icRS 2025

2025 International Conference on Resource Sustainability

July 16-18, 2025

Adelaide, Australia

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The University of Adelaide

2025 International Conference on Resource Sustainability

(icRS 2025)

Welcome to icRS 2025!

The sustainable development of human society depends on resources. Addressing critical societal challenges, such as climate change, resource depletion, and environmental protection, requires sustainable management of resources using interdisciplinary approaches.

The **International Conference on Resource Sustainability (icRS)** series serve as an international platform for researchers and practitioners around the world with diverse background and expertise to share the most recent ideas, outcomes, and practices on resource sustainability.

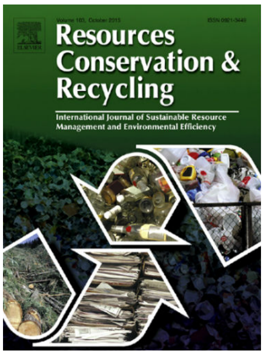
icRS embraces interdisciplinarity, welcoming contributions from ANY discipline including natural sciences, social sciences, and engineering on ANY aspect of resource sustainability. We define resource broadly, including physical resources, biological resources, and "misplaced" resources:

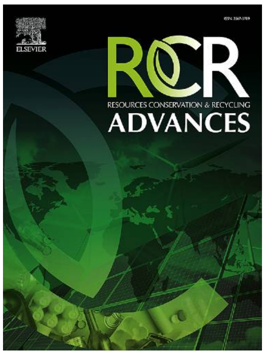
- physical resources: metals, non-metallic minerals, energy, water, etc.
- biological resources: food, forestry, land, ecological systems, etc.
- "misplaced" resources: air emissions, water pollutants, solid waste, etc.

icRS 2025, hosted by The University of Adelaide, will include invited keynote speeches and parallel sessions,on a variety of topics related to resource sustainability.

icRS 2025 is sponsored by the flagship journal in sustainable resources management Resources, Conservation & Recycling (RCR; 2024 Impact Factor: 10.9) and its sister journal Resources, Conservation & Recycling Advances (RCRADV; 2024 Impact Factor: 6.4). High quality papers presented at icRS 2025 will be recommended to special issues in these journals as well as other supporting journals.

We are looking forward to meeting you.





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2025 International Conference on Resource Sustainability

(icRS 2025)

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Paper ID: 100

Optimizing carbon emission paths based on equity: strategies for promoting coordinated regional development in China

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Abstract:

China's ongoing efforts to combat climate change through energy transition and carbon reduction have heightened the disparities within the regional energy-economy-environment (3E) system. This study integrates regional equity metrics, Gini coefficient, and Theil index into the conventional 3E framework, establishing a multi-objective optimization model to investigate carbon reduction optimization strategies aimed at reinforcing regional coordinated development from 2021 to 2030. This study presents four strategies: an economic priority scenario, an energy-saving priority scenario, a carbon reduction priority scenario, and a comprehensive scenario. All strategies demonstrate the potential to narrow the inequality within the regional 3E system, with a consensus that China should maintain an average annual GDP growth rate of approximately 5.1% from 2021 to 2030. Furthermore, critical provinces for implementing energy transition and carbon reduction strategies are identified. Notably, the comprehensive strategy allocates carbon quotas to provinces in a cost-effective manner, with a unit cost of carbon reduction set at 144.91 yuan per ton. Its cumulative GDP from 2021 to 2030 is estimated to be 10.4592 trillion yuan (at constant 2005 prices). These proposed strategies not only address the regional disparities within China's 3E system but also align with the government's objectives of high-quality economic development and regional coordination.

Paper ID: 101

A method for extracting extensive field roads based on dual-temporal branch net

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Abstract:

Field roads are narrow roads that connect fields to villages and between fields to facilitate the transportation of agricultural activities, agricultural supplies and agricultural products. Identifying and extracting field roads plays a key role in promoting agricultural mechanization, increasing productivity and improving resource management. This study considers the significant differences in the characteristics of field roads in different time phases. It proposes a dual time-phase branching network (DTBnet) for extracting field roads using dual time-phase Sentinel-2 remote sensing data. A dual-branching cross-focusing mechanism is designed to combine data from both time-phases for road feature extraction. In addition, dynamic serpentine convolution is introduced into the encoder, and a learnable strip convolution kernel is used to learn the road distribution in the field road extraction task. Our method is validated and analyzed on our own field road dataset and a publicly available road dataset (Deep Globe Road Dataset), with F1 scores of 0.806 and 0.799, respectively, which achieves higher accuracy compared to common road extraction models, and which is suitable for large-scale extraction of field road networks.

Paper ID: 102

Diving into the complexities of the global plastics supply chain: a trade-linked material flow analysis

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Abstract:

Plastic has become an integral part of our lives. Addressing the global environmental concerns of plastics requires a comprehensive analysis along the whole supply chain. Here, we provide a global trade-linked material flow analysis of plastics for the year 2022. Globally, 436.66 Mt of plastics were traded in 2022, with plastics final products alone accounting for 111 Mt. Our findings suggest that plastics are subject to geographical concentration. Plastic feedstocks, predominantly derived from fossil-fuel materials, and the primary production of plastics are concentrated in countries endowed with abundant oil resources and possessing advanced petrochemical industries. Processing and manufacturing are concentrated in large-scale manufacturing regions, with China alone accounting for 40% of global final plastic product output. This geographical concentration has significant implications for global trade dynamics and environmental policies. The analysis also highlights a significant shift in waste management disposal and trade patterns: incineration is emerging as a prominent waste disposal method (34%), plastic landfill is decreasing substantially (40%), while the global recycling rate remained stagnant (9%). A number of developed countries are becoming plastic waste importers, reshaping the global plastics trade patterns. Uncovering the complex plastic supply chain is crucial for reducing pollution and promoting sustainable plastic management.

Paper ID: 103

Fostering Sustainable Innovation Behavior through Human–AI Collaboration: The Mediating Role of Intrateam Climate and the Moderating Effect of Task Complexity in Architectural Design

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Abstract:

In the era of digital transformation, human–AI collaboration has become a strategic focus for organizations seeking to enhance creativity and maintain competitiveness. While previous studies have explored AI's role in creativity, the mechanisms through which human–AI collaboration influences employee creativity, as well as the boundary conditions of this relationship, remain underexamined. This study investigates whether and how human–AI collaboration affects employee creativity, focusing on the mediating role of intrateam climate and the moderating effect of task-related complexity. Using survey data from A-share listed architectural design firms in China, a positive relationship is observed between human–AI collaboration and employee creativity, with intrateam collaboration and competition climates mediating this effect. Specifically, collaboration climate fosters trust and knowledge sharing, while competition climate introduces motivational dynamics that can both enhance and hinder creativity. Further analysis reveals that the positive effects of human–AI collaboration on intrateam climates are more pronounced under low task complexity and diminish under high task complexity. These findings enrich the literature by emphasizing the interplay between human–AI collaboration, team dynamics, and task characteristics in driving creativity. They also provide actionable insights for managers and policymakers aiming to leverage human–AI collaboration for innovation and sustainable growth, particularly in knowledge-intensive and creativity-driven industries.

Paper ID: 104

Low-carbon oriented supply optimization of free-floating bike sharing

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Abstract:

Free-floating bike sharing (FFBS) stands as a pivotal element within low-carbon transportation systems, offering a novel option for the public’s short-distance trips and facilitating connections with public transportation. Nonetheless, the development process often witnesses overinvestment and resource wastage, compounded by a scarcity of studies examining FFBS’s carbon reduction potential from a life cycle perspective. Based on historical FFBS cycling data, we forecast bicycle borrowing and returning demands while measuring carbon emissions from the life cycle. Moreover, we develop a low-carbon oriented supply optimization model of FFBS based on the FFBS demand forecast results. The model aims to minimize enterprise costs and carbon emissions while maximizing user satisfaction. By providing theoretical guidance for enterprise to launch appropriate quantity of bicycles, this model also lays the foundation for comprehensively understanding the emission reduction effect of the FFBS system and promoting the development of low-carbon transportation. Focusing on the FFBS system in Gulou District, Nanjing, the results reveal compelling insights: in the case of considering enterprise market share, user demand satisfaction rates reach 80.87%, accompanied by a noteworthy reduction of 464.354 tons in carbon emissions and a 31.96% decrease in enterprise costs. These results underscore the significant carbon reduction benefits associated with controlling FFBS launch quantities, concurrently reducing enterprise expenses.

Paper ID: 105

Reimagining resource management: Integrating sustainable practices to address global challenges in a dynamic environment

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Abstract:

This study investigates sustainable practices in resource management using a novel Integrated Sustainability Framework (ISF) and employs the Autoregressive Distributed Lag (ARDL) model to analyze the dynamic relationships among key variables. The sustainable management of resources is essential for addressing global challenges such as climate change and resource depletion. By utilizing secondary data collected from existing literature, industry reports, and relevant databases, this research identifies critical sustainability practices, including waste reduction, resource efficiency, and stakeholder engagement. The ARDL model allows for the examination of both short-run and long-run effects of these practices on resource management outcomes, accommodating a mix of stationary and non-stationary time series data. Preliminary findings indicate that organizations implementing the ISF achieved a significant reduction in waste generation and improved resource efficiency over time. Additionally, the integration of artificial intelligence and data-driven tools enhances decision-making processes, leading to more effective sustainability outcomes. This study contributes to the existing body of knowledge by providing a comprehensive analysis of sustainable practices, highlighting the importance of collaborative efforts among stakeholders, including government, industry, and academia. The novelty of this research lies in its systematic approach, combining ARDL analysis with a thorough review of secondary data to offer actionable insights for practitioners. Ultimately, the findings underscore the necessity of adopting a holistic approach to resource management that prioritizes sustainability, paving the way for future advancements in the field. This research not only addresses pressing environmental issues but also serves as a guide for organizations seeking to implement innovative and effective sustainability practices.

Paper ID: 106

Determination of Toxic elements in incinerated hospital waste

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Abstract:

Incineration is one of the most effective method present for disposing of BMW as it reduces the waste to a tenth of its initial volume, lowering the amount of waste that ends up in landfills. The objectives of the study were to characterize and compare leachate from incinerated hospital waste, to measure toxic element concentrations in various leachates, and to assess how leachate properties affect toxic element release from hospital waste. For this purpose, samples were collected from three main hospitals of Peshawar (Lady Reading Hospital, Khyber Teaching Hospital, and Hayatabad Medical Complex), and physicochemical parameters such as pH, total hardness, electrical conductivity, alkalinity, and heavy metals (cadmium., chromium, lead, and nickle). The results showed that pH was alkaline, and the Electrical conductivity (EC), alkalinity, and hardness were in the range set by WHO and USEPA. While turbidity and chloride levels were higher than WHO and NEQS. In Leachate the concentrations of cadmium (Cd) and Nickel (Ni) were in the permissible limit set by USEPA and WHO. While the concentration of lead (Pb) and Chromium (Cr) was higher than permissible limits set by WHO. In Incinerated Biomedical Waste Ash (IBMWA) the concentration of Cd, Cr, Pb, and Ni were higher than the permissible limit set by USEPA for disposal of waste into landfills. The study concluded that heavy metals from leachate can infiltrate groundwater through leaching when ash is disposed of in landfills, leading to contamination. Therefore, it is suggested that Incinerated ash should be treated before disposal in engineered landfills and can be utilized in construction materials like cement and in roads.

Paper ID: 107

Estimation of return dates and return level of extrêmes précipitation of the city of Douala,cameroon

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Abstract:

The problem of extreme phenomena with a more precise estimation of their return periods for early warnings, notably to preserve the safety of populations and properties, arises all over the world. This work develops another aspect in the estimation of Return Levels (RLs) and Return Periods (RPs) of extreme precipitation in particular and natural risk in general. In particular, it gives the Return Dates (RDs) with their Confidence Intervals (CIs). The RPs, the RLs and their CIs for extreme rainfall were also investigated. These estimates were made by approaching the peak over a threshold chosen by the Generalized Pareto Distribution (GPD). The CIs of RPs and RLs were determined by the Delta method. The daily rainfall data used were obtained from the data of the synoptic report for the period 2011 to 2021 for the Douala weather station (more details can be found on http://www.ogimet.com/guia.phtml.en). To validate the methods used, real cases of floods occurred in Douala city were considered: for example, a local press compiled flood dates and mentioned that a flood occurred on the 16 April 2013 in this city. Following the data of synoptic report, the corresponding amount of rainfall was around 150 mm. The results obtained have shown a RD on the 12 August 2014. The confidence intervals of return levels and return dates determined by the Delta method were [131.66, 168.456] and [23/06/2014, 02/01/2015], respectively. These results are in agreement with the data of synoptic report since the rainfall amounts was 132.2 mm (belonging to the confidence interval of return levels), on the 11 August 2014 (belonging to the confidence interval of return dates). These predictions of RDs and RLs with their CIs, at reasonable time scales, can help for efficient management of floods and thus, improve early warnings for safety of populations and goods.

Paper ID: 108

Ecological Rrsk assessment of the shoreline microplastics polymer on the Limbe coastline, Cameroon

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Abstract:

Plastic pollution is an uprising and a global environmental threat to all ecosystems nowadays, particularly on coastal beaches. This problem has challenged environmentalists and/or maritime scientists worldwide to focus on environmental designs on plastic materials. The aim of this study was to determine the microplastic polymer composition and the potential risk factor on the Limbe Coastline. Duplicates of 2×2 m (4m2) quadrants were sampled over 8 months across five purposeful beaches. Collected plastic samples were washed and separated using a 2 mm sieve, and only < 2 mm particles were considered. The samples were subjected to stepwise lab-based procedures of particle filtration, organic digestion, density separation, particle extraction, and polymer identification by FTIR analysis alongside the ecological risk assessment model. PP>PE>PS>PET>PVC plastic polymer/abundance were observed in all sampled beaches on both seasons. From the ecological risk assessment model, the probability for chemical risk and beach contamination risk factor were very high, with values ranging from 0.41 to 151.55 and 3 to 12, respectively. Also, the pollution load index (PLI) and polymer hazard index (PHI) were equally high, with average values of 2.48 and 2.30, respectively. Per polymer risk, the potential ecological risk index of PET was very high, with an average value of 547.47 (Tab. 1). Lastly, the combined risk potential (RI) posed by these polymers on this shoreline shows a category IV indicating danger to both human and maritime life. There is an urgent call for solutions and participation from all stakeholders, especially the scientific community

Paper ID: 109

Agricultural land and Pakistan

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Abstract:

It is commonly known that land is a basic natural resource, which supports lives through agriculture, where superposition of agricultural lands for other uses, especially for urbanization is great concern. Therefore, this study aim is to investigate causes and consequences of agricultural land conversion Pakistan. The country is select as a study, because agricultural land parcels are being greatly converting to residential areas in Pakistan as compared to the other countries. it is also intent to draw the attention of policy makers towards this issue, while sharing a recent experience. Both primary and secondary data sources will be use in this research. The primary data will be collecting through questionnaires, first from the local respondents (accused residents/farmer) in the study area, and second from professional/experts (real estate agents/valuers and physical planner). The data will also be collect through Arial-views and treated through geographic informative system (GIS). While, secondary data will be collect from economic survey of Pakistan, Pakistan bureau of statistics, government offices and websites, UN population division, magazines, daily press and from NGOs and offices. From the Arial-views show that agricultural lands are being considerably decreasing in last four decades. Similarly, on average every respondent has sold about more than four acres of agricultural land in last 10 years. Additionally, the study describes that three types of conflicts (proprietorship, distribution/fragmentation, and encroachment) have influenced the respondent's personal lives, such as; threat to life, lower property values, loss of income, abundance of land. Therefore, Institutional framework with good governance is a need to create or strengthen coherence between land regulatory institutions with powers and capacity to regulate land conversions system. On the other hand, local population needed to be educated regarding agricultural land conversion, through public participation, management and development policy seminars, to ensure sustainable agricultural developed.

Paper ID: 110

China's dining transition undermines food waste reduction efforts

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Abstract:

Reducing food waste is a global challenge for food security and environmental sustainability. However, addressing this issue is particularly difficult due to limited understanding of the social drivers of food waste and effective reduction interventions, especially in an increasingly urbanized world. Using the latest large-scale survey and meta-analysis from 2000 to 2024, this study found that urban food waste per capita in China has been significantly reduced in both home and out-of-home dining settings. Yet, shifting dining habits, from predominantly in-home consumption (86% in 2000) to out-of-home consumption (51% in 2024), has led to an overall increase in food waste from 49 to 52 kg per capita per year, even though food waste within each dining category has decreased substantially over the past 25 years. In 2024, food waste contributed to 232 million tonnes (Mt) of CO_2-equivalent emissions, 2.7 Mt of total nitrogen releases, and the consumption of 155 billion cubic meters of water. Although our integrated reduction scenario demonstrates potential to lower food waste from 57 to 35 Mt by 2030 and generate economic return of $63 billion in social benefits, it falls short of the Sustainable Development Goal (SDG) 12.3 target to halve food waste from 2015 levels due to the ongoing dining transition. Our findings underscore the urgent need to incorporate dining location transitions into future food waste reduction strategies.

Paper ID: 111

Life cycle assessment of various metallurgical processing routes for producing metal commodities from polymetallic nodules from the Clarion-Clipperton Zone

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Abstract:

The urgency of the energy transition to adopt clean energy technologies is increasing demand for minerals, with prospects for nickel, copper, cobalt, and manganese demand to quadruple by 2040 compared to 2020 in the IEA`s Sustainable Development Scenario (SDS) to achieve net-zero greenhouse gas emissions. In this context, deep-sea mining has seen renewed interest. Among the various deep sea deposits, the polymetallic nodules in the Clarion-Clipperton Zone (CCZ) have seen particular interest. Compared to land mining, deep-sea mining is reported to have a substantially lower carbon footprint, with the metallurgical processing stage being the hotspot. In this study, life cycle assessment (LCA) is carried out to compare the metallurgical processing, starting from comminution, extraction and separation (pyrometallurgy and/or hydrometallurgy), refining, and plant services of processing the nodules into valuable metal products (cradle-to-gate approach). There are five metallurgical pathways that are assessed, (1) gas reduction and ammoniacal leach, (2) Cuprion and ammoniacal leach, (3) high-temperature and high-pressure H2SO4 leach, (4) reduction and HCl leach, and (5) smelting and H2SO4 leach. Each process leads to different outputs such as waste, carbon emissions, and different recovery of metal products. The assessment quantifies various environmental impacts through a basket of products approach of processing 1 tonne of wet polymetallic nodules, into three or four metal products. The results will provide information about the advantages and disadvantages in terms of environmental and technical aspects, which can serve as a reference for decision-making for employing the metallurgical processes commercially.

