified results that could be interpreted to aid decision-making challenges of stakeholders on the integration of nutrient recovery system on wastewater treatment facilities for the restoration and improvement of planetary health, and for the planet's sustainability and resilience.

Life cycle assessment of recycling steel in the UK with respect to global scrap markets

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Abstract:

The project RECTIFI, 'Reducing Embedded Carbon Through Transformation In Foundation Industries' brings together the steel, cement and recycling industries with an objective to avoid almost 5 million tonnes of CO2 equivalent a year. The collaboration is part-funded by the UK Government's Transforming Foundation Industries programme. Project partners are: European Metal Recycling (EMR) a world-leading metal and plastics recycler – in partnership with steelmaker Tata Steel UK, Aggregate Industries from the cement sector, Swansea University and specialist mineral processing firm Darlow Lloyd & Sons. The aim of the project is to explore how the use of recycled materials sourced from the 'urban mine' can create a radical shift for the UK's foundation industries on the path for net-zero.

The objective of this study is to assess the potential environmental impacts of creating an innovative new supply chain for high grade recycled steel. One of the aims is to increase the percentage of scrap that can be utilised during blast furnace production in the UK. Formable flat steel products such as those produced by TATA Steel carry a unique combination of volume of production and high scrap quality requirements because contaminants such as copper, from the scrap can deteriorate properties. Increased demand for high volumes of high-quality scrap could have impacts on the European scrap market and have potentially unforeseen consequences, in particular where the supply of scrap steel becomes constrained internationally. This study assesses the environmental impacts of steel scrap recycling it the UK using life cycle assessment (LCA). The system boundary includes the scrap collected from different parts of UK and transport to the scrap sorting sites located in most major UK cities. The functional unit is 1 kg new steel produced. The life cycle impact assessment (LCIA)method is Recipe 2016(H). 18 mid-point impact categories will be assessed and compared.

Development of an ultimate recycling system for spent Lithium-ion batteries through innovative separation technologie

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Abstract:

With the rapid popularization of electric vehicles, formation of a closed loop circulation for spent Lithium-ion batteries (LIBs) has become a critical issue in the field of circular economy. Although recycling technologies such as hydrometallurgical treatment and pyrometallurgical treatment after crushing and grinding process have been indicated feasible to recover critical metals from LIBs, they cannot avoid excessive input of chemicals and energy in processing.

This study proposes to introduce innovative separation technologies, such as electrical separation method using single pulsed power, to directly separate and reuse positive electrode active materials for battery cell remanufacturing. An integrated assessment model framework combining prospective life cycle assessment with dynamic material flow analysis is conducted to the case of Japan, taken the national ambitious target on promoting electric vehicles towards carbon neutral society by 2050 into consideration.

The results indicate the recycling system through innovative separation technologies can substantially reduce potential resource consumption and environmental impacts by shorter recycling process, compared to conventional recycling system. Particularly, such innovative separation technologies can speed up the circulation of critical metals for ultimate resource conservation if spent LIBs are not reused as stationary batteries (compared to the case of reusing as stationary batteries). Innovative separation technologies can also enable a distributed recycling system for spent LIBs, which will reduce the economic cost and negative impacts from warehouse logistics. However, the quality of recycled cathode particles and the performance in scaling up should be confirmed to realize the advantages mentioned before. For maximum resource use efficiency, not only innovative technologies and appropriate resource management policies are required, but also eco design of products for innovative separation is expected.

Exploring wet magnetic separation for the recovery of selenium and residue zero-valent iron in a water-sediment system

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Abstract:

Raw material shortages, a global challenge, have made recycling a vital issue for our society. Magnetic separation is a process commonly used in various industries that uses a magnetic field to separate magnetic materials. While dry magnetic separation (DMS) is frequently used to separate pollutants from contaminated soil, the wet magnetic separation (WMS) approach may be better suited for certain environmental applications, as it does not require excavation, relocation, or drying, which imply extra costs and environmental impacts. Here, selenium (Se), a scarce element that needs to be separated after its immobilization by zero-valent iron (ZVI) to prevent environmental risk, was chosen to be studied in a simulated water-sediment system to assess the use of DMS and WMS to achieve Se and residue ZVI recovery. The results showed that with 1 g L-1 ZVI and 10 mg L-1 Se added to the system, the separation of immobilized Se was improved from 1.19 ± 0.91% to 34.20 ± 0.13% through WMS ($p<0.05$), and from 21.21 ± 1.9% to 92.48 ± 0.16% through DMS ($p<0.05$). The study showed that excessive Se(VI) can cause the formation of weakly magnetic lepidocrocite instead of magnetite, reducing the separation performance of immobilized Se. Higher dosages of ZVI improved the separation performance but cost-effectiveness should also be considered. Furthermore, using WMS can potentially mitigate the variation in microbial communities in response to ZVI and Se, making it a promising long-term solution. Therefore, this study demonstrates the potential of using WMS to recover Se and residue ZVI, expanding the range of applications for magnetic separation beyond dry separation. This approach offers a promising solution for environmental remediation and sustainable resource management, contributing to a circular economy where resources are used efficiently and waste is minimized.

Embrace sustainable ways to minimise waste in the clothing retail cycle – South African perspective

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Abstract:

This research project is seeking to explore knowledge in the field of sustainability in clothing and textiles in South Africa and in the African continent at large through making the retail cycle of companies sustainable with minimisation of waste.

A critical review of circular product attributes and product circularity assessment tools

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Abstract:

The finite nature of resources, growing population, and the negative impacts of relentless consumption render the “take-make-dispose” linear economy approach inadequate to meet the needs of future generations. The evolving concept of the circular economy (CE) has been proposed as a strategy to resolve this challenge by promoting the efficient use of resources, maximizing the value of materials and products through value recovery strategies, and minimizing waste generation. Therefore, adopting the CE concept in product design is crucial. Despite extensive work in the field, ambiguity remains in defining what makes a product circular and the characteristics of circular products. To address this gap, an extensive review and analysis of the literature, from various domains such as circular product design, product circularity, and related areas, were conducted to examine the descriptions and attributes of circular products. Findings were then synthesized to establish a compilation of key circular product attributes presented in this paper. Based on these attributes, the existing product circularity assessment tools were evaluated, and their shortcomings were identified. The outcome of this research will contribute to the development of a comprehensive and accurate product circularity assessment method.