Paper ID: 112

Food insecurity in Northern British Columbia: A future thinking approach in the context of social ecology

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Abstract:

Food security is a growing concern in Northern British Columbia (B.C.), where geographic isolation, climate change, economic disparities, and Indigenous food sovereignty challenges contribute to food insecurity. Despite Canada's wealth and agricultural capacity, many rural and Indigenous communities in Northern B.C. face limited access to affordable, nutritious food due to high transportation costs, climate-related disruptions, and socio-economic inequalities. This study applies Future Triangle and Causal Layered Analysis (CLA) frameworks to assess the region's food security crisis. Findings highlight that structural barriers such as historical injustices against Indigenous communities, reliance on external food sources, and climate-induced disruptions to traditional food systems exacerbate food insecurity. The study emphasizes the need to shift from short-term food aid to long-term community-led solutions, including Indigenous food sovereignty initiatives, local food production, climate adaptation strategies, and policy reforms that address systemic inequalities. By fostering sustainable, locally driven food systems, Northern B.C. can enhance resilience against economic and environmental shocks. This study contributes to national and global food security discussions by advocating for inclusive, equity-oriented approaches that integrate Indigenous knowledge, socio-economic policies, and environmental sustainability.

Paper ID: 113

Navigating resource constraints: Urban land pressures and energy storage in low-carbon transition

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Abstract:

Over 70% of global carbon emissions arise from urban energy systems, making city-focused low-carbon transitions integral to meeting international decarbonization goals. Both theoretical research and practical experience highlight that renewable energy expansion—supported by scalable energy storage solutions (electricity, hydrogen, and thermal)—is critical to balancing fluctuating supply with relatively steady demand. However, the land requirements of these emerging storage technologies often compete with other pressing urban land uses, creating a core challenge for renewable energy deployment in densely built environments. This study examines the tension between limited land resources and expanding energy storage infrastructure by analyzing ongoing renewable energy initiatives in China, particularly in Beijing, Jinan, and Hainan. We develop a spatial supply–demand assessment framework that evaluates land requirements, safety buffers, storage densities, and life-cycle costs for multiple storage technologies. Drawing on interviews and surveys with 52 stakeholders involved in six energy storage projects (conducted from March to October 2024), we gain practical insights into how local planning regulations, public perceptions, and high land costs shape the viability of storage deployments.

Preliminary findings underscore key conflicts concerning urban land and storage facilities. For instance, thermal storage systems can occupy up to 4 km^2—highlighting potential clashes with housing, green spaces, and other development objectives. Although hydrogen storage is widely seen as promising, substantial safety buffers increase spatial pressures and raise public concerns. In high-value urban areas, land expenses can account for as much as 40% of a project's total costs, posing a severe bottleneck to large-scale storage adoption. Consequently, we recommend robust urban planning approaches that identify and harness "misplaced resources," such as waste heat and underutilized land. By integrating advanced digital modeling, mixed-use zoning, and strong stakeholder engagement, cities can more effectively align energy storage infrastructure with broader sustainability targets, ultimately creating more resilient, low-carbon urban futures through comprehensive resource management.

Paper ID: 114

Conceptual Design for the Management of a Community-Based Mangrove in Hamata Village, Marsa Alam, Egypt under the Framework of Water-Energy-Food-Nexus

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Abstract:

Coastal communities worldwide face mounting pressures from water scarcity, energy shortages, and food insecurity, exacerbated by climate change and population growth. This paper presents an innovative, community-based mangrove management model for a coastal village in Egypt, leveraging the WEF Nexus to address the intertwined challenges of resource scarcity, economic vulnerability, and environmental degradation. By integrating sustainable practices across water, energy, and food systems, the proposed model aims to enhance local resilience, promote sustainable resource use, and foster long-term community prosperity. The conceptual design focuses on three key interventions: the enhancement of a desalination plant using Forward Osmosis (FO) technology to increase freshwater availability to 405 m^3/day; the installation of a 2,000 MW/year solar photovoltaic (PV) system to reduce reliance on diesel generators; and the establishment of a mangrove-friendly integrated farming system capable of producing 38,610 kg of poultry meat annually. These measures are designed to address immediate resource deficiencies while building long-term resilience and sustainability. The proposed model not only improves the living standards of the village's projected 2,700 residents by 2029 but also offers a replicable framework for other coastal communities facing similar challenges worldwide. By integrating natural-based solutions such as mangroves, which act as natural reverse osmosis systems and support biodiversity, the project enhances environmental sustainability while providing economic opportunities through aquaculture and beekeeping. The holistic approach ensures that the WEF Nexus is effectively addressed, promoting social, environmental, and economic benefits. The proposed framework is adaptable to other coastal areas, providing a pathway to address climate change impacts and growing resource demands while supporting local livelihoods and ecosystems.

Paper ID: 115

Application of field spectroscopy and Sentinel-2 Satellite data for Estimating Leaf Nitrogen Concentration in Tobacco

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Abstract:

Leaf nitrogen concentration (LNC) is a crucial indicator of monitoring growth conditions and assessing the quality of leaf in tobacco. Optical spectral data obtained from field spectroscopy and multi-spectral satellite (e.g., Sentinel-2) offers high potential for detecting spatiotemporal variability of LNC. In this study, we evaluated LNC estimation in tobacco by leveraging spectral parameters derived from canopy reflectance of both field spectroscopy and Sentinel-2 (S2) data. LNC-sensitive spectral parameters derived from canopy reflectance of field spectroscopy were selected. A Random Forest Regression model was then employed to model LNC estimation using the selected spectral parameters. Our findings revealed that the accuracy of LNC estimation, using the selected spectral parameters derived from field spectroscopy was 0.80 and 0.41% in R2 and RMSE, respectively. Using the selected spectral parameters that could be derived from the simulated S2 multi-spectral bands, the estimation accuracy was not largely reduced (R2 = 0.69 and RMSE = 0.47%). Furthermore, the spatial variability of LNC was generally captured by the real S2 data using the model trained on simulated S2 data, obtaining a relatively lower accuracy (R2 = 0.49 and RMSE = 0.69% for the simulated S2 validation, and R2 = 0.42, RMSE = 0.70% for the real S2 validation). This study highlighted the potential of spectral parameters from both field and satellite data in estimating and mapping LNC in tobacco. However, additional independent field measurements are required.

Paper ID: 117

Spatial pattern and driving mechanisms of dryland landscape ecological risk: Insights from an integrated geographic detector and machine learning model

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Abstract:

Drylands are among the most vulnerable and sensitive regions to global climate and land use changes. As one of the largest inland arid river basins, the Tarim River Basin exhibits diverse land use patterns that have exacerbated ecological risks, degraded the environment, and heightened ecosystem vulnerability. This study analyzed the spatiotemporal evolution of landscape ecological risks in the basin from 1990 to 2020 using a landscape ecological risk model. A novel combination of the geographic detector and machine learning was employed to identify the nonlinear driving mechanisms of ecological risk. Key findings include: (1) Unused land dominated the basin, with land use showing "three increases and three decreases" trends: increases in cropland, construction land, and unused land, and decreases in grassland, water bodies, and forested areas. (2) High-risk areas were predominant, increasing by 2.31%, while low- and medium-risk areas declined by 0.60% and 1.49%, respectively. (3) Ecological risks transitioned from dispersed to aggregated patterns, with significant clustering of high- and low-risk zones. (4) Elevation, NDVI, and distance to urban centers were key drivers in single-factor analyses, while dual-factor interactions, particularly involving NDVI, consistently enhanced risk. These findings elucidate the spatiotemporal dynamics of land use and ecological risks, offering insights for ecological management and sustainable development.

Paper ID: 118

The future of urban public spaces: Modelling the spatiotemporal effects of emerging work patterns on park utilisation

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Abstract:

The advancement in productivity has catalysed the adoption of emerging work patterns in urban environments. There is a well-noticed increase in the proportion of the workforce engaging in remote work, flexible arrangements, and gig employment. These emerging work patterns potentially reshape the spatiotemporal characteristics of residents' demands for public resources and facilities. Through an extensive questionnaire survey conducted in Shanghai, China, this study develops an activity-based model to: (1) capture the spatiotemporal distribution of local residents' park facility usage, and (2) understand how emerging work patterns influence the demand for park facilities. The model framework is built upon the Multiple Discrete-Continuous Extreme Value (MDCEV) structure. Based on this model, we conducted a series of scenario sensitivity analyses to comprehend the effects of various work patterns. The findings suggest that remote working may shift park usage demand from central business districts during evening hours to non-central areas during weekday daytime, whilst positively affecting both the total duration of park visits and the diversity of visit purposes. However, the proliferation of side jobs might reduce evening visitation to parks in central business districts. This study presents a novel activity-based framework for urban resource management and spatial planning, offering insights into how structural changes in population activity patterns affect the demand for public facilities. The implications of these findings are particularly significant for sustainable urban public space management and the formulation of urban facility planning strategies, as they enable policymakers to anticipate and respond to changing patterns of public space utilisation in an evolving work landscape. Moreover, this research contributes to the broader discourse on adaptive urban planning and the optimisation of public resource allocation in response to societal transformations.

Paper ID: 119

The Impact of Pricing on the Timing of Electric Vehicle Charging

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Abstract:

As electric vehicle (EV) adoption increases, managing the resulting electricity demand becomes critical to maintain system reliability and to minimize the emissions associated with electricity generation. The study is motivated by the premise that time of day and location of EV charging varies by a region's generation portfolio including its renewal and storage capacity. In Ontario, the electricity grid is characterized by a substantial base load supplied primarily by nuclear power (50% of generation) and hydroelectric facilities (approximately 25%). This provides stable but relatively inflexible power generation. The province has a dual-peak demand profile—typically occurring in morning and evening hours—is predominantly managed through natural gas generation.
This study investigates strategies to shift the 24-hour marginal EV charging demand away from peak periods in Ontario, with a particular focus on away-from-home pricing mechanisms. We developed a choice-based simulation model that incorporates multiple factors affecting charging behavior. Two key data limitations that plague systems modelers are overcome in our work. First, we employ a travel survey (TTS) to establish parking patterns across a 24-hour period. Second, the research incorporates a stated preference survey conducted with current EV owners to determine factors affecting the price elasticity of charging decisions. Our simulation model predicts charging decisions at each stop based on temporal, spatial, SoC, and price parameters. Initial modeling with 100% EV market penetration indicates unmanaged charging patterns align with existing peak electricity periods and increase peak demand in Ontario. We use discrete choice to estimate charging probability at a location with different initial charging scenarios based on price ranging from free to several times the current price.

Results will inform both the development of pricing policies and charging infrastructure designed to incentivize off-peak charging. The collected price elasticity data will be useful for models in different regions with varying electricity generation portfolios.

Paper ID: 120

Air cooled ferrochrome slag: a feasible coarse aggregate alternative for sustainable concrete

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Abstract:

In recent times, attempts have been made to synergistically integrate industrial by-products with the concrete sector, owing to the growing concerns about environmental sustainability in the construction sector. Ferrochrome slag (FCS) is generated as a by-product in the ferrochrome industry. The high chromium concentration of FCS, the possibility for environmental leaching, and the need for wide-area mass storage pose a formidable obstacle for ferrochrome manufacturers. Therefore, the potential uses of FCS in the construction industry have piqued researchers' interest in the past decade. The properties of FCS are greatly influenced by the cooling mechanism adopted. Earlier research reported that air-cooled FCS (ACFCS) can substitute coarse aggregate due to its superior technical features. Although most studies identified ferrochrome slag aggregate concrete (FCSAC) to have better mechanical properties than natural aggregate concrete (NAC), the acceptability of ACFCS as an environmentally friendly construction material has not yet been standardized due to absence of research, especially on the environmental performance evaluation and microstructural characterization of FCSAC. To promote ACFCS, this study evaluates the environmental impacts of FCSAC (using 100% ACFCS coarse aggregate) by life cycle assessment (LCA) and its microstructural characterization through Scanning Electron Microscope (SEM) imaging. A cradle-to-gate-based LCA was performed using IMPACT 2002+ Method. The results revealed that compared with NAC, FCSAC exhibited enhanced strength and more significant environmental savings by reducing around 7% global warming potential (GWP), 11% acidification potential (AP), and 6% non-renewable energy (NRE) consumption.

Moreover, the damage assessment outcomes indicated that the production of FCSAC can save large resources, reduce climate change, and protect ecosystems from NAC. The SEM analysis showed a compact, narrow interfacial transition zone (ITZ) with decreased portlandite availability in FCSAC. The results offer valuable insights for maximizing the applicability of ACFCS aggregate in the concrete sector.

Paper ID: 121

Comparative evaluation of network constituent materials: durability, operational efficiency, hydraulic performance, and environmental Impact

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Abstract:

Hydraulic infrastructure plays a crucial role in modern water management systems, encompassing a range of projects such as dams, drains, dikes, flood protection systems, and wastewater treatment facilities. This paper presents a comparative analysis of the different constituent materials used in these networks, evaluating their performance against the criteria of durability, operational efficiency, and environmental and hydraulic effectiveness. The focus is on the materials chosen for essential infrastructure, including drainage networks, wastewater treatment plants, desalination systems, and urban developments such as satellite cities. The proper selection of materials significantly impacts the longevity, sustainability, and performance of hydraulic systems. The paper highlights the importance of specialized engineering expertise in the design and implementation of these complex systems. Engineers are tasked with developing project specifications, conducting impact assessments, and ensuring the correct materials are chosen based on rigorous evaluations of durability and economic feasibility. Durability is a key factor in material selection, as hydraulic systems must withstand diverse environmental conditions, ranging from geotechnical challenges in underground networks to surface-level exposure to various environmental elements. The analysis compares materials such as steel, concrete, PVC, and advanced composites, addressing their suitability for different hydraulic and environmental conditions. The paper also explores how the evolving nature of environmental factors, such as climate change and urbanization, impacts the performance of constructed works, necessitating adaptive solutions in materials and designs. It concludes that successful long-term performance of hydraulic networks depends on selecting materials that balance durability with operational needs while also considering environmental sustainability. This study serves as a guideline for engineers and decision-makers in optimizing material choices for the resilience and efficiency of hydraulic infrastructure projects.
Keywords: Hydraulic infrastructure, material durability, operational efficiency, environmental impact, infrastructure performance.

Paper ID: 122

Optimizing recycling strategies for wind turbine blade waste: Insights from evolutionary game theory and system dynamics

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Abstract:

The recycling of decommissioned wind turbine blades poses challenges due to their large size and complex composition, with improper disposal potentially causing environmental pollution and resource waste. Effective recycling requires collaboration among governments, large recycling companies, and remanufacturers, making the development of efficient recycling strategies an urgent task. This study integrates evolutionary game theory and system dynamics to analyze the dynamic interactions and strategic choices of governments, remanufacturers, and recycling companies. Key findings include: (1) appropriate technical and recycling subsidies significantly enhance participation, driving the system toward an efficient collaborative model; (2) initial strategy probabilities influence the speed of system stabilization, but all parties ultimately converge to a cooperative state (1, 1, 1), demonstrating the system's self-regulating capacity; (3) remanufacturers' willingness to adopt green production is driven by both market demand and government policies, with technological advancements further improving economic and environmental outcomes. This study provides insights for optimizing recycling policies and promoting sustainability.

Paper ID: 123

Optimizing resource sustainability: evaluating climate debt offset through EV and HFCV adoption in China's regions

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Abstract:

Amidst global efforts to combat climate change, the adoption of sustainable vehicle technologies, notably Electric Vehicles (EVs) and Hydrogen Fuel Cell Vehicles (HFCVs), plays a pivotal role. This research evaluates the temporal dynamics of Greenhouse Gas Emission Breakeven Time (GBET) for EVs and HFCVs across various regions in China. The study underscores the influence of distinct regional factors such as grid carbon intensity, hydrogen production techniques, and vehicle operation patterns on the environmental outcomes of these technologies. Our findings reveal a marked discrepancy in Well-to-Wheel (WTW) emissions among regions for EVs, with variations exceeding 50%. Conversely, HFCVs demonstrate more uniform emission reductions across different areas. The data indicates an average GBET of 3.39 years for EVs and 1.39 years for HFCVs, suggesting a quicker offset of environmental costs for HFCVs by approximately 60% relative to EVs. This research introduces the concept of "climate debt" to quantify the environmental payback period of adopting green vehicles. The necessity for tailored regional Life Cycle Assessments (LCA) to effectively meet climate objectives is highlighted, alongside the potential risks of increased initial emissions from HFCVs without progress in sustainable hydrogen production. The study advocates for a regionalized approach in the deployment of EV and HFCV technologies, tailored to the specific energy profiles of provinces, to optimize greenhouse gas mitigation. These insights are critical for policymakers and industry leaders, fostering a nuanced approach to sustainable transportation policy and further exploration into the synergy between technological advancements and environmental policy in reducing vehicular emissions.

Paper ID: 124

Promoting daily water and energy conservation with large language model-powered nudges

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Abstract:

Growing pressures on water and energy shortage heightened the urgency of cultivating individual conservation behaviors. While nudging, i.e., providing usage-based feedback, has shown promise in encouraging conservation behaviors, its efficacy is often constrained by the lack of targeted and actionable contents. This study designs a conservation behavior nudge platform based on Large Language Models (LLMs) and investigates the impact of using LLMs-generated customize suggestions on conservation behaviors. We first developed the behavior nudge platform by constructing a text repository containing over 5,000 conservation suggestions extracted from over 3,000 handbooks retrieved by web crawlers and refining a series of prompts. Then, we conducted a randomized controlled trial with 233 university participants lasting for 6 weeks, providing nudging contents each week. Participants were divided into three groups: (i) basic nudging with usage queries, (ii) traditional nudging with usage statistics reports, (iii) LLM-powered nudging that combined usage statistics reports with personalized conservation suggestions. Statistical analyses showed that LLM-powered nudging reduced electricity and bath water consumption by 24.4% and 18.4, respectively. The most significant increases in conservation were observed among individuals with higher baseline water and electricity consumption. Additionally, participants with less positive attitudes and expectations toward nudging exhibited greater conservation efforts. These findings highlight the role of LLMs in promoting individual water and energy conservation, representing a new frontier in the design of behavioral interventions and resource management.

Paper ID: 126

Quantifying the spatiotemporal patterns of atmospheric methane emissions and their associations with environmental factors in Bihar, India

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Abstract:

Methane (CH4) is a potent greenhouse gas with a global warming potential approximately 80 times greater than carbon dioxide over a 20-year timescale. Its atmospheric concentration has increased significantly due to anthropogenic activities such as agriculture, fossil fuel extraction, and waste management. Understanding the spatial and temporal variability of CH4 emissions is crucial for effective mitigation strategies. This study examines the spatiotemporal distribution of atmospheric CH4 over Bihar, India, using satellite observations from the Sentinel-5P TROPOspheric Monitoring Instrument (TROPOMI) between 2018 and 2023. We integrate CH4 concentration data with meteorological variables and vegetation indices, including the Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), and Gross Primary Productivity (GPP), to assess emission drivers and identify regional hotspots and coldspots. Our findings reveal a 2.8% increase in annual mean CH4 levels over the study period, with concentrations ranging from 1887.6 to 1939.9 parts per billion. Peak CH4 emissions occur during the monsoon and post-monsoon seasons (August-October), coinciding with rice cultivation, wetland emissions, and flooding. Spatial analysis identifies hotspots over the mid-Gangetic plains, driven by intensive agriculture, livestock farming, and population density, while coldspots are found in forested and less urbanized southern and northern regions. Statistical analyses show positive correlations between CH4 and vegetation indices (NDVI, EVI, GPP) and relative humidity ($r \approx 0.4$, $p < 0.01$), while wind speed exhibits a negative correlation ($r = -0.33$, $p < 0.01$), highlighting the role of biomass productivity, moisture availability, and atmospheric mixing in CH4 variability. Anomaly analyses confirm agricultural and hydrological factors as key drivers of CH4 emissions. These findings highlight the need for targeted mitigation strategies in flood-prone and agriculturally intensive regions, aligning with India's climate action goals and contributing to global CH4 reduction efforts.

Keywords: Methane; Spatiotemporal; TROPOMI; Hotspots; mid-Gangetic plains

Paper ID: 128

Towards sustainable nanomineral synthesis: Life cycle assessment of xonotlite production via supercritical hydrothermal method

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Abstract:

The production of synthetic nanomineral is crucial for both fundamental materials science research and industrial applications. Among them, calcium silicate hydrate (C-S-H) minerals, have attracted considerable attention due to their broad applicability. This growing interest has driven efforts toward developing environmentally sustainable synthesis methods for nanominerals.

In this study, we present a novel hydrothermal synthesis method aimed at enhancing the production of synthetic minerals to meet industrial demand. Using a life cycle assessment (LCA) approach, we evaluate the environmental impact of xonotlite production via subcritical and supercritical hydrothermal synthesis. Four different scenarios are investigated, including one lab scale and three industrial scale processes. The results indicate that precursors are the primary contributors to the environmental burden of xonotlite production. Industrial scale scenarios exhibit significantly lower impacts on global warming and fossil resource depletion compared to the lab scale scenario, primarily due to the efficient use of concentrated precursors and advanced heat exchange systems. Notably, supercritical conditions offer a more environmentally favorable alternative to subcritical conditions by enhancing process efficiency. Additionally, the choice of calcium source plays a crucial role in the environmental impact, with calcium chloride being approximately 40% more environmentally friendly than calcium nitrate. These findings underscore the importance of production scale, synthesis conditions, and precursor selection in optimizing the environmental performance of xonotlite production.

Paper ID: 129

How does lower cost choose the different portfolios of warrant products? A dynamic simulation analysis from the perspective of trading agents

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Abstract:

In order to promote renewable energy consumption and low-carbon energy transition, China started to implement the Renewable Energy Consumption Guarantee Mechanism (new RPS) in 2019. However, at the early stage of policy implementation, the instability of market development and uncertainty of the behavior of trading entities have affected the pace of energy structure transformation to some extent. In this paper, against the background of the introduction of the renewable energy consumption guarantee mechanism, power generation enterprises and large power users are taken as the main research subjects. Considering the interactions among traditional energy generation market, green power market, green certificate market and excess consumption market, a system dynamics model (SD) is constructed considering the bilateral game. The simulation simulates the changes of product price, trading volume and cost in different warrant products portfolio strategies, and clarifies the different warrant products mixes of large consumers when purchasing electricity under multi-market and multi-product. The results show that large users should fully consider the match between the product supply in the market and the actual demand of users. In order to reduce the total transaction cost of large users, the product portfolio strategy with fewer types of traded products should be prioritized. When large users face three kinds of warrant products such as green certificate (TGC), consumption volume and CCER, the purchase portfolio is guaranteed to choose either one or the other. This study can provide a decision-making reference for the trading of warrant products and the optimization of power purchase strategy for large users direct power purchase.

Paper ID: 130

Machine learning based optimization of wall materials for carbon emission reduction in sustainable construction

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Abstract:

The construction industry is a major contributor to global carbon emissions, with both embodied and operational carbon from building materials playing a critical role in environmental sustainability. This study applies machine learning (ML) to assess and optimize wall configurations by predicting their potential for carbon emission reduction. Using a diverse dataset of building and insulation materials—including conventional options like clay and fly ash bricks, as well as alternative materials such as plastic-infused concrete—the study develops predictive models to evaluate the environmental impact of various material combinations. These models analyze key thermophysical properties, such as thermal conductivity, density, and specific heat capacity, to estimate lifecycle carbon emissions. By leveraging supervised learning techniques, the study identifies material-insulation pairings that offer the greatest reduction in emissions while maintaining thermal efficiency. Early findings suggest that polymer-modified concretes and advanced insulation materials can significantly lower carbon footprints compared to traditional construction methods. This research highlights the potential of AI-driven predictive modeling in guiding sustainable material choices, offering a scalable approach to reducing emissions in the built environment and advancing global net-zero goals.

Paper ID: 131

Opus Helios - A treatise on solar incidence due to the movement of the Earth

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Abstract:

The Sun is the driver of all energy on the surface of the Earth. Besides all forms of life, ocean currents, winds and weather systems derive their energy from the Sun. At a distance of about 149.6 million km from the Sun, the Earth receives solar radiative energy of nearly 1,361 W/m2 which remains fairly constant at the location of one astronomical unit away. However, the energy received at the surface of the Earth varies with the angle of incidence on the surface, which in turn depends on the latitude, time of day and also, the position of the earth in its orbit. It is the difference in incident energy that results in thermal and pressure gradients driving the vast magnitude of wind and ocean currents. The incident radiative power per unit area (I) is related to the Solar Constant (Io) and angle of incidence (i) as I = Io cos (i). To understand the variation of incident solar energy on the Earth, it is imperative to understand the variation of this angle (i) with time, as the Earth performs its celestial dance around the Sun. This paper is an attempt to completely describe and determine the angular position of the Sun with reference to any particular location on the Earth at any particular time. Consequently, it is possible to chart out the incident solar energy across the span of a year at various latitudes on the Earth. Using this relation, it is also possible to determine the length of a day at various times of the year at various locations on the Earth and also how the peak angle of the Sun at its Zenith with respect to any location on the Earth varies with the time of the year.

Paper ID: 133

Decommissioned PV module trade can accelerate global recycling cost reduction but cause regional economic and environmental imbalances

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Abstract:

The world is facing a mounting challenge from the rapid increase in global photovoltaic (PV) waste, as the first generation of PV systems has reached their service life. The environmental and economic performance of PV waste management depends heavily on the selection of appropriate recycling strategies. Here, we develop a comprehensive framework to evaluate recycling strategies across 30 regions from 2020 to 2060, assessing the economic and environmental benefits of local versus outsourced recycling that cover the major recycling technologies. Global PV waste is expected to reach 175–305 MT by 2060, with middle-income countries like China becoming major contributors post-2040. Recycling can reduce GHG emissions by up to 151 million tons by 2030 and yield $3.3–18.9 billion in annual net benefits by 2060. Outsourced recycling lowers costs but raises equity concerns for low-income regions. Subsidies could mitigate these disparities. Our results highlight the importance of tailoring recycling strategies to regional conditions to promote equitable and sustainable PV waste management globally.

Paper ID: 134

Investigating the ethical issues of AI application for climate change adaptation in Kenyan agriculture

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Abstract:

In coping with future climate change challenges to Kenya's agricultural sector, the application of artificial intelligence has gained attention from policymakers as promising solutions. Past studies show that AI-driven solutions, such as predictive analytics and precision farming, can enhance crop productivity and resilience against climate variability. However, the application of AI in agriculture raises several ethical challenges. The Diffusion of Innovations theory postulates that new technology adoption depends on perceived relative advantage, compatibility with existing practices, complexity, trialability, and observability. Thus, ethical implications can affect the diffusion process and trust in technologies. This research investigates the ethical issues surrounding AI-driven climate change adaptation in Kenyan agriculture. A systematic review of 40 peer-reviewed articles and policy reports was conducted in February 2025 using electronic databases such as Google Scholar, Nature, ProQuest, and Web of Science, searching the keywords "artificial intelligence", "climate change adaptation", "ethical issues", "agriculture," and "Kenya". Also, interviews with 15 key informants were conducted to explore in-situ ethical challenges. The findings show that despite the potential benefit of AI adoption, several concerns, such as data privacy (50%), algorithm bias (35%), and farmer inclusivity (15%), needed to be addressed proactively. The respondents expressed concerns over data security and ownership (67%), while algorithmic bias (53%) in AI models often excludes small-scale farmers from benefiting equitably (60%). Ethical AI deployment will be crucial for sustainable agricultural development and climate resilience in Kenya. This study recommends establishing a robust regulatory framework for AI governance, enhancing digital literacy among farmers, and promoting inclusive AI systems that account for diverse farming practices in all agroecological zones.

Paper ID: 135

Addressing the ‘last mile’ deficiency: a bi-objective model for e-waste community transhipment centre location problem

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Abstract:

Although China’s officially released e-waste recycling rate has been higher than the global average in the past decade, the formal reverse logistic network is facing huge competition from informal channels because of the formal network’s inaccessibility to households, resulting in a continuously shrinking formal recycling rate reaching the lowest level of 46.5% in 2020. This paper develops a bi-objective mixed-integer linear programming (BMILP) model to help decision-makers establish residential transshipment centres tackling a ‘last one-mile’ deficiency issue, aiming to improve the formal e-waste recycling rate and maintain the reverse logistic network’s economic viability. Effective heuristic algorithms are developed to search for robust efficient solutions and identify the Pareto front. A real case in the China Yangzi-Delta area is presented to validate the BMILP model's effectiveness in supporting RTC location decision-making. ArcGIS is used to illustrate the RTC centre’s selection from the community in the reverse logistic network on the map. This study offers a reliable and effective model for residential transshipment centre location decisions under realistic uncertainties and facilitates achieving a trade-off between regulatory and economic objectives.

Paper ID: 136

Bridging the Gap Between Recycled Crude Phosphoric Acid and White Phosphorus

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Abstract:

Phosphorus is an important resource not only for agriculture but also for industry. White phosphorus in particular is essential for advanced industries such as semiconductors, without which our society could not stand. However, white phosphorus is produced using an electric furnace method with huge energy consumption and a heavy environmental burden. As a result, its production is limited to only four countries. In recent years, with the progress of the depletion of phosphate rock, some countries have restricted exports of white phosphorus, making its supply extremely vulnerable and unstable. To meet this supply risk, we have developed an innovative process to produce white phosphorus by carbothermic reduction of crude phosphoric acid recovered from domestic phosphorus resources such as sewage sludge, industrial wastewater, and steelmaking slag, instead of phosphate ore.

The carbothermic reduction of phosphoric acid is an extremely unusual reaction that involves a large volume expansion in which 23 moles of the gas phase are generated from 1 mole of phosphoric acid. Since this large volume expansion significantly affects the reaction behavior, this effect must be evaluated for the implementation of the proposed process.

Therefore, a reaction model that takes into account volume expansion was used to evaluate the effects of factors such as the height of the packed bed, the amount of phosphoric acid supplied, the type of carbon, and the particle size of the carbonaceous material on the reaction behavior. Based on these evaluations, the reactor was scaled up. Currently, it is possible to produce approximately 5 kg of white phosphorus per day using waste phosphoric acid stably.

Paper ID: 137

Assessing the impacts of fertilizer subsidy policies on Ghana's academic study trend and characteristics

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Abstract:

Government policies have long sought to make fertilizers accessible to farmers through subsidies as fertilizers are known to enhance farm output and productivity. In this paper, we attempt to show the extent to which this policy emphasis has influenced the trend and characteristics of past academic studies on fertilizers in Ghana. We reviewed 21 peer-reviewed articles and four policy documents. These documents were collected by using databases, such as ProQuest, Web of Science and Google Scholar, with the following keywords: fertilizer policy, fertilizer subsidies, agriculture policy, and Ghana. In examining the contents of these past studies and policy documents, we focused on profitability, productivity, income, fertilizer access, food security, and study areas. The result shows that about 57% of the articles focused on profitability and productivity. In terms of study areas, about 52% examined northern regions. Our comparison between past studies and policy documents show that Ghana's past fertilizer studies closely corresponded with fertilizer policy implementation practices. Subsidies have considerably improved farmers' access to fertilizers, increased fertilizer application rates, enhanced crop productivity, and contributed to mitigating food insecurity. On the contrary, none of the review looked at environmental impacts of increasing inorganic fertilizer use. Our review highlights the need for incorporating sustainability perspectives into studies on food and agriculture in Ghana.

Paper ID: 138

Risk index as a metric for sustainable airport diversion: An efficiency-based model

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Abstract:

Although the main culprit of flight delays points to adverse weather, which can be predicted to some extent, this factor remains uncontrollable. As a result, flights avoid the airspace with adverse weather by rerouting to an alternative aerodrome, which primarily directs the flight to its assigned destination airport. In extreme cases of adverse weather during an aircraft's en route, flights are forced to be diverted to the most viable nearby airport. However, the systematic decision support system of diversion airport analysis has not yet been extensively explored in the literature. Currently, air traffic controllers operate under rules of thumb that only consider diversion crude airport characteristics. Such an unstructured manner of selecting a diversion airport is not sustainable in the long run and does not guarantee an optimal choice among available alternatives. Therefore, this paper intends to characterize the alternative diversion airports in terms of its risk index, which consists of elements that affect the viability of an alternative airport. The concept of airport diversion risk index has been prematurely introduced in the literature with a lack of in-depth contextual representations and mathematical rigor. As an approach to this paper, the measurement of airport diversion risk index will be enhanced further to include realistic considerations and relevant decision criteria. Then, this index will serve as one of the model components for analyzing the flight diversion process. To ensure that this model reflects reality, a case study will be conducted involving the following elements: (a) actual airport configuration, (b) integration of multiple-stakeholder perspectives, (c) uncertainty in the flight diversion decision process, and (d) sustainability component of decision-making. Incorporating a sound optimization framework into the flight diversion decision process leads to a more structured and informed decision analysis, which air traffic controllers can easily adopt as a decision support tool.

Paper ID: 140

Global economic impact assessment of future water scarcity under climate change

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Abstract:

Water scarcity is an escalating global challenge that threatens economic stability and sustainable development. Climate change, population growth, and increasing water demand are expected to intensify water scarcity, leading to significant economic loss. Understanding the economic impact of future water scarcity under climate change is essential for developing effective adaptation and mitigation strategies. Here, we assess the dynamic economic consequence of water scarcity under the RCP8.5-SSP5 scenario for the years 2030, 2050, and 2080, considering both the direct economic impact from local water scarcity and the indirect impact propagated through trade. We first quantify the potential direct economic loss imposed by local water scarcity across sectors at the sub-basin level. Furthermore, we integrate a multi-regional input-output (MRIO) model to capture the potential economic loss transmitted through global supply chains. Our findings indicate that the economic impact of water scarcity will continue to intensify over time. The potential economic loss due to water scarcity is projected to reach $14.3 trillion (95% CI: 12.6–16.0 trillion) in 2030, $18.8 trillion (95% CI: 16.5–21.1 trillion) in 2050, and $22.6 trillion (95% CI: 19.7–25.4 trillion) in 2080. While the overall global economic impact of water scarcity is increasing, some regions will experience improvements in water scarcity and reduced economic impact. Our analysis also reveals the amplification effect of supply chain, where trade-related indirect economic impact is approximately 1.4 times greater than the direct economic impact caused by local water scarcity. By mapping the spatial and temporal evolution of water scarcity-induced potential economic loss, this study provides insights for policymakers to develop targeted water resource management strategies and enhance supply chain resilience in a rapidly changing climate.

Paper ID: 141

Polymer membranes for copper, iron and zinc removal from wastewater

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Abstract:

With the objective to assess the suitability of cellulose acetate (CA), polysulfone (PSF) and silica (SiO_2) for wastewater treatment, this work presents the results of preparation and characterization of PSF blended CA hybrid filtration membranes (CA/PSF) as well as PSF blended and SiO_2 embedded CA hybrid adsorption membranes (CA/PSF-SiO_2) for copper (II), iron (II) and zinc (II) ions removal from contaminated aqueous solutions. The membranes were prepared by phase inversion, using granules of CA, PSF and SiO_2 dissolved in N, N Dimethyl formamide (DMF). From the scanning electron microscopy (SEM) used to determine the morphology of the membranes, different pore sizes are seen at their rough surfaces and cross sections. The porosity and pore sizes of the membranes, determined by differentiation varied from 26.8±0.3 to 81.1±0.3 µm and 1.26 to 1.38%, respectively. The contact angles of the membranes ranged between 49 and 76° on their glass side while their ranged between 56 and 77° on their air side. The hybrid filtration polymer membranes allowed the uptake of more than 90% of the metal ions initially present in the contaminated solutions which were concentrated at 40 mg L^{-1}. Adsorption experiments were carried out with CA/PSF-SiO_2 membranes. The adsorption capacity of these compounds was shown to be higher than numerous other literature known adsorbents, reaching 70 mg g^{-1} for CA/PSF 85/15-SiO_2 towards Cu (II). Finally, by coupling adsorption with ultrafiltration in the tangential mode, the removal of Cu (II), Fe (II) and Zn (II) was found to be improved, allowing to reach a removal efficiency of 95% towards Cu (II) at a metal concentration of 60 mg L^{-1} , and a promising removal efficiency around 98% at a very high metal concentration of 900 mg L^{-1}.