A critical review on spatially explicit life cycle assessment methodologies and applications

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Abstract:

The number of life cycle assessment (LCA) studies that have involved spatial information in the life cycle inventory (LCI) and/or life cycle impact assessment (LCIA) stages of the LCA methodology have steadily increased in recent years. However, an up-to-date critical review of these spatially explicit LCA studies is lacking, which is a barrier to wider employment of such methodology in decision making. This study aims to: (1) critically review the existing LCA studies involving spatial information in both methodologies and applications; and (2) summarize the different approaches to integrating spatial information into LCI and LCIA. A total of 83 journal articles are scrutinized, including 41 articles focusing on LCIA methods and 42 on LCI and LCA applications. Crop and bioenergy production are the most prevalent topics, covering over 60% of case studies. Geographical information system (GIS) is the most commonly adopted tool for generating LCI data with high spatial resolution. Integrating spatial information into LCA stages using GIS, Matrix-based algorithms in Python or MATLAB, and LCA software tools such as openLCA and Brightway can produce more granular and accurate results, particularly on locating hotspots of life cycle impacts and more accurately evaluating localized environment impacts. This study also provides practical recommendations on how to incorporate spatial information into LCAs using readily available approaches, making it easier to apply spatially explicit LCA more widely in the future.

Combining urban agriculture and data center cooling: a novel approach with small-scale vertical farming modules

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Abstract:

The Global Electronics Council (GEC) Sustainable Development Research Report emphasizes that reducing energy consumption in digital infrastructure is an effective strategy for reducing society's carbon emissions. Strengthening indoor and outdoor air circulation can effectively reduce the dependence of data centers on air conditioning. However, in order to extend the life of digital equipment, it is necessary to remove particles from outdoor air. We designed a modular small-scale vertical farming (SSVF) module and conducted a series of experiments to explore the SSVF module's ability to remove atmospheric particles and reduce the reliance of edge computing devices and servers on traditional air conditioning. The high-speed fan in the server can provide a large pressure difference for the small-scale VF module, effectively increasing the air flow rate in the SSVF module, and allowing multiple modules to be connected in series to achieve better filtering results. Experimental results show that a single SSVF module can filter about 10% to 20% of atmospheric particles, and connecting multiple modules can further improve the removal efficiency. The SSVF system can significantly and effectively reduce the traditional energy consumption cooling of edge computing. In addition, the SSVF system can also serve as a sustainable facility to provide additional carbon absorption in urban agricultural production.

Land pollution caused by the clothing retail industry: a proactive approach in supporting sustainable product life cycles

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Abstract:

South Africa is predicted to be the 11th worst offender of leaking land-based plastic into the ocean globally, third-most in Africa after Egypt and Nigeria (Jambeck, J. *et al*., 2015). South African clothing fashion retailers contribute a significant amount of waste through their retail cycle process and fast fashion approaches to maximize profit; this would be considered pre-consumer waste (Anguelov, 2015). Consumers have become accustomed to fast fashion and the pace at which product is available to purchase (Fletcher, 2013: 162). A South African fashion retailer, produces pre-consumer waste and post-consumer plastic and textile waste. Most garments produced in the fashion industry that are synthetic and synthetic materials degrade very slowly, often hundreds of years or never, eventually ending up being incinerated, in a landfill, or in the ocean, hurting the environment and natural habitat (Carlotto & Mcreesh, 2018). Consumers buy clothing and plastic products and as trends change, they continue to dispose of them, creating post-consumer waste (Brookes, 2019). In a circular economy approach, materials such as are designed with the intention to reuse and recycle (Niinimäki, 2018). The aims and objectives of the study were to dissect the retail cycle to identify the types of waste (non-recyclable textile and plastic waste that negatively affect issues regarding plastic and textiles within their planning, marketing, buying, design, technology, distribution, and operations. A qualitative research method was utilized for the collection of textual or numerical data (or both) for analysis, interpretation or advancement of understanding, reported in a narrative, textual fashion. The qualitative research design was based on a case study strategy; a single case study in this instance focused on one retail company within the local clothing industry, a South African fashion company. A more sustainable retail cycle was developed, focusing on reducing waste and creating more sustainable processes within the company's retail cycle.

An enterprise input-output model for industrial symbiosis assessment and optimization: a case study of Ulan Buh Demonstration Eco-industrial Park

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Abstract:

At present, land desertification is still one of the major obstacles to the economic and social development of China's desert areas. To effectively solve this problem and promote sustainable development, some areas have applied the concept of eco-industrial park (EIP) to desert industries and have established EIPs in desert areas. However, there are few studies focusing on the industrial symbiosis (IS) assessment and optimization of EIPs in desert areas. Therefore, we took the Ulan Buh Demonstration Eco-industrial Park (UBD-EIP) in the Ulan Buh Desert, China, as a research object and proposed a new methodological framework for IS assessment and optimization based on the Enterprise Input-Output (EIO) model. Then, we adopted this method and integrated the benefit evaluation indicators to assess the status of existing and potential IS in the study area, optimize the waste exchange relationships, and quantify the economic and environmental benefits of IS. The results showed that the current IS established in the study area through the exchange of cattle manure and farm wastewater has brought some economic and environmental benefits, although perfect IS has not been achieved. Optimization of the waste exchange relationships revealed that both waste optimization scenarios also did not achieve perfect IS, but brought significant benefits to the study area. For example, the exchange of cattle manure and licorice stems and leaves brought economic benefits of 13,255,000 yuan and 2.6 million yuan respectively. Meanwhile, emissions had been reduced by 33,000 tons of cattle manure and 1,000 tons of licorice stems and leaves was reduced, and inputs had been saved by 11,000 tons of purchased organic manure and 1,000 tons of purchased alfalfa. This study provides a theoretical guidance for IS assessment and optimization in the study area and other EIPs, as well as a reference for promoting sustainable development of desert industries.

Methodology of mass balance accounting for environmental claims of a specific material

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Abstract:

Mass balance accounting (MBA) is one of the chain of custody models. It certifies the traceability of the claim made on materials or products with a set of specified characteristics, e.g., the origin of raw materials. The characteristics are preserved throughout relevant systems and are allocated among outputs from the system. Originally, an MBA was used to identify a product from the certified source or to quantify the ratio of the source in a product, e.g., the ratio of wood from the certified forest. Recently, it is used for an environmental claim, e.g., to allocate GHG emissions and the recycled content of materials from the designated system. However, the MBA was established as one of the certification models of traceability, and scientific discussion on the methodology has not matured. If it is applied to the environmental claim, it may cause an unfair claim. Here, we developed the methodology of MBA applicable to environmental claims of materials. We defined the requirements when applying the MBA as it shall be confirmed that the environmental impacts caused by the target systems are reduced. Assuming that a claim is achieved by the newly established process easier than the conventional process. The environmental impacts caused by the conventional process with MBA applied and by the new process without the MBA are compared. If the latter one is smaller, the MBA does not perform fairly. MBA shall be applied to a combination of inputs and outputs for which attribution of the target characteristic is technically possible. The total of the claimed input shall not exceed the actual input. Possible balancing levels are within a batch, a factory, a company, and between companies. Based on our methodology, the MBA can be applied to make an environmental claim fairly and transparently.