Paper ID: 142

Synergistically effect of ZnS-Fe2O3 heterojunction with enhanced photoelectrochemical performance and towards efficient degradation of organic dyes: Mechanism and degradation pathways

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Abstract:

Solar light-driven photocatalytic is the next step in environmental attention, and it can employ 17 sustainable energy to address environmental issues. The photodegradation activity indicated 18 that ZnS/Fe2O3 nanohybrid displayed excellent photocatalytic efficiency for the Rhodamine B 19 (RhB), achieving 95.6 % decomposing rate in 60 min, which was 2.6 and 10.3 folds better than 20 that of bare Fe2O3 and ZnS photocatalysts. The work also explored the potential 21 photodegradation routes of RhB in agreement with liquid chromatography-tandem mass 22 spectrometry (LC-Mass) examination. Furthermore, the nanohybrid photocatalysts carried out 23 antibacterial efficiency of 100% against Escherichia coli (E. coli), under the same conditions. 24 Nanohybrids exhibit low ferromagnetic action with a magnetize rate of 2.72 emu/g at a 25 maximum applied magnetic plot of 1 kOe. The photocatalyst exhibited long-term stability over 26 6 repeated tests. Electron paramagnetic resonance (EPR) tests verify that the important reason 27 affecting the RhB dye removal by ZnS/Fe2O3 nanohybrid is the capacity to create more •O2- 28 and •OH radicals, which is a primary factor for the outstanding antibacterial efficiency of 29 ZnS/Fe2O3 nanohybrid against E. coli. The distinguished photocatalytic capability of 30 ZnS/Fe2O3 nanohybrid was ascribed to the promoted visible light ability and the rapid 31 transferring of charge carriers, which were confirmed by the UV-vis absorption spectrum, 32 photocurrent test, and fluorescence analysis. It was illustrated that the Z-scheme heterostructure 33 led to a notable improvement of charge carrier migration and separation influences. At the same time, the combination of Fe2O3 and ZnS serves as photogenerated electron capturers by greatly 35 improving the photocatalytic capability.

Paper ID: 143

Biodiversity impacts of land occupation for renewable energy infrastructure in a globally connected world

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Abstract:

The transition to renewable energy exacerbates direct land occupation by infrastructure, leading to habitat degradation and biodiversity loss. However, the biodiversity loss driven by the production and consumption of different renewable energy deployment scenarios remains largely unquantified. Quantifying biodiversity loss associated with land occupation of renewable energy infrastructure is essential for a sustainable energy transition. Here, we developed a novel dataset to evaluate renewable energy-related biodiversity loss by considering the current infrastructure setting and future development pathways. We found that the land occupation of renewable energy infrastructure resulted in global biodiversity loss equivalent amounting to global pdf in 2015. Severe biodiversity loss was concentrated primarily in densely populated and economically advanced countries, such as China, the United States, Brazil, India, Australia, Russia, and countries across Western Europe. International trade accounted for 14% of this biodiversity loss. Future renewable energy transition scenarios will lead to a global cumulative biodiversity loss of – global pdf during 2015-2060. By 2060, ambitious energy transition policies are projected to lead to a 1.7 – 1.8-times increase in biodiversity loss. The results underscore that while renewable energy could tackle climate change, its deployment should avoid encroaching on biodiversity hotspots.

Paper ID: 144

Application of new sewage sludge fertilizer to tea cultivation and its impact on the environment

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Abstract:

The recent spike in fertilizer prices has affected the entire agriculture, and the tea industry is no exception. In response to this situation, as a national policy, sewage sludge is being recycled into fertilizer and circulated within the community. However, since sewage sludge contains a large amount of heavy metals, its safety is an issue.
In this study, a new sewage sludge fertilizer with reduced heavy metal content was prepared by mixing local biomass with sewage sludge (dewatered sludge), which is available in stably supply. This fertilizer was applied to tea gardens for 5 years (18 m2 [1.8 m x 10 m x 3 replications]) to evaluate its effectiveness as fertilizer and environmental impact. When the yield and quality (total nitrogen, theanine, catechins, and heavy metals) of tea leaves from the new sewage sludge fertilizer application area were compared with those from the conventional fertilizer application areas (rapeseed oil cake and compound fertilizer), no statistically significant differences were observed. No accumulation of heavy metals in the soil was also observed. Furthermore, tea cultivation tends to produce nitrous oxide (N_2O) due to the large amount of fertilizer applied, and the measured N2O gas emission tended to increase after fall fertilizer application and branch preparation, but at an annual fertilization rate of 50 kg N/10a, N2O gas emissions were between 0.3-0.4 mg N2O m^{-2} h^{-1} in all test plots.

From these results, the new sewage sludge fertilizer can be applied to tea cultivation at the present stage, and at an annual fertilization rate of 50 kgN/10a, it is considered to have a low environmental impact.

Paper ID: 145

Rapid 3D instance proxy reconstruction of urban sewer networks from generic data: A learning-based and spatially explicit approach

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Abstract:

The digitalization of large-scale urban underground infrastructures—particularly sewer systems—has long remained an unresolved challenge due to numerous data acquisition obstacles. These include the subterranean nature of the environments, discrepancies and inaccuracies between design specifications and actual installations, low collection efficiency, and high resource and cost consumption. In this paper, we address these challenges in reconstructing urban sewer systems from geospatial data and propose an efficient workflow alongside several novel algorithms for the high-efficiency instance-level 3D reconstruction of sewer networks in large-scale urban settings. Specifically, we introduce a novel learning-based approach that leverages urban remote sensing imagery as the foundation for delineating the sewer network topology by extracting pipeline nodes and their interconnections. Subsequently, a spatially explicit algorithm is employed to generate a 3D network model that authentically represents the key hydraulic performance characteristics of the sewer system based on urban spatial data. Through comprehensive hydraulic performance evaluations, we demonstrate that our method achieves a high-fidelity reconstruction of urban sewer networks. The generated scene proxy models provide a 3D voxel representation of sewer systems within extensive urban contexts. When applied to urban sewer planning, these instance-enhanced proxy models significantly improve data integrity and accuracy, thereby supporting more precise drainage system design, optimized maintenance strategies, and enhanced assessments of potential flood risks.

Paper ID: 146

End-of-life management of plastic packaging: a LCA-based comparison of recycling technologies

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Abstract:

Plastic packaging waste poses a significant and growing threat to resource sustainability. This presentation investigates the application of Life Cycle Assessment (LCA) to evaluate end-of-life management strategies specifically for plastic packaging, focusing on enhancing resource recovery through advanced recycling technologies. The research employs LCA to comparatively analyze mechanical and chemical recycling pathways for common plastic packaging types, such as PET bottles and polyethylene films. The study rigorously quantifies the environmental performance of these pathways, assessing key LCA indicators including fossil resource depletion, global warming potential, energy demand, and plastic waste generation. Furthermore, the research examines the impact of critical factors like plastic sorting efficiency and recycling infrastructure on the environmental effectiveness of each recycling pathway. The presentation will demonstrate how LCA can identify environmentally preferable recycling solutions for specific types of plastic packaging, guiding strategic decisions towards a circular economy for plastics. This research emphasizes the crucial role of LCA in developing tailored and resource-efficient end-of-life systems for plastic packaging, ultimately contributing to mitigating plastic pollution and promoting sustainable resource management in the packaging sector.

Paper ID: 147

Effect of biochar on mitigating nitrate leaching in highly permeable sandy soils

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Abstract:

Excessive use of nitrogenous fertilizers leads to nitrate leaching into groundwater. Mitigating these losses with synthetic nitrification inhibitors is costly and less environmentally friendly. This study aimed to assess the effect of biochar and biobased nitrification inhibitors on nitrate leaching losses. An experiment was conducted with shallot onions grown in lysimeters of 0.25 m^2 filled with Sandy Regosol soil to a depth of 1 m. The treatments included: recommended fertilizer (RF) only (T1), Neem leaf-extract-incorporated urea with RF (T2), Bamboo leaf-extract-incorporated urea with RF (T3), and RF applied to biochar-incorporated soil (T4). Irrigation and other management practices were consistent across all treatments. Growth and yield were recorded, and leachate was collected weekly from lysimeters and analyzed. There was a significant difference ($P<0.05$) in nitrate leaching among treatments. Cumulative nitrate leaching during the cropping period was significantly reduced in T4 (85 kg/ha) and T3 (112 kg/ha) compared to the control (133 kg/ha), while T2 did not show a significant difference. The difference in yield corresponded to nitrate leaching: the highest yield was recorded in T4, while the lowest yield was recorded in T1. This study demonstrates that incorporating biochar into highly permeable Sandy Regosol significantly reduces nitrogen leaching by 35% and increases yield.

Paper ID: 148

Has the Belt and Road Initiative reshaped the ecological sustainability of Eurasia: A perspective of three-dimensional ecological footprint

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Abstract:

Based on data of ecological footprint and ecological carrying capacity for the Eurasian from 2000 to 2022, this paper employs a three-dimensional ecological footprint model to conduct a multi-scale analysis of sustainability on the Eurasian. Furthermore, a difference-in-differences model is used to further analyze the impact mechanism of the "Belt and Road" Initiative (BRI) on the ecological footprint of the Eurasian, and the differential impact of the BRI on the ecological footprint of different countries is demonstrated in multiple dimensions by combining quantile regression and heterogeneity analysis. The study findings indicate: (1) From 2000 to 2022, the Eurasian's unsustainable development situation has been deteriorating, with the ecological footprint depth increasing from 1.966 ha/cap to 2.513 ha/cap and the per capita ecological footprint size slightly decreasing from 1.092 ha/cap to 1.023 ha/cap. (2) Based on the ecological footprint depth and per capita ecological footprint size, 83 countries are classified into 9 types of sustainable development. Asia exhibited low size-medium depth and low size-low depth types, indicating weak sustainability, while Europe was predominantly characterized by the low size-medium depth type, with a more optimistic sustainable situation. In terms of country size, the sustainability of 6 countries weakened and 6 countries improved. (3) The BRI has a significant positive impact on the ecological footprint of Eurasian's countries, indirectly affecting them through mechanisms such as industrial structure, technological innovation, and foreign direct investment. Quantile regression shows the BRI has a more pronounced promotional effect on countries with lower ecological footprint. Additionally, heterogeneity analysis reveals the BRI has a greater impact on countries with lower ecological footprint depth, lower per capita ecological footprint size, and weaker sustainability. The research findings can provide important guidance for implementing the "2030 Agenda for Sustainable Development" and formulating relevant policies, thereby enhancing the long-term sustainability of the BRI.

Paper ID: 149

Does intention matters anymore? A revisit and navigating new directions

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Abstract:

An area that draws much attention and continued to be worth discussing in the behavioural research sphere is the intention-behaviour relationship. Intention-behaviour relationship has long been hazy due to many factors including measurement compatibility, operationalization of variables and even order of variable in a study. Several systematic reviews in various domains including health and environmental behaviour have continued to study on the intention-behaviour relationships. It is apt to revisit the relevancy of intention and importantly whether intention is sufficient to well-inform stakeholders and policymakers of timely strategies or actions to promote environmentally friendly behaviours. Scholars may depart from traditional intention-behaviour relationship and seek to explore direct assessment of actual behaviour with consideration to detect or reduce measurement variability that are commonly present in self-reported research design. Thus this paper aims to present a critical and holistic perspective of the intention-behaviour disparity and offer contemporary propositions to navigate a new research agenda for future exploration. Taking into consideration the over-exploitation of Theory of Planned Behaviour (TPB) in most behavioural-related research, it is suggested future scholars weigh into the huge potential and relevancy of contextualization such as external forces (i.e., local government support, infrastructure) to improve correspondence of these two crucial factors apart from improving methodological robustness.

Paper ID: 150

A bibliometric analysis of water scarcity research and sustainable management solutions

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Abstract:

Water scarcity is an increasingly pressing global challenge, exacerbated by climate change, population growth, and unsustainable water management practices. This bibliometric review aims to evaluate the advancement of research on water scarcity and sustainable solutions, emphasizing key trends, influential studies, and emergent themes. The specific objectives of this study are to (i) assess the trajectory of research on water scarcity, (ii) identify innovative and sustainable water management strategies, and (iii) evaluate the roles of policy and technology in mitigating water shortages. The methodology implements a bibliometric analysis of research articles obtained from the Web of Science and Scopus databases, utilizing VOSviewer to investigate publication trends, citation networks, keyword co-occurrence, and international research collaborations. The findings indicate that solutions such as desalination, water recycling, rainwater harvesting, and smart irrigation techniques are increasingly gaining traction. Furthermore, integrated water resource management (IWRM) and policy interventions are pivotal in addressing water scarcity. Nonetheless, challenges, including high costs, energy-intensive processes, and unequal distribution of water resources, continue to represent significant obstacles. Recommendations include enhancing investments in energy-efficient water technologies, fortifying transboundary water governance, and supporting community-based conservation initiatives. This study offers critical insights into the progress, challenges, and future directions of water scarcity research, serving as a comprehensive guide for sustainable water resource management.

Paper ID: 151

Supplementary calcium with in situ mulch technology boost biological carbon sequestration

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Abstract:

The root-zone warming technology (e.g., biodegradable mulching) is an effective strategy to realize the potential of the bioenergy with carbon capture and storage (BECCS) framework. However, the hidden risks associated with elevated root-zone temperatures in dynamic environments have not been rigorously assessed. Through chlorophyll fluorescence imaging, we established a rapid evaluation method. Herein, we present evidence that the PSI photochemical quantum yield (ϕPSI) limits the conversion of CO_2 into biomass. The ϕPSI ratio is thus used as a diagnostic indicator for root temperature stress. At the optimal root temperature, ion flux-driven systemic signals spread through the leaf veins to trigger spatiotemporal systemic acquired acclimation (SAA), reversing the effects of cold stress. Pre-addition of 15 mM Ca^{2+} provides optimal calcium storage elasticity, translates into steady-state concentrations, and links with soil calcium bioavailability through glutamate receptor-like (GLR) ion channels. This process facilitates the ROS/Ca^{2+} waves, which provide a rapid priming basis for the induction of a complete SAA response. These results suggest that foliar calcium fertilizer should be supplemented in a timely manner to ensure optimal photosynthetic carbon fixation. Even a simple change in fertilization habits may subvert physiological processes, even reverse pathological damage.

Paper ID: 152

Increased regional environmental footprints for good and equitable development in China

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Abstract:

Achieving equitable human well-being within the biophysical boundaries is still challenging. In this study, we constructed a subnational safe and just framework to investigate past and future environmental footprints of human well-being development in China. Results show that while more socioeconomic thresholds have been achieved between 2007 and 2017, the environmental footprints supporting this progress increasingly transgressed the local boundaries. Eastern China regions achieved the most socioeconomic thresholds but also exceeded the boundaries for most environmental footprints. These footprints were largely (13.5-28.3%) virtually shifted to western and northern regions, aggravating the inequitable environmental and socioeconomic development across regions. We find that provinces or cities following the most sustainable development path in a greater region (e.g., Shanghai as a model for eastern China) could substantially reduce the environmental footprints of human well-being improvement. We conclude that while there is no uniform model for safe and just development for all regions, there are tailored pathways for regions sharing similar socioeconomic status.

Paper ID: 153

Evaluating local perceptions of sustainable utilisation of non-timber forest products and their potential to improve livelihoods in Ghana's forest fringe communities

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Abstract:

The sustainable utilisation of Non-Timber Forest Products (NTFPs) holds significant promise for livelihood improvement within forest fringe communities in Ghana. While local communities benefit from NTFPs, there is limited understanding of the locals' perceptions with regard to the potential of NTFPs to alleviate poverty. This research evaluated the intricate interplay of local perceptions with regard to climate change, value addition and the multiple uses of NTFPs, and their influence on livelihood improvement. The study employed a multidimensional approach, incorporating quantitative, qualitative and systematic review methodologies. Surveys and interviews were conducted to gather data on the perceptions of local communities of climate change, value addition to NTFPs and the multiple uses of NTFPs, as well as social factors that influence their perception. In addition, a systematic review using the PRISMA method was used to assess the potential of NTFPs to alleviate poverty. The findings underscored the significance of education, religion and gender, which are pivotal in shaping local perceptions of NTFPs and their potential to improve livelihoods. The systematic review showed the potential of NTFPs to alleviate poverty in Ghana and in other parts of the world. Initiatives that enhance market accessibility and create value-addition opportunities should be considered to uplift communities economically. Furthermore, policy frameworks and institutional support can emerge as essential elements in shaping local perceptions. In conclusion, this research elucidated the vital role of local perceptions for the sustainable utilisation of NTFPs to improve livelihoods within Ghana's forest fringe communities.

Paper ID: 154

Navigating wind turbine evolution, materials challenges, and end-of-life in the 2050 energy transition

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Abstract:

Wind energy is one of the most promising sources of clean, renewable energy, playing a crucial role in mitigating the negative impacts of climate change. The global transition to renewable energy is essential for the decarbonization of the planet, aligning with the Paris Agreement's objective to limit global warming to well below 2°C, ideally 1.5°C, compared to pre-industrial levels. However, the rapid global expansion of wind energy raises important concerns regarding the material requirements and associated environmental impacts. In this study, we conduct an in-depth analysis of the evolution of both onshore and offshore wind turbines, focusing on key factors such as capacity, rotor diameter, and hub height. This analysis helps us understand the effects of turbine size scaling over time and assess their material composition, uncovering the mineral requirements, environmental impacts, and estimating the decommissioning needs of wind turbines from 2000 to 2050. We also explore the necessary electrical grid infrastructure for integrating both onshore and offshore turbines into the grid. Our findings highlight a significant demand for metals, categorized into three risk levels: extreme risk (Dy, Tb, Nd, Pr, Nb, Mo, and Cu), high risk (steel and Ni), and medium-low risk (Al, Cr, B, and Pb). Material shortages may become a concern by the end of this decade. Moreover, extending turbine lifespans by 5-10 years could reduce material usage, energy consumption, water usage, and CO2 emissions by 8.8% to 16.2% compared to a standard 20-year lifespan. The results also indicate an exponential increase in end-of-life wind turbines, underscoring the urgent need for strategic planning, supportive policies, and effective management to address this critical issue promptly.