Data-driven Dual ESG Index Using Random Forest Regression

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Abstract:

Environmental, Social, and Governance (ESG) rating, also known as ESG assessment, measures the listed companies' non-financial performances. Conventionally, ESG assessment was made based on experts' knowledge and generated a one-dimension ESG index, which tends to be subjective and dimension-limited. Nowadays ESG data are online accumulated from listed companies, third-party reports, social news, etc., which provides an opportunity to let ESG data speak. Therefore, this paper introduces a data-driven dual ESG index (DESGI) using random forest regression to reveal the ESG data insights and enrich the ESG assessment dimensions. Inspired by the academic credit system, the DESGI contains two dimensions: ESG credit and ESG GPA measuring the width and depth of corporate sustainability performances. Based on the ESG data from 100 textile and apparel companies over the last 10 years, the case study demonstrates the feasibility of data-driven ESG analytics using random forest regression due to its advantages of high speed and adaptability to missing data. The results show that: 1) DESGI enriches the ESG assessment dimension by measuring the width and depth of corporate sustainability performance; 2) The major ESG metrics show the non-linear effects on ESG performance, which can generate managerial implication for listed companies and ESG regulator; 3) Data-driven ESG analytics provides predictor to foresee the annual corporate sustainability performance, which gives opportunities to the listed companies to make optimal ESG strategies.

Carbon price prediction research based on decomposition-reconstruction and SSA-LSTM

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Abstract:

As the pace of action to curb global warming accelerates, carbon trading markets are becoming increasingly important in promoting the achievement of net zero greenhouse gas emissions. A reasonable carbon price is a necessary condition for the stable operation of carbon trading market. Considering the non-stationary and non-linear characteristics of carbon price, this paper followed the strategy of "primary decomposition-reconstruction-secondary decomposition-prediction", pre-processed the carbon price data with Sample Entropy (SE), Fluctuation Dispersion Entropy (FDE) and Hurst reconstruction methods respectively, and then used the Long Short-Term Memory (LSTM) model with optimized parameters by sparrow search algorithm to predict. The results show that: 1) the prediction results of the LSTM model are better than the four prediction models of Temporal Convolutional Network (TCN), Gate Recurrent Unit (GRU), Gradient Boosting Decision Tree (GBDT) and Autoregressive Integrated Moving Average model (ARIMA), indicating that the model is suitable for carbon price prediction research; 2) the combined "decomposition-reconstruction" model can effectively improve the accuracy of carbon price prediction, and the performance of the three reconstruction methods on carbon price data is different; 3) the combined FDE-ICEEMDAN-VMD-LSTM model based on the FDE method has better prediction results, and the comparative experiments in Hubei, Guangdong and Shanghai carbon markets show that the model is robust. The combined model proposed in this study improves the accuracy of carbon price prediction, which will help regulators and enterprises to grasp the future price trend of the carbon market accurately and develop targeted policies and measures.

Calcined clay as a sustainable cementitious material

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Abstract:

The construction industry is considered as one of the most vibrant and economically driven, but also intensive energy consuming and the major global natural resources exploiter. Consequently, significant environmental impact and unsustainable practices might be generated. Although the construction industry has made tremendous efforts to minimize the depletion of natural resources and promote the incorporation of several recycled and by-products materials, the usage of natural non-renewable physical resources remains indispensable. Rocks and clays are the two most crucial natural resources used in construction either in their natural state or after a manufacturing process. This research aims to enhance sustainability of one of the main used building materials (Portland cement), but also one of the most pollutant components of cement-based materials. Local clay was procured, characterized, treated mechanically, and thermal to be then used as a partial substitute for ordinary Portland cement (OPC) in mortar production. The heat treatment of the raw clay was optimized to ensure the lowest environmental impact with the possible highest reactivity. The resulted clay-pozzolana/cementitious was incorporated in mortar as a partial substitute for OPC at different percentages (10% to 50%). The compressive strength and durability of the modified cement mortar were evaluated. The results show a small decrease in the flow, while the density and strength of the hardened mortar were not significantly affected by the NZS replacement. In the meantime, the porosity and absorption have decreased by around 1%. As comparison to the control mortar, blended cement mortar with NZS showed better resistance to sulphuric acid and (sulphate + chloride). In addition to the mortar enhancement performance, the developed cementitious system is economic and environmentally friendly than the control. The study promotes usage of locally sourced, environmentally friendly materials since they improve building performance and service life while having little negative influence on the environment.

Potential of organic wastes hydrolysate as an alternative carbon source for microbial oil synthesis

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Abstract:

Biofuel produced by microbial oil is a green alternative to traditional fossil fuels for the characteristics of high cetane number, non-toxicity, low-sulfur, and non-aromatics. Microbial oils are synthesized by oleaginous micro-organisms, which can accumulate more than 20% lipids of their dry cell weight. Yarrowia lipolytica was regarded as a model yeast to produce lipids and can utilize volatile fatty acids (VFAs) as carbon sources to accumulate microbial oils. Fruit and vegetable waste (FVW) and kitchen waste (KW) have the characteristics of high moisture content, high organic matter content, easy hydrolysis, and can be fermented and hydrolyzed to produce VFA, which can be convert into microbial oils by Yarrowia lipolytica. This study explored the potential of sythesising microbial oil using the FVW and KW hydrolysate by Yarrowia lipolytica, while the synthetic media were also tested for comparison. After 5 days of hydrolysis, TVFA content of KW fermentation hydrolysate was higher than that of FVW fermentation hydrolysate, which was 70-100 g/L and 6-25 g/L, respectively. Besides, the fermentation hydrolysate contains abundant nitrogen sources and trace elements such as K, Ca, Mg and Fe, which can be used to culture microorganisms without adding related nutrients. Finally, the cell mass was about 10.45-13.40 g/L and the microbial oil yield was about 2-3 g/L when using hydrolysate as substrate to systhesis microbial oil by Yarrowia lipolytica. The main fatty acids of microbial oil were C16 and C18, which are the same as the fatty acids of common vegetable oil and soybean oil. FVW and KW hydrolysates were proved to be viable alternative mediums for microbial oil products, in which the produced cell mass and lipids were comparable to synthetic media. This feasible lipid production strategy will help reduce the production cost of microbial oil and provide a novel treatment idea for FVW and KW.

Upcycling of End-of-Life-Vehicle (ELV) plastic as a replacement to natural fine aggregate in concrete

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Abstract:

Plastics account for up to 10 wt% or 50 vol% of a vehicle. At the end-of-life stage of a vehicle, the mechanical recycling of plastics is challenging due to the highly heterogeneous polymer types. Currently, landfilling remains the prevalent disposal option in most regions, including Australia, where energy recovery is not viable. Nonetheless, upcycling of ELV plastics as a replacement to sand in concrete offers a promising solution for waste management and resource conservation. This study investigates the physical and mechanical performance of concrete containing ELV plastics. A plastic aggregate preparation programme was designed to process real-world ELV plastics into particles of less than 4.75 mm, with more than 90% between 1.18 and 4.75 mm. Under a designed concrete mixing and casting programme, the ELV plastic partially replaced the natural sand in concrete at varying percentages (0, 15, 25, 35, 40, and 45%) by volume. Concrete cubes of 100 mm and beams of dimensions 100 mm x 100 mm x 350 mm were cast and tested for 7 and 28-day curing periods. The effect of varying ELV plastic content on the workability, density, compressive and flexural strength of concrete was investigated. The results indicate that the workability, density, compressive and flexural strength of concrete decreased as plastic content increased. However, compared to previous studies that used recycled plastics (PET, LDPE, etc.) and already-commercialised plastic aggregates produced by extrusion of soft plastics, this study demonstrates that ELV plastics have lower strength reductions under high replacement ratios. The proposed process has better cost-effectiveness due to the minimal pre-treatment required for ELV plastics and higher replacement rates. In summary, the study suggests that ELV plastics can be used at a high replacement rate for non-structural applications such as kerbs or footpaths.

Comparative assessment of curing time in cold mix asphalts: impact of rice husk ash and fly ash

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Abstract:

Cold Mix Asphalt (CMA) offers a sustainable alternative to conventional Hot Mix Asphalt (HMA), especially for low-traffic conditions. However, there exist several challenges to utilizing CMA in pavement construction which include but not limited to prolonged curing time, high moisture susceptibility and comparatively poor performance in comparison with HMA. In literature, several research attempts have been put forwards to explore and mitigate the aforementioned issues using several additives. With this background, this study will investigate the efficacy of Fly ash and Rice Husk Ash as additives to improve the curing time of CMA. The major research scopes include fundamental characterization of control CMA, selection of appropriate dosage of additives, evaluate the workability of CMA, assess the curing time and comparison of various CMA with control one. In this study, mix design of CMA will be carried out for various levels of traffic using different compaction efforts. In addition, the curing time for CMA will be evaluated for various types of emulsions. Furthermore, a statistical analysis will be employed to compare and contrast the impacts of fly ash and rice husk ash on curing time. It is envisaged that the study findings will help reduce the construction time for CMA along with superior performance, and thus advancing the state-of-the-art pertaining to the adaption of sustainable technologies in flexible pavement.

Quantitative assessment of workability for hot mix asphalt: inclusive study on mix variables

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Abstract:

The workability of Hot Mix Asphalt (HMA) plays an integral role in the successful construction of flexible pavement. Workability not only refers to the ease of handling and paving of the mixture but also to the superior compaction characteristics. In practice, an optimum compaction effort ensures that the laid mixtures attain the desired set of mix variables post-construction. As the HMA exemplifies temperature-dependent viscoelastic properties, several mix variables in HMA offer a complex interaction that in effect contributes to the ease of compaction of HMA. With this background, this study will investigate the workability of HMA and quantify the impact of mix variables on workability of HMA. The scope of this study will include a comprehensive characterization of aggregate gradations, rheological investigation of asphalt binders, an experimental investigation on the compaction behaviour of HMA, and quantitative assessment of variables that potentially contribute to the compaction energy of HMA. In this study, Superpave Mix Design method will be adopted to measure the compaction mechanism of HMA that comprises mix variables such as types of asphalt binders, viscosity at compaction temperatures, the activation energy of HMA, aggregate structures, etc. Furthermore, a predictive model will be developed using the fundamental mix variables which will help predict the optimum compaction energy in terms of gyrations. It is envisaged that the research findings will provide important insights to the compaction mechanism of HMA, and thus advancing the state-of-the-art pertinent to the superior quality of construction for flexible pavements.

Prediction of fracture properties for asphalt mixtures using machine learning algorithms

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Abstract:

Cracking constitutes the fundamental mechanism for fatigue and low-temperature cracking of asphalt mixtures. Owing to the heterogeneous distribution of aggregate and time-dependent properties of asphalt mixtures, the assessment of cracking becomes very complex subject, especially under mix-mode loading. Thus, a rational characterization and prediction of fracture properties necessitate an understanding of the fundamental properties of asphalt mixtures. Although several research studies explored the experimental investigation of fracture properties using multiple test methodologies, there exist challenges to predicting cracking resistance at various temperatures for different types of mixtures. The objective of this study will be to develop machine learning algorithms to predict fracture properties of asphalt mixtures with various mix variables. The scope of this work will include experimental investigation of cracking properties using Semicircular bending test, development of predictive models using multiple non-linear regression analyses, construct the machine learning algorithms to predict fracture properties and then assessment of the accuracy of predictive properties. It is envisaged that the study findings will help develop rational predictive models to estimate fracture properties of asphalt mixtures, and thus advancing the state-of-the-art pertaining to the evaluation and analysis of flexible pavement.

Viscoelastic characterization of fracture properties for asphalt mixtures using extended finite element method

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Abstract:

Cracking is one of the major distress mechanisms for the failure of flexible pavements. Due to the heterogeneous properties of the aggregate-binder interface and temperature-dependent viscoelastic properties of asphalt mixtures, the assessment of cracking resistance poses involves complex analysis, especially under mixed-mode loading mechanisms. Thus, a rational characterization and estimation of cracking resistance call for an in-depth understanding of the fundamental properties of asphalt mixtures. Although several research studies explored the experimental investigation of fracture properties through various laboratory test methodologies, there exist challenges to predicting cracking resistance in the ambit of viscoelastic behaviour. With this background, this study will estimate the cracking resistance of asphalt mixtures through Extended Finite Element Method (XFEM). The research scope will include viscoelastic characterization of asphalt mixtures through dynamic complex modulus |E*| test, development of Prony series parameters of asphalt mixtures, performing Semicircular bending test to determine cracking properties, develop XFEM model to simulate cracking resistance of asphalt mixtures. It is envisaged that the study findings will help understand the cracking mechanism of asphalt mixtures and thus advancing the state-of-the-art pertinent to the development and construction of superior-performing pavement in future.

Considerations for rejuvenating larger amounts of recycled asphalt binder

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Abstract:

Over the last several years, recycled asphalt pavement (RAP) has become more prevalent in paving of flexible pavements and other applications in highway construction. However, it is generally understood that high ratios of recycled asphalt materials in an asphalt mixture embrittles the mix and contributes to premature cracking and failure of the pavement structure. Therefore, there have been efforts in recent years to emply rejuvenators to mobilize recycled binder and soften the virgin binder to reduce the stiffness and brittleness of the overall mix. While this technique has been employed successfully, many areas still have excess RAP and desire to utilize higher contents in their pavements rather than virgin materials. In this study, the research team explored the benefits of three rejuvenators based on their ability to restore ductility as measured in a realistic stress state to that of an asphalt mixture. The findings of this study revealed that some rejuvenators had anti-aging properties that were not captured by tests within the linear viscoelastic testing suite. Solubility analysis also explored the efficacy of these materials when large contents of recycled binder were used to establish limits based on polarity of the blend.Finally, a secondary study of the use of RAP in pavement base layers is briefly discussed and a framework for maximizing RAP usage in a flexible pavement is presented.