Paper ID: 155

Synergizing traditional and technological approaches for sustainable resource management: Enouncing food security through integrated watershed development in Ethiopia

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Abstract:

Food security, contingent on sustainable resource management, remains a pressing global challenge, with Ethiopia's central highlands disproportionately affected by natural resource degradation (NRD), climate change, and population pressures. This study examines the integration of traditional Watershed Development and Management (WDM) practices with emerging technologies to advance resource sustainability and food security in the Shanqur-Teraqo and Mendi-Tufessa watersheds. Employing a mixed-methods approach—literature review, participant observation, and case study analysis—the research identifies prevalent traditional WDM techniques, including soil bunds, agroforestry, and check dams, which foster ecological balance but rely on labor-intensive methods. While these practices promote localized sustainability, their efficacy is constrained by limited scalability and adaptability to escalating environmental stressors. Notably, emerging technologies such as precision agriculture, GIS, IoT, and AI—critical for optimizing resource use, predicting erosion, and enhancing data-driven decision-making—were absent in the study area. The findings underscore the transformative potential of harmonizing indigenous knowledge with technological innovations to achieve sustainable resource management. Such integration could mitigate NRD, improve water retention, and boost agricultural productivity while ensuring long-term ecological resilience. Recommendations emphasize pilot programs to evaluate the socio-economic and environmental impacts of combined strategies, alongside policy reforms and capacity-building initiatives to incentivize technology adoption among smallholders. By bridging traditional practices with cutting-edge tools, this synergy offers a scalable framework for balancing productivity with environmental stewardship, addressing immediate food security needs, and safeguarding natural resources for future generations. The study advocates for a holistic approach to watershed management, positioning resource sustainability as a cornerstone of climate resilience and equitable rural development in Ethiopia and analogous contexts globally.

Paper ID: 156

A framework for achieving optimal patterns of sustainable agricultural mechanization: integration of E-LCA, S-LCA, and MOLP

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Abstract:

The objective of this research is to develop a comprehensive and systematic framework to ascertain the optimal mechanization levels for paddy production systems in the Ramhormoz region, located in southwest Iran. This framework combines methodologies from environmental life cycle assessment (E-LCA), social life cycle assessment (S-LCA), and multi-objective linear programming (MOLP). Shannon's entropy method is utilized to give weights to the social indicators, while the social performance of diverse stakeholder groups in S-LCA was quantified through the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). For the assessment of environmental impacts within E-LCA, the ReCiPe 2016 Endpoint method was applied. The process of multi-objective optimization was conducted through linear programming models. Results from E-LCA underscored ecosystem quality, human health, and resources as the paramount impact categories. It was observed that Water-Seeded and No-Till systems had the minimum and maximum impacts respectively. From the perspective of S-LCA, the Dry-Seeded system was identified as having superior social performance, whereas the Unpuddled-Transplanted system was at the lower end of the spectrum among the paddy production systems examined. The Pareto optimal solutions highlighted stable mechanization patterns, predominantly involving the Water-Seeded and Dry-Seeded systems. A comparative analysis using the weighted sum method indicated that an increase of 20% in the weight of the environmental function necessitates focusing solely on Water-Seeded and Dry-Seeded systems, which would entail a 12% reduction in the paddy cultivation area relative to the current status. Furthermore, a sensitivity analysis of the extreme points pinpointed the drill seeder in the Dry-Seeded system as the most significant constraint. In conclusion, this research presents a comprehensive and robust framework that integrates both environmental and social aspects for sustainable agricultural mechanization. This framework provides critical insights and recommendations for policymakers and practitioners in the realm of sustainable agricultural practices.

Paper ID: 157

The regional and personal disparities of global renewable energy use from four perspectives

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Abstract:

Global climate change demands a rapid transition to renewable energy for sustainable development and carbon neutrality. However, existing frameworks often overlook the dynamics of renewable energy use across production, consumption, final production and income perspectives of the economy, thereby limiting understanding of global energy transitions. This study addresses this gap using a multi–regional input–output (MRIO) model to analyze renewable energy use globally from 2000 to 2021 through multiple perspectives. Our findings reveal significant disparities in renewable energy use across nations. The Unite States is the largest renewable energy user by four perspectives in 2021, e.g., the production– (5451701.9 tera–joules (TJ)), consumption– (6560930.8 TJ), final production– (6560930.8 TJ) and income–based (5759438.4 TJ) renewable energy use, while developing economies like China, India, and Brazil show rapid growth, particularly in income–based renewable energy use. Furthermore, resource–exporting nations, as primary suppliers for global renewable energy, promote renewable energy use, making a substantial contribution to the energy transition. Sectoral analysis highlights the significance of electricity, gas, and water industries in renewable energy use. This study provides a comprehensive framework for analyzing renewable energy use, offering valuable insights to policymakers to accelerate equitable and sustainable energy transitions. By bridging the gaps in understanding energy disparities, this study contributes to the discourse on global climate strategy and renewable energy policy development

Paper ID: 158

From past to future: mapping the trajectory of tire wear particles

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Abstract:

Tire wear particles (TWPs) are increasingly recognized as a significant source of microplastics, posing environmental and health risks due to their persistence and widespread distribution. Originating from tire-road friction, TWPs accumulate on road surfaces and subsequently dispersed through either airborne pathway to air, or non-airborne pathways like stormwater and road runoff, contaminating soil and water bodies. Understanding the intricate intersectoral flows of TWPs is crucial for developing effective mitigation strategies and conducting risk assessments. In this study, a dynamic probabilistic material flow analysis (DPMFA) coupled with Storm Water Management Model (SWMM) was established to track the movement and fates of TWPs in Hong Kong from 1980 to 2023. The modeling incorporated factors including tire rubber imports, consumption, exports, stocks, recycling, and delved deep into the generation, emission transportation, accumulation and fate of TWPs. Moreover, dynamic interactions between vehicles, pavement and TWPs during storm weather events were examined. The model also predicts and evaluates the impact of future tire rubber consumption and TWP emissions up to 2050, based on scenarios including baseline, enhanced drainage system management, and improved transportation policies. Preliminary results reveal the percentage of rubber emitted from tire wear and rubber granules, and release to the natural environment, alongside the efficiency of street cleaning and wastewater treatment in mitigating TWP release. By detailing the potential impact of targeted interventions tire-derived microplastics, this study highlights the critical need for robust policy frameworks that guide the management of TWPs and their associated environmental consequences.

Paper ID: 159

Human-centric disaster resilience: uncovering social inequity in climate change

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Abstract:

Climate change is intensifying the frequency and severity of extreme weather events, disproportionately affecting socially vulnerable populations. However, social inequities in disaster resilience remain underexplored. This study proposes a human-centric framework to assess community resilience, focusing on equitable availability of essential services during climate change-induced flooding. We combined flood hazard maps with demographic and socioeconomic data to measure significant spatial and social inequities in resilience among different sub-populations. We observed a stark polarization effect in community resilience: most communities experiencing either high or low levels of service availability, with few in the middle range. Our study also reveals that middle-income communities generally demonstrate higher resilience compared to both lower and higher income groups. These findings highlight the urgent need for equity-focused disaster resilience strategies to mitigate the exacerbation of social inequities driven by climate change. Our research offers valuable insights for policymakers seeking to enhance urban resilience and develop more inclusive and effective strategies that meet the needs of all social groups.

Paper ID: 160

Urban local renewable energy participatory planning mechanism and path

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Abstract:

Integrating locally sourced renewable energy with the retrofitting of existing communities presents a significant opportunity for green urban renewal. It offers a key pathway to optimize the integration of energy production and consumption, mitigate the urban heat island effect, and address climate change. However, in practice, there is a lack of mechanisms and pathways to incorporate public participation into local renewable energy planning and management, which is crucial for promoting efficient production, consumption, and operation of local energy systems.

This study, based on participatory theoretical approaches and drawing from case studies in Germany and the Netherlands, incorporates stakeholder collaboration networks into local renewable energy planning. It proposes a participatory planning approach centered around local policies and resources, driven in phases by guiding entities and subsidy policies to enhance cooperation and feedback among participants. A participatory planning pathway has been developed, including: (1) Analyzing local resources, policies, and economic conditions; (2) Identifying and classifying stakeholders; (3) Engaging stakeholders in phased planning processes; (4) Ensuring multi-party supervision, benefit and risk management, and feedback mechanisms. Urban planners are expected to play a key role in guiding the release of benefits from urban energy transitions.

Paper ID: 161

Evolution of public participating behavior in personal carbon accounts under the shock of emotions and values: considering individual information forgetting and diffusion in social network

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Abstract:

Personal carbon accounts (PCA) are an important tool for tapping the carbon emissions reduction potential of consumption side in China, but the public’s motivation to participate is generally low. Therefore, it is crucial to stimulate the public participation behavior in PCA and achieve the evolution from individual participation to group behavior. This study improves the traditional information dissemination model by introducing individual information forgetting and diffusion ability. And the interaction model of participation behavioral decision-making of PCA was constructed by combining static questionnaire data. Furthermore, the agent-based modeling was used to simulate the effects of emotions and perceived values on the evolution of group behavioral decision-making. The results show that: (1) Regarding the single emotion, the increase of influence coefficients of positive and negative emotions both can enhance the willingness to participate in PCA and the proportion of participants, but the promotion effect of negative emotions is more significant. (2) In terms of single value, economic and environmental incentives are more effective than achievement and hedonic incentives, which can boost the proportion of participants to more than 70%. With the increase of incentive intensity, the shorter the time for the proportion of participants to reach the equilibrium state, and the more stable the group decision-making state. (3) The combined effect of economic and environmental incentives can make the proportion of people participating in PCA exceed 80%, and the promotion effect is significantly better than that of a single incentive. However, the public’s sensitivity to economic incentive decreases with elevated negative emotions. These findings deepen the understanding of the evolving process of participation behavior in PCA and provide valuable references for the formulation of support policies.

Paper ID: 162

Uncertain value evaluation of Power to hydrogen project under diversified policy tools

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Abstract:

This paper employs the real option model to explore the power to hydrogen project investment decision issues under diversified policy tools by accounting for multiple uncertain factors. Specifically, using real option theory and first-order non-homogeneous value function (FONHVF) algorithm, we derive analytical solution for investment and environmental value under three incentive tools: government subsidy, CCER scheme and hybrid tool. A case study of the Kucha green hydrogen demonstration project evaluates the investment trigger conditions and uncertainty value under different policy tools, then performs sensitivity analysis on the key elements. Our study demonstrates that CM&S eases immediate investment requirement for lower electricity price and achieves higher investment value under varying electricity price drift rate and lower uncertainty of electricity price, but S plays vital roles in achieving higher investment value when facing higher uncertainty of electricity price. From perspective of government, S would be an effective way to achieve higher environmental value at every level of electricity price and uncertainty of electricity price. However, investment triggers value of electricity price and optimal stopping boundary for all incentives are inversely related to electricity price drift (volatility), subsidy intensity and CCER price.

Paper ID: 163

Cooperation strategy of Power-Hydrogen project deployment under Nash bargaining fairness concerns in option games

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Abstract:

We studied the issue of cooperative strategy selection for a low-carbon supply chain, composed of a hydrogen equipment company and a renewable energy generation company, both with fairness concerns and facing the uncertainty of market demand, to cooperative investment in the PTH project. We incorporated Nash bargaining fairness concerns into the real options game theory and designed two cooperation strategies: cost-sharing (CS) and supply chain finance (SCF), setting up four models based on the level of fairness concerns: CS, SCF, CSN and SCFN. Our research results show the following: Firstly, compared to the fairness-neutral SCF, the fairness-concerned SCF leads to later investment timing and higher green hydrogen prices due to investors' fairness concerns. However, compared to the fairness-neutral CS scenario, a fairness-concerned CS strategy with a reasonable profit-sharing ratio promotes faster deployment of the PTH project, lower green hydrogen prices and higher channel efficiency, which remains robust even compared to the SCF strategy. Secondly, HC, with higher fairness concern, tend to set higher equipment sales prices, resulting in later investment timing and higher green hydrogen prices, but RC’s greater focus on fairness leads to the opposite favorable outcomes. Thirdly, an increase in market demand uncertainty generally leads to unfavorable outcomes, but in the CSN scenario, considering market demand uncertainty, bargaining power, and fairness concern levels to determine an effective profit-sharing ratio yields favorable outcomes under high market demand uncertainty. Finally, when HC places more emphasis on fairness, the CS strategy is key to achieving higher channel efficiency and higher investment value for both HC and RC. However, when RC holds dominant position in the channel relationship and places more emphasis on fairness, SCF strategy becomes the key to achieving high investment value and channel efficiency.

Paper ID: 164

Public participation behavior in personal carbon accounts: the role of climate emotions

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Abstract:

Given the generally low rate of voluntary participation in Personal Carbon Accounts (PCA) in China, there is an urgent need to study the antecedents of public's participation behavior in PCA to contribute to carbon emissions reduction on the consumption side. Specifically, this study adopted the theory of interpersonal behavior (TIB) to construct a theoretical framework to explore the impact of climate emotions on public's participation behavior in PCA. Empirical tests were conducted with data collected from 807 questionnaires from residents in various Chinese areas. The results revealed the positive association of positive climate emotions with climate change perceptions (CCP) and public's participation willingness in PCA, as well as the positive association of CCP and participation willingness. However, the negative association of negative climate emotions was confirmed with CCP and participation willingness. In addition, CCP was the critical transmission mechanism by which two types of climate emotions can affect participation willingness. Finally, the analysis confirmed the moderating effect of individual low-carbon habits. The facilitating effects of positive climate emotions on participation willingness as well as participation willingness on participation behavior were stronger among individuals with high levels of low-carbon habits. In the practical field, it also provides implications on how to stimulate Chinese public to participate in PCA through climate emotions and perceptions.

Paper ID: 165

Green synthesis of bi-functional Fe@C nanoparticles from collagen bio-waste: a sustainable approach for energy storage and environmental remediation

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Abstract:

The sustainable synthesis of multifunctional materials from bio-waste is highly desirable for various industrial applications. In this work, we present a green synthesis route for bi-functional iron-encapsulated carbon (Fe@C) nanoparticles derived from collagen bio-waste, tailored for energy storage and environmental remediation. A simple high-temperature treatment converted the insulating, paramagnetic collagen-$FeCl_3$ scaffolds into highly conductive and ferromagnetic Fe@C nanoparticles. Structural and morphological analysis confirmed that Fe nanoparticles exist in multiple phases within a graphitized carbon matrix, forming core-shell nanostructures. The mesoporous Fe@C nanoparticles exhibited exceptional photocatalytic performance, achieving 100% degradation of methylene blue within 80 minutes under sunlight irradiation. Furthermore, the incorporation of Fe nanoparticles within the graphitic carbon framework enabled outstanding lithium-ion storage properties, delivering a high reversible specific capacity of ~384 mAh/g after 75 cycles. This study demonstrates a cost-effective, scalable, and sustainable approach for converting industrial bio-waste into high-performance nanomaterials for energy and environmental applications.

Paper ID: 167

Closing the carbon loop: How EU battery regulations reduce EV lifecycle emissions

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Abstract:

This abstract explores the role of the new EU battery regulations in reducing the overall carbon emissions associated with electric vehicle (EV) life cycles. The European Union’s regulatory framework—set to be fully implemented by 2025—integrates stringent environmental performance criteria at every stage of the battery’s life, from raw material sourcing and manufacturing to in-use performance and end-of-life recycling. Central to these rules is the mandate for reduced carbon footprints and increased recycled content, which compels battery manufacturers to adopt cleaner production methods and to optimize resource efficiency. A key mechanism introduced is the “battery passport,” a digital record that provides transparent data on battery chemistry, production energy sources, and recycled material percentages. This tool not only enhances traceability and accountability across the supply chain but also facilitates effective end-of-life management by ensuring batteries are properly collected, repurposed, or recycled. In doing so, the regulation encourages a circular economy model where valuable materials are continuously reintegrated into new battery production, significantly lowering the need for virgin resource extraction and reducing greenhouse gas emissions. Moreover, the framework includes rigorous due diligence policies to verify supplier claims and enforce compliance, thereby fostering innovation and competitiveness in sustainable battery technology. The combined effect of these measures is a substantial reduction in the life cycle carbon emissions of EVs, supporting the EU’s broader decarbonization goals while setting an international benchmark for environmental sustainability in the automotive sector. This paper discusses the operational principles of these regulations and examines their potential to transform the EV battery market, ultimately contributing to a greener, more sustainable transportation future.

Paper ID: 168

Green solvents for efficiently separate and recovery of polyethylene terephthalate (PET)

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Abstract:

Polyethylene terephthalate (PET) is a versatile, relatively low-cost thermoplastic and one of the most widely produced plastics, but its non-biodegradability and extensive use have led to significant accumulation and environmental risks. Traditional mechanical recycling results in an aesthetically and mechanically inferior product, making it difficult to compete with low-cost virgin material.

In this study, we employed a solvent-based recycling strategy for PET from mixed plastic waste stream based on an in-house developed “function-cost-sustainability” framework to design and screening biobased solvent for this purpose. The framework includes the application of Hansen Solubility Parameters (HSPs), Conductor-like Screening Model for Real Solvents (COSMO-RS), and techno-economic analysis (TEA) as well as life-cycle assessment (LCA)for economic feasibility and sustainability assessments.

Following this framework, we discovered a biobased solvent dimethyl isosorbide (DMI) with a favorable solubility (0.30 g mL-1) of PET in 8 min at 180 °C. The recycled PET was similar to those of virgin PET, with minimal degradation (< 2%) and negligible loss of thermal performance. By controlling the temperature, DMI can sequentially separate PET from PS, PE and PVC. In addition, we identified another green solvent Cyrene as an effective co-solvent for the alkaline hydrolysis of PET under relatively mild conditions, achieving nearly complete PET degradation into terephthalic acid (TPA) with a high yield (98.2%) within 10 minutes at 90 °C.

In summary, green solvent-based recycling can effectively reduce the consumption of non-renewable resources and offers a sustainable approach to the recycling and reuse of solid waste. This strategy enables the efficient recovery of PET waste with the advantages of high efficiency and scalability. Moreover, it demonstrates the potential for selectively recycling target polymers from mixed plastic waste, providing a sustainable solution for plastic waste management.

Paper ID: 169

Future shifts in environmental footprints of the global agricultural system

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Abstract:

This study quantifies future global environmental footprints of agriculture, focusing on greenhouse gas (GHG) emissions, land use, and water use across three Shared Socioeconomic Pathways (SSPs 1, 2, and 3). Using the IMAGE-MAGNET model, agricultural footprints are calculated for 28 global regions via an environmentally extended multi-regional input-output (EE-MRIO) model. Projections extend to 2025, 2035, and 2050, with a baseline year of 2017.

In 2017, primary agricultural sectors were responsible for 16% of global GHG emissions, while consumption-based emissions of these sectors contributed 6%. Under SSP1, agricultural consumption-based emissions increase by 8% in 2025, then decline by 2% in 2035 and 2050. In contrast SSP2 shows continuous increases of 9%, 12% and 16%, while SSP3 exhibits larger growth rates of 9%, 15% and 19%. Regionally, China is the largest driver of agricultural GHGs in 2017 and 2025, followed by India. By 2035 and 2050, particularly in SSPs 2 and 3, East and West Africa are seen to emerge as dominant drivers. These shifts highlight sub-Saharan Africa's growing role in future emissions.

Consumption-based emissions from primary agricultural sectors are relatively low, whereas consumption of processed food, meat, dairy, and vegetable oils drives 20-30% of global GHG emissions. When only these latter "agri-related" sectors are considered, China, the USA, and Western Europe are the largest contributors, followed by India, the Middle East, Southeast Asia, Brazil, and South America. The study explores how demand for specific agri-related commodities drives emissions across agricultural sectors.

Similarly, the analysis covers global land and water use linking agricultural and agri-related sectors, offering a comprehensive view of future agricultural impacts. The study concludes with policy recommendations for each SSP scenario, emphasizing regions and sectors where demand-side interventions are key to mitigating global agricultural impacts.

Paper ID: 170

Evaluation of Urban Park Green Space Accessibility and Layout Optimization in the Context of an Aging Population

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Abstract:

With the accelerating aging of the Chinese population, ensuring that the elderly have equitable access to park green space resources is of vital importance for improving their quality of life. Taking Mudan District, Heze City as an example, this study analyzes the spatial accessibility of parks in the context of aging and puts forward layout optimization strategies.

Based on mobile phone signaling data, the age - shift algorithm is used to predict the distribution of the elderly population. The Gaussian two - step floating catchment area method is employed to evaluate park accessibility.

The results show that approximately 9.8% of the elderly population live in areas with zero accessibility, and 23.7% live in low - accessibility areas, indicating a spatial imbalance in the supply - demand ratio between the park system and the elderly population.

To address these issues, a systematic optimization strategy is constructed. Firstly, the location - allocation model is applied to optimize the park layout with the goal of minimizing travel and construction costs. Secondly, in areas with insufficient park land, linear parks are built along both sides of roads, and the entrances and exits of existing comprehensive parks are optimized and upgraded. Thirdly, taking the opportunity of urban renewal, marginal spaces are explored for the construction of park green spaces. Fourthly, pedestrian infrastructure is improved to create an elderly - friendly walking environment.

After optimization, the park service coverage rate has increased significantly. Notably, 87% of the elderly population can reach nearby parks within a 15 - minute walk. This study not only provides a better leisure environment for the elderly in Mudan District but also offers practical examples and theoretical references for other cities facing similar problems.

Paper ID: 171

Navigating sustainability: how economic and environmental policies shape rare earth mine supply and climate risk mitigation

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Abstract:

Recently rare earth elements (REEs) have gained significant attention given their instrumental role in green energy technologies. Despite the growing scholarly focus, there has been limited exploration of how specific economic and environmental policies—such as economic and climate policies uncertainty, climate physical risk, clean energy patents, investment in clean energy, research and development expenditures, and natural resource depletion—affect REE mine production, both in the short and long term. We combined a dynamic panel ARDL-ECM-based Pooled Mean Group (PMG) approach with Temporal Causal Modelling (TCM) and ARIMA model. The outcomes reveal that a 1% increase in economic uncertainty and clean energy patents is associated with a 0.09% and 0.40% increase in REE production, respectively. A 1-unit increase in long-term R&D, climate uncertainty, and climate risk results in 8.54 and 1.29 units increase, and a 0.31 reduction in REM production, respectively. The outcomes of TCM reveal that reciprocal causations between clean energy patents, economic and climate policies, R&D expenditures, and climate risks will significantly increase global REE production, reaching nearly 1200 kilotons by 2050 (242% surge). Implementation of regional ARIMA models further validates the projections, revealing that China will continue to be the largest contributor to this increase (almost 450 kilotons), followed by Myanmar (55 kilotons) and Australia (18 kilotons). This is driven by growth in clean energy patents (200% increase), economic and climate policies uncertainty, and R&D (almost 25% of GDP). This growth coincides with a reduction in climate physical risks by 300%. These findings imply that mining REE and economic and environmental policy frameworks are inherently interconnected and thereby cannot be addressed in isolation. Thus, we advocate for a balanced, strategic approach to managing critical resources—one that fosters green-tech innovation, ensures economic and environmental policy stability, and mitigates climate risks—to support a sustainable global economy.

Paper ID: 172

Techno-economic analysis (TEA) and life cycle assessment (LCA) of a commercialized 2500 ton/d scale sludge-to-energy utility in a textile industrial park

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Abstract:

This study developed a TEA-LCA model based on real-time and high-resolution operation data of a large-scale sludge-to-energy utility in a textile industrial park in China. Based on a 2500 t/d sludge incineration project in a dyeing and printing industrial park in East China, this study established a chlorine, material, and energy flow analysis model targeting minimal process units to reveal the flow processes quantitatively. We evaluated environmental and economic benefits through TEA and LCA bases. The results showed that: 1) The chlorine content of the sludge fed into the incinerator was 1.4 to 2.4 mg/kcal and the initial hydrogen chloride concentrations in the flue gas were 170 to 250 mg/Nm3, which were 14.6 and 2-5 times that of coal-fired thermal power plants, respectively. 2) The energy utilization efficiency of the case study's printing and dyeing sludge drying, and incineration reaches 78.1%. Compared to sludge landfills, this process can reduce greenhouse gas emissions by 647 kgCO2eq per ton of dry sludge from a full life cycle perspective. 3) When the coal blending ratio is controlled below 20% of the received base mass ratio, printing and dyeing sludge incineration can produce good economic and environmental benefits. 4) Increasing the ratio of co-generated steam and electricity from 50% to 100% resulted in a 22.0% improvement in economic benefits and an average carbon emission increase by approximately 8.0%. 5) Increasing the moisture content of sludge before incineration shifts the Pareto frontier towards improved economic performance while reducing carbon emissions. The study demonstrates that utilizing drying and incineration coupled heat and power production methods for printing and dyeing sludge has beneficial economic advantages and can reduce pollution and carbon emissions.

Paper ID: 173

Exploring the circular economy future of lithium-ion batteries in Australia

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Abstract:

Despite being a major raw material supplier in the global battery supply chain, Australia faces significant challenges in managing end-of-life (EoL) lithium-ion batteries (LIBs). While interest in promoting a circular economy of LIBs in Australia is growing, there remains a lack of quantitative analysis to support policymaking and industrial actions. This paper firstly quantifies the future LIB demand, EoL arisings, battery repurposing, and material recycling potential across eight Australian jurisdictions. This is achieved by developing a comprehensive material flow analysis model that covers 20 types of LIB-containing applications, considering different climate scenarios, battery lifespan, and battery chemistry mix assumptions. EoL LIB waste is projected to reach 54-108 kilo tons (kt) by 2035, marking a 5-10 times increase between 2022 and 2035, with three-quarters concentrated in three eastern states. Passenger cars account for two-thirds of the total LIB waste, with the remaining one-third originating from other applications. The repurposing potential for EoL electric vehicle batteries is sufficient to eliminate the need for new battery imports to meet the demand for battery energy storage systems as early as 2040. Material recycling potential for EoL LIBs by 2050 is projected to reach 10-16 kt for Li, 31-63 kt for Ni, 7-13 kt for Co, 6-12kt for Mn, 84-121 kt for Cu, and 74-114 kt for Al. Between 2025 and 2050, cumulative material recycling potential for six metals from EoL LIBs would reach 1,616-2,842 kt, with an estimated economic value of 18-33 billion USD. These findings underscore the urgent need to enhance LIB collection systems and develop onshore repurposing and recycling capabilities to advance a circular economy for LIBs in Australia, with broader sustainability implications for other countries facing similar challenges.

Paper ID: 174

Sustainable plastic management in microbial protein production

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Abstract:

The recycling and sustainable management of plastic waste represent a critical challenge in global environmental governance. As the world's largest producer of edible fungi, China annually produces over 40 million tons of edible fungi, concurrently generating approximately 1.2 million tons of agricultural plastic waste, with mushroom bags composed primarily of polypropylene (PP) and polyethylene (PE) accounting for 83% of the total. Due to high contamination rates and limited sorting technologies, landfilling (62%) and open burning (28%) remain the predominant disposal methods, leading to secondary environmental risks such as microplastic leakage and dioxin emissions.This study employs a coupled Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) model to evaluate four treatment pathways: mechanical recycling, chemical depolymerization, open burning, and landfilling. The results indicate that mechanical recycling reduces environmental impact indicators by 49% and 33% compared to landfilling and open burning, respectively, with a global warming potential (GWP) of 0.82 kg CO_2-eq/kg plastic and a net present value (NPV) 25% higher than that of chemical recycling.Based on an ARIMA time series model (R^2=0.963) fitted to China's edible fungi production data from 1978 to 2024, it is projected that by 2030, the widespread adoption of mechanical recycling systems could achieve an annual reduction of 1.7×10^6 tons of CO_2 equivalent, equivalent to 12.4% of China's agricultural sector carbon reduction target for 2025. This study pioneers a multidimensional evaluation framework for edible fungi plastic waste, providing evidence-based decision-making support for the closed-loop management of agricultural plastics in developing countries.

Paper ID: 175

Green hydrometallurgical recoveryof silver from waste photovoltaic cells using α-amino acids: Mechanism study and process development

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Abstract:

Driven by the goal of carbon neutrality and the global trend of energy transition, the photovoltaic (PV) power generation has played a crucial role in energy structure and its deployment has been accelerating rapidly. Crystalline silicon (c-Si) PV cells represent 85–90% of the current PV market and intensively consume silver as an electrode. When the c-Si PV cells become end-of-life, their recycling value is dominated by silver at a grade of more than 300g/t which is considerably higher than the grade in most virgin silver ores. Due to pressures from resource depletion and environmental pollution, there is an urgent need to develop efficient and environmentally friendly method for silver extraction from the waste c-Si PV cells. The present study investigates the hydrometallurgical extraction of silver using green and non-toxic lixiviant of α-amino acids, and studies the mechanism behind the silver leaching and optimise the leaching conditions. The results indicate that under alkaline conditions, the chelation ability of the bidentate ligands glycine and valine is significantly weaker compared to amino acids with additional donor atoms (O, N) in their side chains, such as glutamic acid, histidine, and serine, leading to lower extraction. The leaching parameters of amino acid concentration, temperature, initial pH, and oxidant dosage were found crucial to enhancing the silver leaching efficiency. Leaching mechanism and product analyses indicate that Ag^+ predominantly coordinated with $-COO^-$ and $-N-H$ groups to form stable chelated ring complexes. Finally, histidine and glutamic acid were identified as more promising silver lixiviants due to their superior leaching performance, and the leaching of PV cells was optimised to obtain the best leaching results.

Paper ID: 176

AI-enabled circular economy approaches for green hydrogen: Advancing clean energy transitions and sustainability

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Abstract:

The transition to green hydrogen (GH) is a cornerstone of decarbonising global energy systems and achieving climate neutrality. However, upscaling GH production presents critical challenges in sustainability, including resource efficiency, life cycle impacts, and socio-economic trade-offs. This study employs a multi-disciplinary systems approach, integrating Life Cycle Assessment (LCA), Circular Economy (CE) strategies, and Artificial Intelligence (AI)-enabled optimisation to assess and enhance the sustainability of GH supply chains.

First, we apply LCA to quantify the environmental footprint of GH production across different electrolyser technologies—Proton Exchange Membrane (PEM) and Alkaline Water Electrolysis (AWE)—within the Australian context. Our findings highlight that material inputs, particularly critical minerals like iridium and platinum, significantly influence the carbon and water footprints. Advanced recycling strategies can mitigate environmental burdens, supporting circular economy principles.

Second, we explore CE-driven pathways for resource efficiency, emphasising material recovery, energy cascading, and closed-loop electrolyser manufacturing. By integrating Material Flow Analysis (MFA) and system dynamics modeling, we identify leverage points to minimise waste generation and optimise resource flows.

Third, we leverage AI-based predictive modeling to optimise GH production, storage, and distribution while considering techno-economic and socio-environmental trade-offs. The study underscores the role of digital twinning, smart data analytics, and machine learning in enhancing decision-making for GH infrastructure planning.

Our results reveal that AI-assisted CE approaches can reduce GH production costs by up to 30%, lower emissions by 40% compared to conventional hydrogen, and improve lifecycle efficiency. This research offers actionable insights for policymakers, industry stakeholders, and researchers, advocating for policy incentives, regulatory frameworks, and cross-sectoral collaborations to accelerate GH deployment.

By aligning AI, CE, and LCA methodologies, this study contributes to clean energy transitions, circular economy strategies, and climate resilience, advancing sustainable hydrogen economies worldwide.

Paper ID: 177

A systems-thinking approach to marine plastic waste: Advancing circular economy and life cycle strategies for sustainable waste management

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Abstract:

Marine plastic pollution presents an escalating global crisis, particularly in archipelagic nations like Indonesia, where plastic waste leakage into the ocean threatens biodiversity, public health, and economic sustainability. Addressing this challenge requires a systemic, interdisciplinary approach, integrating Life Cycle Assessment (LCA), Circular Economy (CE) frameworks, and Sustainable Waste Management (SWM) strategies to mitigate environmental impacts.

This study employs causal loop diagrams (CLDs) and systems thinking to visualise the complex interactions between land- and sea-based plastic waste sources. The analysis reveals that riverine transport of mismanaged plastic waste is the dominant contributor to marine pollution, exacerbated by weak waste management infrastructure, Extended Producer Responsibility (EPR) gaps, and socio-economic barriers. Using an LCA-based perspective, we assess the environmental footprint of plastic leakage, examining critical intervention points across the waste lifecycle to inform circular economy solutions.

Our findings highlight that EPR implementation, waste valorisation, and circular design strategies are key enablers for transitioning from a linear to a circular plastics economy. Policy-driven interventions, such as plastic taxation, advanced recycling technologies, and closed-loop supply chains, demonstrate potential for reducing marine plastic pollution by up to 70% by 2025, in alignment with Indonesia's Presidential Regulation No. 83/2018 on Marine Waste Management. Furthermore, digital modeling tools and AI-driven waste tracking systems can enhance waste reduction strategies by optimising collection, processing, and recycling efforts.

By integrating LCA, CE, and SWM methodologies, this research provides practical insights for policymakers, industry leaders, and sustainability practitioners. A holistic, data-driven approach to plastic waste governance can drive transformative change, ensuring a sustainable, resilient waste management system that safeguards marine ecosystems and supports global climate change mitigation efforts.

Paper ID: 178

Selling green electricity to SMEs of China: exploring main concerns and potential strategies

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Abstract:

In 2024, China began to promote electricity retailing market, which will enable small and medium enterprises (SMEs) to participate in green power trading through green power retailing, which is previously only available to large-scale power consumers, and will help to share the costs of the power system's cleaner transition. However, in recent years, most of the studies on green power purchase intentions have focused on residential green power products, and there are fewer studies exploring the purchase intentions of companies, so how to assess the green power purchase intentions of SMEs and propose promotional strategies has become an urgent issue. Therefore, this study obtains the calculation model of SMEs' willingness to purchase green power through research and data analysis, and provides strategic suggestions for promoting green power selling from the perspective of power retailers and the government through simulation. First, potential factors affecting SMEs' willingness to purchase green power are selected by literature review. Second, calculation model of SMEs' willingness to purchase green power is obtained through questionnaire survey (sample size=1000), Lasso regression and machine learning. Four types of typical SMEs' power user groups were obtained through K-means clustering, and finally the purchase willingness of each type of group was calculated. Then, an agent-based model is constructed based by Anylogic and three types of agents are set up, i.e. the government, power retailer and power user. Data from Guangdong power markets in 2024 and typical user groups are selected and the calculation model obtained by machine learning is set as the dynamical purchase intention function of power users. Price discounts, mandatory regulation, incentives, public promotion and other measures can be selected as promotional actions by power retailer and the government. Finally, strategy implications to promote the purchase of green power retailing products by SMEs are presented.