Leveraging greener polymers for environmental and economic benefit

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Abstract:

Switching to a more environmentally friendly plastic that retains similar properties to meet application-specific requirements doesn't necessitate any innovative technology or changes in processes, and it instantly offers seamless ecological advantages without affecting the functionality of the product. We scrutinized prevailing trends in polymer production and the potential economic and environmental benefits that could be realized through conscious selection of eco-friendly polymers during the manufacturing process, as well as in recycling or incineration stages. Polypropylene, polystyrene, polyvinylchloride, and polylactide emerged as environmentally preferable polymers for various applications. When manufacturing these polymers instead of application-specific alternative polymers, we observed reductions of up to 69%, 72%, and 85% in fossil depletion, energy resources, and potential climate change impact, respectively. The recycling process of these polymers consumed 49% less energy and emitted 63% less carbon dioxide compared to their application-specific alternatives. Making environmentally conscious choices in polymer selection, along with recycling, can provide substantial ecological advantages in the existing industry, at a minimal additional cost, and is a key factor in meeting fast-approaching climate goals.

Preparation of uniform multi-doped micro-nano LiFePO4/C cathode material from waste steel slag

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Abstract:

Steel slag, a bulk industrial waste from steelmaking process involving valuable elements such as Fe, Al, Mg, Mn, etc., was a potential secondary resource in an urgent need of recycling and high-added utilizaiton. In this study, a fast coprecipitation carried out in an effective high mixing continuous rotating reactor (HMCRR) coupling aging process was developed to synthesize uniform micro-nano FePO4 particles under violent turbulance and strong shear after significant high-tempearture pre-treatment and purification of the slag, followed by in-situ carbothermal reduction method to obtain LiFePO4/C composites with excellent performance, achieving waste-to-resource process. The reaction mechanism of the pre-treatment process was proposed through TG-DSC and XRD results. Besides, the influence of operating parameters of the HMCRR covering gap width of reaction zone and rotating speed on morphology, particle size distribution and tap density of FePO4 products were researched and conditions were optimized. The characterization results indicated that suitable operating condition would maximize the reactor's promotion for synthesis of advanced micro-nano FePO4 products with smaller size distribution, superior morphology and more uniform doping, for it could equip the reaction system with excellent mass transfer ensuring intensive mixing of raw materials before reaction started. Owing to the synergistic positive effects of advantageous morphology for the confinement effects, shear force and efficient mass transfer of HMCRR and heteregeneous cation-doping influence, the well-behaved LiFePO4/C cathode material obtained from steel slag embraing minimized Li+ transition distance, enhanced structure stability and increased electronic conductivity could exhibit a discharge capacity of 161.60, 155.27, 143.55, 134.08, 121.23, 101.08 and 81.57 mAh/g at 0.1, 0.2, 0.5, 1, 2, 5, 10C, respectively, with excellent cycling stability.

Microplastics in food waste biological treatment facility: Occurrence, detection and their implications

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Abstract:

Plastic pollution is affecting the aquatic and terrestrial ecosystems and severely affecting our plant. One of such recent issue is their impact on food waste biological treatment facilities. In Hong Kong, plastic waste accounts for 21% of total municipal solid waste (MSW). An average of 9,684,741 plastic bags is disposed of every day which accounts for ~768 tonnes (7% of total MSW) causing the increase in micro plastics by 11 times in the past 3 years. The mis-management of plastics and plastic pollution is causing the formation of macro (> 5 mm), micro (< 5 mm) and nano (< 1 µm) plastics. In terrestrial ecosystem, the plastic pollution is affecting the food waste treatment. Recent studies have reported that the microplastic pollution in food waste directly affects the biological treatment such as anaerobic digestion and composting. In this study, presence of macro, meso and microplastic in food waste biological treatment facility in Hong Kong was detected and their transport within the facility was assessed. Different types of conventional plastics such as polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS or styrofoam) and others were identified at different concentrations. All the waste and product streams such as food waste, liquid digestate, solid digestate, effluent wastewater and compost in the treatment facility was affected with macro-meso-microplastic at various concentrations. In this study, the occurrence and transportation of microplastic at different stages of treatment inside the food waste treatment facility is demonstrated.

A novel organic solid waste treatment system for producing high-quality biofertilizer by combing aerobic bioliquefaction and microalgal cultivation

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Abstract:

Direct application of untreated or conventionally-treated organic waste, especially kitchen waste, may cause phytotoxicity to crops and adversely affect environment. In this study, we developed a novel organic solid waste treatment system for producing high-quality biofertilizer by combing aerobic bioliquefaction and microalgal cultivation. In the first step of this system, the aerobic bioliquefaction reduced the solid wastes volume by 97% within 36 hours and turned almost all the waste into liquid digestate. The liquid digestate was high in total carbon, total nitrogen, and salinity (EC = 27.75 mS cm-1, CaCl2 content = 1.20%, NaCl content = 0.50%), and it contained low molecular organic acids such as acetic acid, propionic acid, maleic acid, butyric acid, pentanoic acid, caproic acid and octylic acid. Even after a 10-fold dilution, a seed germination experiment revealed that the liquid digestate exhibited considerable phytotoxicity to crops like radish, pakchoi, and rice. In this newly designed system, the liquid digestate was used to culture microalgae in the second step. *Dictyosphaerium sp.* was isolated as a suitable microalgal species for culture in this digestate, which promoted lettuce growth in hydroponic systems and yielded high algal biomass after 11 days of cultivation. After the microalgae cultivation, the liquid digestate was converted into an algal culture with the pH increased from 5.34 to 8.90 and the electrical conductivity decreased from 2775 μS cm-1 to 1680 μS cm-1. The radish seed germination rates in the liquid digestate increased from 3.1% to 93.0% after the microalgae cultivation. Pot experiment also showed that applying the algal culture produced from liquid digestate effectively increased the biomass of the vegetable crops. Preliminary results showed that the algal culture created from liquid digestate following ultrasonication contain 20 different amino acids and auxin. This study provides a sustainable approach for conversion of organic waste to valuable bioproducts.

Nitrogen-high manure from protein-high food waste from a large dining room

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Abstract:

Waste food management is one of the most challenging environmental problems in the recent years. Understanding the transformation of carbon (C) and nitrogen (N) during the disposal process is critical for assessing the sustainability of a waste food disposal strategy (WFDF). This study compared the economic and environmental feasibility of two conventional WFDFs (composting and animal breeding) in terms of the C and N transformation. In the pigeon feeding experiment, the pigeons completely rejected the waste food on its own. The pigeons, however, showed a good appetite for the mixture of commercial feed and waste food. As compared to feeding with the commercial feed alone, feeding with the mixed feed significantly ($P < 0.05$) enhanced the pigeon growth and dung yield, since the waste food was richer in nutrients than the commercial feed. We compared the C and N transformation in pigeon breeding with waste food (PBWF) systems with that in a conventional waste food composting (WFC) system. Results showed that the organic manure yield from the waste food was 0.203 kg dw/kg dw and 0.217 kg dw/kg dw in PBWF and WFC, respectively. The most abundant fungal genera were *Pichia*, *Dipodascus* and *Candida*, respectively on day 20, 40 and 100 during composting while the most abundant bacterial genera was *Lactobacillus* across the composting times and the relative abundance of this genera decreased with the composting time. In particular, we observed enrichment of risky bacterial species (e.g. *Clostridioides_mangenotii*). The results demonstrated that PBWF was more economically and environmentally viable than CWF. Integration of FT-IR, Raman and stable isotopic analysis enhanced our understanding of C and N transformations in both CWF and PBWF.