Paper ID: 179

The impact of technological advancement, renewable rsources and energy on per capita CO2 emission: A panel data analysis

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Abstract:

The deadline for achieving sustainable development goals (SDGs) is approaching. The per capita CO2 emission, excluding land use, land use changes and forestry, is an important indicator of ambient air quality that can be used as a proxy of environmental quality and is critical to climate change (SDG13). In this background, the share of renewable energy as a percentage of total energy consumption can be taken as a direct representative of affordable and clean energy (SDG7). Access to renewable resources might be represented through access to renewable water sources and forest areas as a percentage of a country's total area. The technological advancement over the years cannot be ignored and might be represented by access to electricity, clean fuel, mobile, broadband, telephone, and internet users, all measured in percentage. Moreover, we live in a globalized world where free trade is revered, and capital and labour are mobile. The level of globalization might be represented through international trade, net inflow and outflow of foreign direct investment. In this background, the present paper considers the per capita CO2 emission as the dependent variable and develops renewable resources, technological development, and globalization index using principal component analysis. It uses all three indexes and renewable energy as a percentage of total energy consumption as regressors. Finally, it indulges in a panel data analysis considering 107 countries of the world from 2010 to 2020. The outcome reflects that renewable energy as a percentage of total energy consumption and renewable resource index leads to the decline of per capita CO2 emission in a statistically significant way. Technological advancement/modernization, on the other, increases the per capita emission of CO2, and that is statistically significant. Lastly, the impact of the level of globalization is statistically insignificant. The paper ends with valuable policy-level suggestions based on the findings.

Paper ID: 180

Skipping protein feeding for Oreochromis niloticus culture in the Bangladesh: growth and cost analyses

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Abstract:

The fish farming sector is experiencing remarkable growth, and its economic success depends mostly on an efficient production strategy and cost management, which are essential to ensure the sustainability and profitability in this sector. The main goal of this research was to analyze the production costs and growth performance of Oreochromis niloticus through alternate feeding schedule. Supplementary feeds (14% and 28% crude protein) were provided either daily (control) or on alternate days (experimental) at a given percentage of body weight, ranging from 10% initially to 5% at the end of the study. Growth, production, expense and income were considered under the two strategies. Despite the cost of feeds was cut in half by the trial feeding treatment, feeding on alternate days did not reduce Nile tilapia growth or production performance variables, and yields were not significantly different. The earnings were higher in alternate-day feeding strategy than the control strategy and a trend choosing larger fish among the controls was not significant. Although feed conversion ratios varied considerably among the experimented farms, the improved efficiency in the experimental groups was consistently observed and was statistically significant. It is concluded that the production and economic return of Nile Tilapia culture through alternate feeding schedule was very encouraging.

Paper ID: 181

Directeur

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Abstract:

Bonjour je suis le directeur de entrepise ziza automobil , je voudrais assister a votre mangifique journe pour ameliorer votre connaissance international

Paper ID: 182

Manufacturer trade-ins and the endowment effect: Profitability and environmental impact

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Abstract:

Trade-in programs have long been used to manage frictions in customer-to-customer transactions of used goods, which can otherwise hinder manufacturers' ability to sell new products. While trade-ins promote product reuse, they may also increase total production and resource consumption. We examine the endowment effect as a behavioural friction in secondary markets that reduces owners' willingness to sell their used products. By developing a behavioural model that accounts for the endowment effect, we analyse how manufacturers can strategically design trade-in programs to influence secondary market dynamics. Our findings reveal that, in the stationary equilibrium of the game between manufacturers and customers, the endowment effect enhances manufacturer profitability by granting greater control over the secondary market and enabling reverse price discrimination. Crucially, we show that trade-ins, when designed to manage the endowment effect, do not necessarily increase total production. By identifying conditions where trade-ins simultaneously boost profitability and limit total production, we challenge the assumption that alleviating the endowment effect, such as through non-ownership business models, is always beneficial for manufacturer profits and environmental impact.

Paper ID: 183

Spatio-temporal patterns and mitigation strategies of agricultural organic waste-related greenhouse gas emissions in China

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Abstract:

Global warming calls for immediate action on greenhouse gas emission reduction. As a large agricultural country, China generates massive agricultural waste, leading to high emissions yet holding great potential for cutting them. Understanding waste treatment carbon emissions is vital for formulating effective strategies.

This study investigates the spatio-temporal patterns, treatment pathways, and GHG contributions of agricultural organic waste (i.e. crop residues and livestock manure) across China, aiming to identify region - specific mitigation strategies. By integrating Material Flow Analysis (MFA), life cycle assessment (LCA), and carbon accounting models. Data from literature reviews, field surveys, and regional statistical yearbooks (2013–2022). The system boundary covers organic waste treatment processes—including composting, anaerobic digestion, and direct disposal—as well as substitution effects of organic fertilizers on synthetic inputs.

The findings reveal distinct regional differences in waste management. Provinces with intensive livestock farming, such as Sichuan, Inner Mongolia, and Shandong, are confronted with environmental risks due to the improper handling of livestock manure. On the other hand, areas with high crop residue production, like Heilongjiang, Henan, and Hebei, grapple with issues like open burning, which is not only an inefficient disposal method but also a major source of pollution.

Through scenario - based evaluations, we demonstrated the potential of MFA - LCA - guided strategies for emission reduction. These strategies, such as region - specific anaerobic digestion - compost systems, can reduce direct emissions from untreated waste and indirect emissions by substituting synthetic fertilizers with organic ones. This research underscores the necessity of implementing province - specific policies. These policies can enhance the conversion of waste into resources, align with national carbon neutrality goals, and contribute to the global drive towards low - carbon agroecosystems.

Paper ID: 184

Leveraging 4th industrial revolution technologies for market intelligence and contractor development: opportunities and challenges

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Abstract:

The Fourth Industrial Revolution (4IR) fundamentally transforms market intelligence and contractor development by leveraging advanced digital technologies. Key innovations such as artificial intelligence (AI), big data analytics, and the Internet of Things (IoT) lead this transformation, enabling businesses to make more informed decisions, enhance competitiveness, and improve operational efficiency within the contracting sector. This study aims to achieve three objectives: (1) analyse the impact of 4IR technologies on market intelligence, (2) assess their role in contractor skill development and business sustainability, and (3) propose strategies for effective adoption. To meet these objectives, the research employs a mixed-methods approach that combines a comprehensive literature review with expert interviews. This multifaceted approach allows for a thorough evaluation of current industry trends and practices, offering valuable insights into contractor development in the era of 4IR. The findings reveal that integrating 4IR-driven market intelligence significantly enhances forecasting capabilities and strengthens risk management processes. However, the study also identifies key challenges that hinder broader adoption, including significant implementation costs and a widespread digital skills gap within the workforce. To address these challenges, the study offers several recommendations to facilitate a smoother transition to 4IR technologies. It advocates for increased investment in digital training programs to equip contractors and their teams with essential skills. Furthermore, the research emphasizes the need for supportive policies that encourage technology adoption and foster collaboration among industry stakeholders—such as contractors, technologists, and policymakers—to drive innovation and promote sustainable contractor development.

Paper ID: 185

The impact of government regulation on the quality of solid waste information disclosure in heavily polluting enterprises

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Abstract:

Solid waste pollution is a global problem, one of the keys to solve this problem is to improve the quality of environmental information disclosure in heavy polluting enterprises. In 2019, China began to build Zero Waste City, mainly to solve the problem of solid waste pollution, and construction of the second batch of cities began in 2022. This study takes two batches of Zero Waste City Construction (ZWCC) as a quasi-natural experiment and constructs a difference-in-differences model to explore the impact of government regulation on the quality of solid waste environmental information disclosure in heavily polluting enterprises. The study finds that ZWCC can significantly improve the quality of environmental information disclosure for solid waste from heavily polluting enterprises, and this result has not changed after a series of robustness tests. The mechanism tests find that the positive impact of ZWCC is to improve the enterprise's environmental protection system and environmental information reporting, reduce inefficient investment and increase research and development (R&D) investment. Heterogeneity analysis find that the positive impact of ZWCC is stronger for enterprises with higher media and investor attention and for larger scale enterprises. The study also finds that ZWCC can further reduce the degree of financing constraints and supply chain concentration of enterprises after improving the quality of solid waste information disclosure. The study provides evidence that ZWCC is effective and provides policy recommendations for further addressing the problem of solid waste pollution.

Paper ID: 186

Casting of High-Performance Multicomponent Superalloys from Nickel-Based Metal Scraps Enriched with Electronic-Waste

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Abstract:

The rapid obsolescence of electronic devices has led to an exponential increase in e-waste generation, creating a significant environmental concern. However, e-waste also represents a valuable source of secondary resources, containing substantial quantities of metals. Recycling electronic waste (e-waste) has gained significant attention as a sustainable solution to recover valuable materials while mitigating environmental pollution. This study aims to examine the casting of multicomponent superalloys from foundry returns alloyed with e-waste. Six different alloy compositions categorized into two groups (three high in NiCrMo phase and three high in NiMo phase) were cast via mould method and investigated. Two reference samples from each category free of e-waste were utilized as standards for comparison purposes. SEM-EDS, optical microscopy, XRD, XRF, and hardness tests were used for assessment. The findings show that the addition of e-waste profoundly alters the microstructures, resulting in the formation of Cu-Sn and Ni-Sn intermetallic phases and Pb-rich inclusions, which are mostly found in interdendritic areas, phase segregation, and the creation of Cu-rich boundaries. The trend is that the precipitates are greater in the 6% e-waste alloyed samples than in the 3% e-waste alloyed samples. Hardness results showed that alloys alloyed with Cu-Sn-Pb e-waste had a substantial decline in hardness, with the highest value of 323.6±16 Hv. According to the obtained results, high-performance alloy manufacturing has the potential for sustainable recycling solutions as long as impurity-induced problems are managed by optimal processing techniques.

Paper ID: 188

China's biodiversity loss driven by consumption at the city level

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Abstract:

Biodiversity is threatened by direct land use and ultimately driven by human consumption. However, few studies focus on the biodiversity loss embodied in human consumption at the city level. In this study, we integrated a Chinese multiregional input-output (MRIO) table consisting of 313 regions (309 cities and 4 provinces) and 42 socioeconomic sectors with the latest characterization factors of biodiversity loss affected by land use, considering land use intensities and land fragmentation to assess consumption-based biodiversity loss at Chinese city-level. We found that per-capita and per-expenditure biodiversity loss is higher in the southwest region which is rich in biodiversity and low-density population with lower per-capita expenditure. From the economic sectors, we can see biodiversity loss was mainly driven by agri-food sector and mainly driven by pasture use in high-quality wilderness areas. However, housing, services, manufacturing, and clothing all largely contributed to biodiversity loss in low-quality wilderness areas. In addition, the biodiversity loss driven by cropland and forest accounts for a larger share compared to high-quality wilderness areas. In addition, low-quality wilderness areas had higher proportional imported biodiversity loss since these regions are highly developed densely populated areas with higher urbanization rates. We hope our comprehensive assessment can guide biodiversity conservation and sustainable consumption at the city level in China.

Paper ID: 189

Strength and sustainability aspects of blast furnace slag-silicomanganese fume-based cement mortars

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Abstract:

The increasing demand for construction materials has intensified concerns regarding resource depletion, energy-intensive processes, solid waste generation, and carbon emissions. In response, concrete technologists have explored alternative materials to develop sustainable and high-performance mixtures. This study investigates the partial replacement of ordinary Portland cement (PC) with two locally available industrial by-products, blast furnace slag (BFS) and silicomanganese fume (SMF), in mortar design using response surface methodology (RSM). Twenty-five mixtures were prepared by varying BFS (0–50%), SMF (0–20%), fine aggregate (FA)/binder (b) ratio (1.5–2.5), and water (w)/b ratio (0.35–0.45). The results showed that the 28-day compressive strength ranged from 8.5 MPa to 61.7 MPa. Optimization yielded a predictive model with a high coefficient of determination (R2 = 0.96) and favorable sustainability characteristics. The optimal mixture consisted of 33% PC, 50% BFS, 17% SMF, an FA/b ratio of 2, and a w/b ratio of 0.35, demonstrating superior eco-strength efficiency based on life-cycle assessment and mechanical performance. SWOT analysis identified strengths and opportunities, though some weaknesses and threats associated with blended materials require further assessment. The findings support efforts to enhance sustainability in concrete production, aligning with the UN Sustainable Development Goals (SDGs).

Paper ID: 190

Development and Characterization of bio-compatible Mg-0.5Ca-x(x = 0.6, 0.9 and 1.2)Mn Alloys Suitable for Orthopedic Implants

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Abstract:

Magnesium alloys have good strength to weight ratio, high fracture toughness, low modulus of elasticity, low density, bio-compatible, biodegradable and osteoconductive properties which made them potential material used for orthopedic and cardiovascular surgery implants. This study focuses on the development and characterization of magnesium-based alloys containing magnesium, calcium and manganese. Rectangular billets with x% of Mn (x= 0, 0.6, 0.9, and 1.2 wt%) were cast in steel mold at temperature 720 oC using vacuum furnace, the produced alloys were machined using lathe to cylindrical billets of 18 mm diameter. By the use of electric shaft furnace, homogenization heat treatment was carried out at the temperature of 380 0C for 8 hour and quenched in cold water. After, the solution-treated (T4) samples were machined to 16 mm diameter, then hot rotary swaging process was carried out. The morphology of the magnesium grains and the phase composition of the produced alloys were performed with an Optical microscope, while the mechanical tests and corrosion behavior of the alloys were determined. Optical microscopy showed the arrangement of Mg2Ca eutectic compound at the grain boundaries of α-Mg and Mn which dissolved in the solid solution of the produced alloys. Mechanical test results showed that the hardness value of the alloys increased with increase in Mn addition and Mg-0.5Ca-0.9Mn alloy recorded the highest value of 13.72±0.7Hv. The compressive strength of Mg-0.5Ca-1.2Mn alloy demonstrated the highest UCS (ultimate compressive strength) of 206.13±10 N/mm2 and others were within the range of compressive strength of human bones (100 to 230 MPa). The corrosion rates of the alloys were observed to decrease with the addition of Mn, the least corrosion rate (5241 mpy) is recorded by alloy with 1.2Mn wt%. The findings may be helpful for the researchers in improving clinical biomedical applications.

Paper ID: 193

Resource constraints of energy transition: analysis of platinum demand in the hydrogen energy industry

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Abstract:

Hydrogen energy has become an important strategic choice for the global energy transition, and more than 30 countries, including China, have issued roadmaps for its development. As a key catalyst for proton exchange membrane electrolyzers and fuel cells, the demand for platinum rises with the development of the hydrogen energy industry. Considering that China, as the world's largest platinum consumer, has only 0.12% of the global reserves of platinum resources, the risk of contradiction between supply and demand cannot be ignored. Therefore, it is necessary to measure the platinum demand for the development of the hydrogen energy industry under the push of energy transition. In this study, we first analyze the characteristics of platinum flows driven by China's hydrogen energy industry by using the dynamic material flow analysis method. Platinum inventory and scrap volume for the hydrogen energy industry were then estimated based on the scale of the hydrogen energy industry under the carbon neutral scenario and the technological development of the future under three different scenarios. The study found that the total amount of platinum entering the hydrogen energy industry in 2018—2022 is 1 634.185 kg, the platinum entering the use stage is 1 676.31 kg, of which the platinum still in use is 1 563 kg, the platinum entering the waste management stage is 86.11 kg, and the total loss of platinum is 77.105 kg. The platinum inventory driven by the hydrogen energy industry under the carbon-neutral scenario in 2050 is 1 614.40 t, 802.19 t and 357.60 t under the baseline, conservative and aggressive technology scenarios, respectively, and platinum scrapping is 58.16 t, 24.41 t and 9.92 t. It is expected that platinum recycling for China's hydrogen energy industry can alleviate platinum import pressures in the future.

Paper ID: 194

Enhancing concrete sustainability: evaluating pyrolysed coffee biochar for concrete applications and field performance

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Abstract:

The accumulation of organic waste in landfills contributes significantly to environmental challenges, particularly through methane emissions. Spent coffee grounds (SCG) constitute a notable fraction of this waste, necessitating innovative recycling strategies. One promising avenue is their incorporation into concrete as a sustainable material alternative. However, due to the high organic content of raw SCG, direct use in structural applications is impractical. This study explores the thermal conversion of SCG into biochar via pyrolysis to assess its impact on concrete properties. Pyrolysed SCG, produced at different temperatures, was incorporated as a partial replacement for fine aggregates in concrete mixtures at varying substitution levels. The modified concrete's mechanical and microstructural characteristics were evaluated using advanced analytical techniques, including compressive strength testing, microscopic imaging, and chemical composition analysis. Results indicated that pyrolysis altered the physicochemical attributes of SCG, enhancing its compatibility with cementitious systems. Specifically, biochar produced at 350 oC significantly improved the strength of concrete by about 30% while reducing its environmental footprint. This research underscores the potential of converting organic waste into functional materials for sustainable construction. Further exploration into large-scale production and field performance was necessary to bridge the gap between laboratory findings and real-world applications. Therefore, a world-first field trial on coffee biochar concrete was conducted to evaluate its performance under real construction and environmental conditions.

Paper ID: 195

Moral persuasion and normative regulation: How transgenerational education affects green consumption behavior across different power distance orientations

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Abstract:

The upward intergenerational transmission of green concepts from children to parents can help promote the transition to green consumption behavior. This process can alter consumer perceptions and behavioral orientation, but it hinges on the pre-existing attitudes towards power distance of parents. It is thus of practical significance to explore the pathways through which environmental education initiated by children affects their parents' consumption behavior, and to analyze how cultural values shape the process by which children receive environmental education that ultimately encourages their parents to adopt green consumption practices. This study introduced the concept of transgenerational education and constructed a model to examine its impact on green consumption behavior under the pervasive moderating effect of power distance orientation. Through two phases of field experiments, we found that transgenerational education initiated by children not only directly influenced their parents' green consumption behavior but also promoted such behavior through two mechanisms: moral persuasion and normative regulation. Furthermore, power distance orientation had a semi-permeable moderating effect on these pathways. On the one hand, transgenerational education fostered green consumption behavior by enhancing the perception of green parental responsibility, and power distance orientation moderated the relationship between responsibility attribution and green consumption behavior. On the other hand, transgenerational education shaped group norms within families. It exerts normative pressure on behavioral choices, and it was influenced by the level of power distance orientation in the family.