Treatment and Resourcization of Waste Incineration Bottom Ash for the Synthesis of Zeolite and Applications

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Abstract:

The recycling and reuse of waste incineration bottom ash (WIBA) is an important and popular environmental issue in Taiwan. How to effectively improve the quality and reliability of WIBA reused products is concerned and requested by the public. In order to develop alternative and feasible resourcization methods of WIBA, this study applied the alkali-fusion and hydrothermal technology to synthesize zeolite as reused products for wide applications. The removal efficiency of chloride in WIBA, the optimum operating conditions of zeolites synthesis, and the properties of synthesized zeolite were investigated.

Experimental results show that WIBA can be reused into high quality and high value products through proper treatment processes. The optimum operating conditions of zeolite synthesis from WIBA were Si/Al ratio= 20, alkali/ash ratio= 2.0, hydrolysis L/S (liquid/solid) ratio= 150, and hydrothermal time= 24 hours. The content of chloride in WIBA can be significantly reduced to less than 0.02% and the removal efficiency of chloride was nearly 100%. The synthesized zeolite had good surface properties and the specific surface area was high as to 853.19 m2/g. The results prove that the alkali-fusion and hydrothermal methods can be used to effectively remove the chloride in the WIBA and simultaneously synthesize high-quality zeolite products, which is conducive to promoting the applications and valorization of WIBA.

Kinetics and thermodynamic analysis of pyrolysis of paper waste

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Abstract:

The growth in municipal solid waste generation poses a severe challenge to effective waste management. Paper waste is a substantial component of municipal solid waste, with global variations ranging from 7% to 25%. Among several pathways for energy recovery, the pyrolysis of paper waste provides an effective alternative due to high mass conversion rates (>50%) and good overall efficiency (>60%). However, the complex nature of reactions in pyrolysis poses a significant challenge for its reaction modelling and predicting the final output from the process. The reaction kinetics and thermodynamics could help us understand the underlying process better. This study aims to predict the accurate thermo-kinetic and the associated thermodynamic parameters for paper waste using various reaction models from four solid-state reaction mechanisms. The Coats-Redfern integral method with 21 different reaction models is applied to determine the best-fitted reaction model for the experimental data in regions I and II. We found that the Zhuravlev and Jander diffusion models are the best-fitted models with the highest correlation coefficient values ($R^2>0.96$) for region I (237-397oC) and ($R^2>0.99$) for region II (397-631oC). The activation energy values vary from 108-126 KJ/mol for region I and 5-21 KJ/mol for region II. The Jander diffusion model exhibited a lower normalized root mean square error than the Zhuravlev model, indicating a strong correlation with the experimental data. The enthalpy of the reaction and Gibbs free energy values for regions I and II show that pyrolysis of paper waste is an endothermic and nonspontaneous process.

Microalgae-bacteria consortia for net zero wastewater treatment using a combined top-down and bottom-up approach

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Abstract:

The increasing global demand for wastewater treatmet brings a significant environmental burden of energy consumption and greenhouse gas (GHG) emissions. Conventional activated sludge process has limitations in costs, space, capacity, and especially aeration energy consumption. Microalgae-bacteria consortia (MBC) technology can overcome these limitations and achieve a zero-carbon system by reducing energy assumption and GHG emission and produce valuable by-products. To develop MBC to convert wastewater into extracellular biopolymers, understanding the mechanisms of synergies between microalgae species and bacterial communities is essential to find engineering approaches to control the MBC. We designed a combined top-down and bottom-up method for enrichment of MBC compartments.

The bacterial communities, using top-down method, are enriched and selected to degrade wastewater organics, and form granular cores for the MBC. The microalgae species, using bottom-up method, were isolated from campus lake at the University of Surrey, and characterized for their metabolic functions. Then interactions between the two compartments were studied to optimize performance for wastewater treatment, carbon capture/utilization, and yield of extracellular polymers.

The bacterial community enrichment used aerobic sludge as inoculum. Granular sludge started to form around day 28, and the largest observed granule reached 20 mm in diameter by day 50. The presence of fabric-like structures on the granule surface suggested the presence of EPS, which could play a crucial role in the formation and stability of the granules. Results showed that the system achieved 90% COD removal, 10% phosphate removal, and ammonia removal efficiency of 10% (phase 1) and 59.87% (phase 2). The dissolved oxygen (DO) level might be the main reason caused the increasing removal efficiency of NH4+. Microalgal species were isolated from the university lake and showed distinct colony and cell morphology, indicating similarity with Scenedesmus and Chlorella species. Different species showed various synergies between the microalgae and bacteria.

Enhancing anaerobic ammonium oxidation (anammox) for nitrogen removal from UK sewage using granular activated carbon

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Abstract:

Anaerobic ammonium oxidation (anammox) for sewage nitrogen removal is a promising approach reducing energy consumption by ~50%. However, the slow growth rate and high sensitivity of anammox bacteria pose challenges in engineering applications. A few studies have demonstrated that adding granular activated carbon (GAC) facilitated anammox performance, indicating potential development of future anammox technology. However, the feasibility of GAC-anammox in UK environment has not been investigated and the underlying mechanism of GAC-anammox system remains largely unclear. The present study aims to figure out above research gaps in the microbial community, function and biofilm morphology using metagenomic sequencing, qPCR, scanning electron microscope (SEM).

The study was carried out at room temperature with two parallel reactors, one with GAC (R1) and one without (R0). After 75 days, NH4+-N removal efficiencies (NRE) started to increase continuously and reached to 99.1% and 97.4% of R1 and R0 on day 172, respectively. R1 showed significantly ($p<0.05$) higher NRE and lower NO3--N accumulation than R0, but no significant difference was shown in NO2--N removal.

The SEM showed similar morphology of the cell aggregates, but the metagenomic sequencing showed difference between two reactors. Candidatus Brocadia (0.2% in seed sludge) dominated in both reactors but was lower in R1 (37.0%) than R0 (44.7%), indicating higher anammox activity with GAC in R1. Meanwhile, other functional nitrogen removal bacteria in R0 were also higher than those in R1. Nitrite oxidizing bacteria (NOB) was 0.041% in R0, but only 0.005% in R1. Denitrifiers in R0 was 0.54%, and 0.32% in R1. Higher NOB and denitrifiers in R0 might result in lower NRE and higher NO3--N accumulation, because of NO2--N utilisation. Thus, GAC might enhance anammox activity of competing for NO2--N through inhibiting the NOB and denitrifiers to keep sufficient NO2--N concentration for anammox bacteria.

Has the carbon emission trading scheme induced investment leakage in China? Firm-level evidence from China's stock market

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Abstract:

This study utilizes the selective coverage of the Emission Trading Scheme (ETS) in China and attempts to explore the causal link between the policy and investment leakage. Based on the comprehensive firm-level subsidiary data of 4480 A-share listed companies from 2003 to 2021, with the application of the staggered difference-in-differences (SDID) method, for the full sample, we find that the ETS generally has significantly led the regulated firms to expand the gap between the investment outside and inside the pilot area by 1.4%, with the number of subsidiaries outside the pilot area increasing by 3.678, revealing that the policy has indeed induced investment leakage. The dynamic effects show that the impact manifests itself from the fourth year of the ETS treatment which could be attributed to the time-lag between invisible investment decision and tangible subsidiary establishment. The outward investment expansion of the regulated firms could be accounted by the rising operating cost due to the compliance of the ETS. The ETS policy intensity and the social responsibility act as moderators on the investment leakage effect. Considerable differences exist across pilots and sectors when the difference-in-difference-in-differences (DDD) method is employed to investigate the heterogeneity. The regulated firms in the eight carbon-intensive sectors report significant relocation and investment leakage due to the ETS relative to its counterfactual scenario. This study offers us the insight of how the policy drives the investment from the pilot area towards the non-pilot area, providing the first direct empirical econometric evidence on the domestic investment leakage accompanying the gradual ETS policy implementation in China and contributing to the theory of the carbon haven effect.

How can repair businesses improve their service? A consumer perspective on operational aspects of repair services

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Abstract:

Repairing broken products is not yet preferred to replacing them with new ones. A major problem is that repair is typically perceived as too expensive, time-consuming and inconvenient. In order to change consumer behaviour and thus increase repair rates, repair must be an attractive option compared to buying new products. To achieve this, repair service providers need to offer convenient services and continuously improve their processes. Our study aims to identify the most important operational aspects for (potential) consumers of repair services. First, operational aspects were compiled based on an extensive literature review, complemented by expert interviews. Then, the importance of these aspects from a consumer perspective was determined through a survey of more than 600 participants. We find that the most important items are related to information and economic aspects, as well as confidence-building measures and communication skills. Comparing the importance of the items in relation to different product options shows that the results are a general representation of the importance of operational aspects, independent of the specific product. The results of this study will help repair businesses to optimise their services and policy makers to identify promising entry points for effective policy measures to promote repair. As this is ongoing research, we will also present ideas on how to improve the study through further approaches such as data-driven methods (e.g., exploratory factor analysis or cluster analysis) or analytic hierarchy process.

Prediction and analysis of urban activity based on spatial-temporal location modeling

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Abstract:

Based on the continuous acceleration of urbanization, the level of urban activity has become one of the important indicators for urban development and management. Urban activity is influenced by multiple factors, and most of the current research focuses on a single factor, lacking comprehensive consideration, which leads to incomplete prediction results. In this study, we propose a spatio-temporal prediction and analysis model for urban activity that takes into account both temporal dependencies and spatial characteristics based on spatio-temporal location modeling. The model is built on POI (Points of Interest) data, where we first use the LSTM (Long Short-Term Memory) model to capture the temporal sequence data of POIs in the city and the dependencies between POIs at different time periods. Then, we employ the CA (Cellular Automaton) model to model the spatial diffusion relationships of urban activity, including the spatial distribution of POIs within the city and the connections between different regions of the city. Finally, we integrate the relationships between time and space to construct a comprehensive model for predicting and analyzing urban activity. We conducted experiments on real datasets from different cities and achieved good prediction accuracy and analysis performance. The contributions of this study are twofold: Firstly, we propose a novel model for predicting and analyzing urban activity, which can provide decision support for urban planning and management. Secondly, by combining the LSTM and CA models, we effectively model spatio-temporal location data, and this approach can be widely applied to the processing and analysis of spatio-temporal data in other fields. Our research has both theoretical significance and practical value, providing technical support for urban development.

Unsaturated and accelerating material stock accumulation in china's megacities as urbanization approaches 80%

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Abstract:

Buildings, infrastructure, and durable goods can be compared to the "bones and muscles" of cities. They grow with urbanization process and are an intuitive reflection of city scale, however their evolution law is still unclear. Megacities are typical samples for studying urban metabolism due to their long lifespan and large throughput. This study constructed an accounting list including 111 types of in-use stocks, and explore their phase characteristics, services capacity, resource and environmental impact, and socioeconomic driving law in 8 China's megacities. Their in-use stocks accumulated rapidly, from no more than 350 Mt in 1978 to the gigaton level in 2018, the increase was between 6 and 248 times. The GDP growth of China's megacities has generally reduced their dependence on stock accumulation, but population growth and the deepening of urbanization are still inseparable from stock accumulation. Stock service capabilities are higher in Shenzhen, Guangzhou, and Shanghai, their economic benefits brought by material stock are also considerable. The improvement of stock productivity and resource utilization efficiency has reduced 154-505 Mt CO2 emission, and saved 11-594 (Í106) tce of energy and 132-380 Mt of food. When the urbanization rate reaches about 80%, the relationship between the per capita material stock and the urbanization rate enters a "highly sensitive period." For every 1% increase in the urbanization rate, their per capita buildings, infrastructure, and durable goods increase by an average of 13.5, 1.9, 0.6 t/cap respectively. Our results provided a decision basis for effective formulation of targeted resource circulation and stock refinement management objectives, and the evolution law also anticipates other cities' future development.

Closing the nutrients flows loop using a systems approach-Stakeholders perspective

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Abstract:

The adverse effects of mismanaged organic waste on the environment are well known. The natural balances of nitrogen and phosphorus are greatly disturbed by the current practices of organic waste management, and a significant proportion of these essential nutrients are wasted. In Leicestershire, the fragmented and siloed approach to waste management and lack of data for certain waste streams adds to the challenge of re-organising nutrient flows from linear to circular. This paper reports on the NERC funded project that adopted a systems approach for quantifying the nutrients flows, analysing the opportunities and re-designing of the current organic waste flow system through technological interventions and business models, with a case-study in Leicestershire, UK. Critical to the process is the stakeholder engagement as the parameters driving the nutrients management are controlled by the practitioners in the management and collection of agriculture, food manufacturing, domestic, institution and hospitality food waste, green waste, and sewage, and waste processing facilities at the regional scale and abiding policies. This necessitates inclusion of stakeholders' perspective for systematic screening of options and strategies in their region of concern. Three workshops were conducted to discuss three overarching questions: (1) which nutrient streams are key in the re-designing of the system from linear to circular?; (2) what are the challenges in the current waste management system? and (3) which technical and business opportunities are most viable in Leicestershire context? The workshops were attended by representatives from local authorities, scientific experts, Environment Agency, and private waste management facilities. The collaboration with stakeholder began with joint mapping of the system followed by data validation and assessment of the technical and business options using the feasibility and impacts parameters metrics. The project is the demonstration of importance of stakeholder-driven process for tailoring the academic inquiry to the local context.

Residential water and energy consumption prediction at hourly resolution based on a hybrid machine learning approach

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Abstract:

Predicting water and energy consumption at high resolution over a short-term horizon is critical for water and energy resource management. Water and energy are shown to be closely interlinked in household consumption. However, hourly predictions are often based only on historical consumption data for the resource being predicted, with activity or appliance information and household attribution as additional information. Few studies have used aggregated water and energy consumption for predictions. Within this context, the current study proposed a novel hybrid machine learning model based on the Prophet time-series model, Gated Recurrent Unit network, and self-adaptive weights, called the Prophet-GRU model, which could jointly include historical water and electricity consumption as inputs for hourly water or electricity prediction. Data on hourly water and electricity consumption in six households in Beijing during January–March 2020 were used to train and validate the Prophet-GRU model. The goodness of fit indicator (R2) and prediction accuracy (mean squared error and mean absolute error) for the water and electricity predictions were evaluated. Compared with the single input of water or electricity, with the combined input of data of these two resources, the proposed Prophet-GRU model achieved improvements of 29.2% and 48.5% in R2, for water and electricity consumption prediction, respectively. Our results could help better understand water-energy linkages and promote collaborative water and energy management practices.

Waste management in clothing and textiles: A circular economy approach in the redesign of clothing waste through small social enterprises

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Abstract:

Despite efforts to donate clothing to second-hand shops and charity organisations, a significant portion of post-consumer clothing waste remains in landfills (Manieson & Ferrero-Regis, 2022). Alternatives to the existing disposal methods, landfilling or incineration, are required to address the problem's scale. Research has shown that developing countries are the global market for second-hand clothing. While trade plays an important role in the economy, not all second-hand clothing is sold or donated to the target market; half of the second-hand imported clothing is in landfills, polluting the environment. There is a need for a more innovative solution through community participation to promote sustainable fashion practices and reduce the impact of post-consumer clothing waste. Therefore, it is vital to develop sustainable solutions that promote a clean environment by extending clothing lifespan and reducing landfills burden. As the study aims for the community-based approach, the outcome will promote the industry's sustainability, conserve resources, and create employment opportunities while providing community awareness for responsible consumption and production. This research explores the effect of a design through social enterprises in redesigning post-consumer clothing waste from second-hand shops and charity organisations to extend clothing lifespan, reduce landfilling, and encourage responsible consumption and production. This approach will ensure the uniqueness of the upcycling strategies from group to group, providing varying choices for consumers. The research will provide new insights into the feasibility and viability of community-based approaches for managing post-consumer clothing waste. Additionally, it will contribute to identifying best practices and opportunities for improvement, which can be used to inform future research and policy decisions in this area.

Utilising stakeholder engagement activities to support the development a Sustainability Framework for Bio-based projects.

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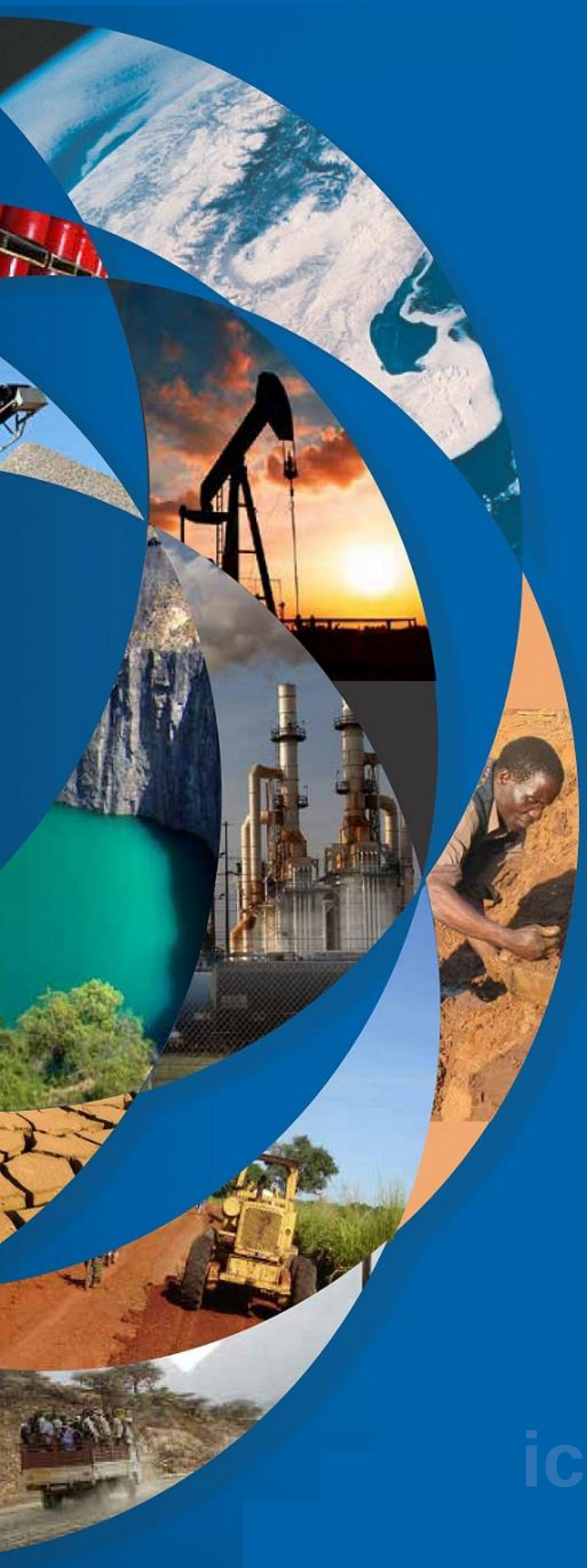
Abstract:

Sustainability seeks to meet the needs of the present generation, across social, economic, and environmental aspects, without compromising the ability of future generation to do the same. Across different sectors, many frameworks have been developed to engage with or improve sustainability, however comparisons between them can be challenging; as frameworks tend to vary by purpose, value, and context. Within European strategy, policy and research, sustainability has been a key theme over the last two decades, where in recent iterations the inclusion of circular economy principals and the exploitation of the bioeconomy have come to the forefront. Within this, the development and uptake of bioplastics (namely those that are bio-based and/or biodegradable) is one avenue that the European Commission has been keen to explore. Despite this growing attention, frameworks to ensure the sustainability of bioplastics do not yet exist. In order to develop a Sustainability Framework for Bio-Based Projects, a literature review was undertaken to identified common themes from previously published frameworks, specifically noteworthy goals and strategies. Building on this theoretical consensus, stakeholder engagement activities investigated the level of emphasis current bio-based projects placed on these common goals and strategies. Finally, to verify the findings of these stakeholder activities, a survey of published researchers and industry experts was also undertaken.



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