Paper ID: 196

Assessment of material stock and carbon emission reduction potential of solar photovoltaics at the city level in china

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Abstract:

China's installed capacity of solar photovoltaic (PV) systems accounts for approximately 50% of the global total. The high material intensity of PV systems has placed considerable pressure on the availability and recycling of metal resources. This study monitors the inventory and carbon emission reduction associated with PV systems and their key metal materials at the city level from 2010 to 2024. The findings indicate that by 2024, China's PV installed capacity will reach approximately 444.77 GW, with the Northwestern and North China Plains accounting for 278.87 GW (62.70%), the Southwest region contributing 74.05 GW (16.65%), and the Eastern coastal region covering 53.04 GW (11.93%). The total aluminum usage is estimated at 6.18 million tons, followed by copper (34.1 kilo tonnes), silicon (30.0 kilo tonnes), and silver (2.1 kilo tonnes). Under theoretical conditions, China's PV systems are projected to facilitate carbon emission reductions of approximately 981.04 million tons by 2024. Clarifying the inventory of PV systems and their materials at the city level is crucial for developing diversified, refined management and recycling policies.

Paper ID: 197

Predicting carbon emissions through the integration of financial, management, policy, and green propensity dimension: an interpretable MLP-based analysis

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Abstract:

Climate change is one of the most urgent challenges of the 21st century, driving global efforts toward achieving carbon neutrality. This study aims to strengthen the understanding of carbon reduction by developing a multidimensional analytical framework leveraging machine learning techniques. Although existing research has explored the impact of policies, management structures, and corporate operations on green innovation, there remains a lack of an integrated framework that consolidates these factors and investigates their interactions. To address this gap, the study employs a Multi-Layer Perceptron (MLP) model to predict carbon emissions and utilizes interpretable machine learning methods to elucidate the key influencing variables and their interactions. The study utilizes data from listed companies (2008-2022), covering financial, managerial, policy, and green propensity indicators, to train the MLP model. Preliminary results indicate a high prediction accuracy (R-squared of 0.89) and demonstrate that financial features, particularly company size and production activities, have a significant impact on carbon emissions. Policies such as carbon peak and water pollution prevention also play a crucial role, while management and green propensity characteristics exhibit moderate influence. Additionally, the study reveals varying degrees of interaction among factors from different dimensions. The findings aim to provide actionable insights for policymakers and corporate managers, facilitating the green transformation of industries and establishing a data-driven decision-making framework.

Paper ID: 198

Blockchain for construction waste management: A smart contract-driven framework for Enhancing Traceability and Circular Economy Practices

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Abstract:

With inefficient material use, obscure waste disposal, and poor recycling methods, the construction sector contributes significantly to the worldwide waste production, which has a negative impact on the environment. It is challenging to track the origins of garbage, ensure suitable disposal, and support circular economy principles with traditional waste management systems since they rely on fragmented documentation and manual record-keeping. In order to provide real-time traceability, accountability, and automated enforcement of sustainable waste management regulations in the construction industry, this study suggests a novel blockchain-based smart contract system.

In contrast to traditional methods, this study investigates how blockchain technology can be combined with Internet of Things (IoT) sensors and artificial intelligence (AI)-powered predictive analytics to develop a decentralised, self-executing waste monitoring system. Real-time data on material consumption, waste creation, and recycling status may be gathered by IoT-enabled construction sites, and AI-driven analytics can forecast potential for waste reduction. All parties involved, including contractors, trash processing companies, and regulatory agencies, may access verifiable waste records thanks to the blockchain ledger's assurance of data immutability, that prevents illegal disposal and greenwashing.

The smart contract mechanism further enforces compliance by automatically penalizing non-compliant practices and rewarding sustainable behaviors, such as efficient material reuse and recycling.

By implementing this novel blockchain-IoT-AI integration, the research aims to shift the construction industry towards a data-driven, transparent, and fully accountable circular economy model. This study will analyze real-world pilot projects and propose a strategic roadmap for large-scale adoption. The findings will provide a groundbreaking perspective on self-regulating waste management systems, setting a precedent for future smart and sustainable construction practices.

Paper ID: 199

Environmental Impact of 5G Energy-Saving Techniques from a Socioeconomic Perspective

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Abstract:

The increasing development of the fifth generation (5G) technology has transformed global internet experience , but its advancement has also raised concerns about energy consumption and greenhouse gas (GHG) emissions. It is essential to evaluate not only the energy consumption of new energy-saving techniques in the information and communication technology (ICT) sector, but also their environmental impact on the broader socio-economic system. In this research, a series of new integrated energy-saving techniques from both the base station (BS) and user-equipment (UE) of the ICT sector are introduced first. Then, integrating the input-output model from economics, an environmentally extended Input-Output (EEIO) model targeted at the ICT sector is developed. Finally, this model is applied to evaluate the contributions of new 5G technologies to energy saving and emission reduction across various sectors of the socio-economic system. The results reveal the fact that, at the BS, 'Deep reinforcement learning-based sleep mode' has profound emission reduction effects. Moreover, compared to the BS, energy-saving techniques at the user end have a greater emission reduction impact at the socio-economic level. Within the socio-economic system, sectors such as financial and insurance activities, and computer programming, are most affected by the emission reduction effects of new ICT technologies. The findings offer valuable insights for optimizing energy-saving communicating techniques and supporting the sustainable development of the ICT sector.

Paper ID: 200

Biomass - derived lixiviant for sustainable extraction of metals from cathode material of lithium-ion batteries

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Abstract:

This study aims to demonstrate a benign and low-emission metal-extraction technology to recover critical metals from cathode active material (CAM) of spent lithium-ion batteries (LIBs). Despite the potential of spent LIBs as a valuable secondary metal resource, its recycling faces challenges due to the lack of efficient yet sustainable technology. Processing the global production of LIBs in 2025 alone with conventional hydrometallurgical process would demand around 2.3 million m^3 of lixiviant (volume equivalent to > 900 standard Olympic swimming pool), with an estimation of about 5 m^3 of lixiviant required per ton of spent LIBs. The use of inorganic lixiviants results in large amounts of toxic tailings and sludge, necessitating extensive and expensive secondary waste management. To this end, we have successfully formulated a unique green and 100% biodegradable lixiviant derived from the pyrolysis of waste biomass to substitute conventional inorganic lixiviants, such as hydrochloric acids, sulphuric acid and hydrogen peroxide, which have been widely applied in the conventional hydrometallurgical processes for metal recovery from spent LIBs. The green lixiviant eliminates the need for an additional reducing agent to extract metals from spent LIBs, while offering faster kinetics and excellent metal-extraction efficiencies. Experimental results indicated that its high content of organic acids and phenolic substances enables all lithium and > 95% of nickel to be extracted from the spent LIBs in just 30 minutes. The recovered metal products, such as nickel oxalate, exhibit high purity compared to commercial products and demonstrate significant potential for reuse in CAM regeneration. The performance of the green lixiviant facilitates a shift towards greener alternatives and delivers a powerful yet environmentally friendly metal-extraction solution for spent LIBs at a fraction of the cost. Further, its production can promote the circular economy by repurposing waste biomass (e.g., wood chips) into a valuable lixiviant for LIB recycling.

Paper ID: 201

Natural antioxidants: from scientific hypothesis to practical reality

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Abstract:

Despite the interest in natural antioxidants and the focus on their potential application in many industries in recent decades, the commercialization remains elusive due to the longtime of extracting and the difficulty of retrieving for further use. this investigation aimed to reduce the extraction time of natural antioxidants, facilitate the retrieving, and formulation into an easy commercial formula without decrease their efficiently. Comparative with conventional extraction and retrieving operation methods [Socked in extraction solvent (SIE), Soxhlet (SE), and freeze-dried (FD)], both difference in pressures (DIP) and dried under vacuum techniques (VD) were used, and the obtained natural extracts were applied in beef patties. A device that operates at different pressures has been designed for the extraction process, and another device that operates at vacuum pressure has been designed for the retrieving operation. Three forms of natural antioxidant (liquid, freeze dried, and dried under vacuum) from four sources (Hibiscus leaves. olive leaves, orange peels, and potato peels) were compared. The antioxidants and antimicrobial characteristics were measured for the natural extracts, while physical and chemical properties of beef patties were evaluated. The usage of difference in pressures (DIP) technique in extraction process led to reduce the time of extraction from 48 h to 6 h, while mixing the antioxidant extracts with soya flour and then using vacuum dried (VD) technique in dried the antioxidant extracts reduce the time of dried from 48 h to 45 min. The results showed that the extracts processed by (DIP) and (VD) techniques showed better antioxidant and antimicrobial properties than the extracts processed by conventional extraction methods ($p < 0.05$), and the behavior of the extracts processed by (DIP) and (VD) in beef patties was better than the extracts processed by conventional extraction methods ($p < 0.05$).

Paper ID: 202

Evaluation of the occurrence of emerging contaminants and application of the Fenton process for their removal in a municipal wastewater treatment plant in Durango, Mexico

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Abstract:

The objectives of this study were to evaluate the occurrence of 27 emerging contaminants throughout the process (primary, secondary and disinfection) of a municipal wastewater treatment plant (WWTP) located in the state of Durango, Mexico, and to apply the Fenton process as a tertiary process for their removal. The detection and quantification of emerging contaminants in the wastewater were performed using techniques and equipment such as solid phase extraction (SPE) and liquid chromatography coupled to mass spectrometry (UPLC-MS/MS). The results showed that the primary process and the disinfection process used at the WWTP were not able to remove any of the quantified emerging contaminants, while the secondary process (activated sludge process) removed most of them. However, although it was observed that the secondary process had the capacity to remove most of the emerging contaminants that were quantified; emerging contaminants such as DEET, ciprofloxacin, and triclosan could not be removed by this process, prevailing in the effluent generated by the WWTP, being a potential risk to human health, flora and fauna, since the effluent generated is used for irrigation of crops and irrigation of green areas in the city of Durango. In addition, the results showed that the Fenton process is a viable method for use as a tertiary process for the removal of emerging contaminants in wastewater, as laboratory tests showed that emerging contaminants such as acesulfame-K, caffeine, ibuprofen, triclosan, and carbamazepine were almost 100% removed in the wastewater from the secondary process (activated sludge process) of the WWTP.

Therefore, it can be concluded that the processes used in the WWTP lack the capacity to remove all the emerging contaminants and that advanced oxidation processes, such as the Fenton process, are required to perform such removal so that the treated wastewater can be returned to the environment with better quality.

Paper ID: 203

Per- and Polyfluoroalkyl Substances (PFAS) in Carpet: Significant Disparity in Potential In-Use and End-of-Life Exposure Risks in the United States

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Abstract:

In this study, we present the first temporal and spatial analysis of the quantity and fate of per- and polyfluoroalkyl substances (PFAS) in the U.S. carpets . By integrating stocks and flows modeling, transportation modeling, and multiple datasets on population, landfills, and precipitation, we estimate the carpet PFAS in each census tract and landfill from 1990 to 2060. We find that nationally, 75-722 tonnes and 80-798 tonnes of PFAS were accumulated in in-use and landfilled carpet stocks respectively in 2020, which emit 0.06-5.7 tonnes and 0.33-4.5 tonnes/year of PFAS to indoor air and landfill leachate. We further identify significant disparities (p-value < 0.05) in exposure risk where in-use carpet PFAS emissions are higher in populations with a lower percentage of people of color and lower exposure risk to other environmental contaminants such as PM 2.5, whereas end-of-life carpet PFAS exposure risks are higher in racial minority communities and those already with a higher exposure risk to other environmental contaminants. Adopting aggressive PFAS phase-out policies would effectively mitigate the in-use exposure but would fail to mitigate the end-of-life risks. By 2060, over 11.6 million people (a 17% increase from 2020) will live within 10 kilometers of landfills with PFAS accumulation up to 5,028 kg. Our study underscores the importance of top-down assessments of PFAS flows and associated risks and calls attention to the overlooked environmental justice issues in national PFAS mitigation policies.

Paper ID: 204

Biomass-based concrete could effectively decarbonize buildings in Mexico

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Abstract:

The building sector's substantial material consumption is associated with considerable negative environmental impacts, prompting efforts to identify sustainable alternatives. Through integration of life cycle assessment (LCA) and building energy simulation, we demonstrate that buildings made with “sargassum-based concrete” (SBC), a concrete containing aggregates made from unwanted biomass, could achieve notable climate change benefits. The main reason is SBC’s reduced thermal transmittance that lowers the energy demand for cooling and heating. Using Mexico’s climate and typical residential house as a case study, we estimate that SBC buildings can reduce life-cycle greenhouse gas emissions in 29 out of 32 Mexican states over a 50-year lifespan. The savings can reach up to 15.8 % in states with extreme climates (hot or cold) and further increase with extended building longevity. These findings highlight biomass-based concrete as a viable strategy for biomass utilization and building decarbonization in regions where similar resources are available.

Paper ID: 205

Selenium treatment via integrating flow electrode capacitive deionization (FCDI) and bio-electrochemical systems (BES)

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Abstract:

Selenium pollution in aquatic environments poses a major global challenge, with a significant gap in effective treatment technologies. In this study, we explored a novel approach integrating flow-electrode capacitive deionization (FCDI) with bio-electrochemical systems (BES) for the removal and reduction of selenate and selenite ions in one compact reactor. Our integrated system was electricity-driven, eliminating chemical usage. Up to 76 % selenium removal from the waste streams was achieved, followed by up to 66 % and 54 % reduction of selenate and selenite to elemental selenium respectively. The addition of acetate, a carbon source, enhanced selenate reduction by 14 % but lowered selenite reduction by 21 %, suggesting the substrate-dependent and bio-electrochemical-driven nature of selenate and selenite reduction respectively. Metagenomic sequencing revealed that Geobacter sulfurreducens and Pseudomonas stutzeri two known Se-reducing species, likely contributed to both selenite and selenate reduction through up-regulating functional genes related to sulfide reductase, fumarate reductase, and multi-heme c-type cytochromes. Thauera spp. and Alishewanella spp., two species not previously associated with selenium reduction, were likely involved in selenite reduction via the up-regulation of genes related to sulfite reductase and selenium reductase.

Paper ID: 206

Non-hazardous industrial waste in the United States: 100 Million tonnes of recoverable resources

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Abstract:

Despite the large volume of non-hazardous industrial waste (NHIW) being generated globally, systematic NHIW reuse policies are lagging, largely owing to piecemeal understanding of generation volumes, locations, chemical constituents, and future trends. Herein, we demonstrate how to estimate the mineral and energy flows embedded in the 200-300 million tonnes of NHIW in the United States using information from process engineering and economic projections. We estimate that the minerals contained in NHIW are on the order of 100 million tonnes and with electricity potential lectricity at 200 billion kWh annually from 1990 to 2016. Both are expected to increase by roughly 50% from 2017 to 2050. The electricity potential and bulk mineral contents (e.g., CaO and SiO2) are modest compared to the total level of consumption of these resources (<3%), but there are county-level hotspots along the west coast with opporunities possibly large enough to yield significant material benefits at the local scale. Two lower-volume minerals, phosphorus and titanium, are noteworthy from a material substitution standpoint. They are estimated at 0.5-2.0 million tonnes in NHIW annually, which is 10-20% of current consumption and up to 50-80% in hotspot states. Although there are difficulties in cross-national generalization, we anticipate that the workflow steps themselves would be transferrable to other countries to be able to yield the chemical, locational and temporal information needed to inform the design of region-specific NHIW reuse programs and the development of NHIW valorization technologies.

Paper ID: 207

Sustainable management of passive cooling adoption: a monte carlo risk assessment

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Abstract:

The transition towards sustainable buildings is essential for mitigating climate change and reducing resource consumption in the built environment. Passive cooling technologies offer a resource-efficient approach to minimising energy demand in residential buildings. Despite extensive research on passive cooling technologies, their adoption remains limited in Australian residential buildings. Through a series of studies, a progressive examination has been conducted on this issue, first identifying key adoption barriers through a systematic literature review, then validating their significance through expert interviews and survey assessments. These investigations have consistently highlighted that the primary challenges are not technical but stems from end-user knowledge gaps, policy constraints, economic barriers, and market-related uncertainties. Building on these findings, this study applies the Monte Carlo Simulation (MCS) to quantify the risks associated with passive cooling adoption from a project management perspective. The analysis models how identified barriers influence project time, cost, and quality – the core elements of project management – to assess their impact on project success. The model incorporates five barrier categories – policy, knowledge, economic, market, and technical – to simulate various adoption scenarios. This probabilistic approach enables a data-driven understanding of risk exposure levels, highlighting the likelihood of cost overruns, delays, and quality deficiencies, while also informing risk mitigation strategies. By integrating quantitative risk assessment with sustainability challenges, this paper presents a critical step in translating conceptual barriers into measurable project risks. The findings will provide construction industry decision-makers with actionable insights to address non-technical obstacles to passive cooling adoption, supporting more effective policy interventions and investment strategies. Ultimately, this study contributes to resource sustainability by facilitating the integration of passive cooling solutions into mainstream residential construction.

Paper ID: 209

Cross-regional collaborative management network of construction waste in the Guangdong - Hong Kong - Macao Greater Bay Area

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Abstract:

Many cities are facing outstanding contradictions with huge amounts of construction waste but limited of local disposal capabilities, bringing massive pressure to the urban environment. Developing a comprehensive cross-regional collaborative management network has become a critical way to deal with this contradiction. However, no research has revealed the mechanism of the formation and evolution of this network. This study is facing on the cross-regional construction waste management network in the Guangdong-Hong Kong-Macao Greater Bay Area. The study is designed to analyze the structure, form, and characteristics of cross-regional management networks and to present suggestions for cross-regional management of construction waste in the Greater Bay Area. The project expands the existing research from a closed-area network to a cross-regional network, which could expand the boundaries of the theoretical research of construction waste. The results could provide a theoretical basis for improving the recycling rate and the effectiveness of cross-regional management of construction waste in the Greater Bay Area and key urban agglomerations in China.

Paper ID: 211

Water-energy-food nexus coupling coordination across Chinese provinces: Spatiotemporal evolution and interactive effects of influencing factors

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Abstract:

With China's rapid economic development and accelerating urbanization, water resource scarcity, surging energy consumption, and food security pressures have become increasingly prominent. The coupling coordination of the Water-Energy-Food (WEF) Nexus has emerged as a critical challenge constraining regional sustainable development. This study constructs a comprehensive evaluation model for provincial WEF Nexus development, systematically measures the coupling coordination degree of the WEF Nexus, and employs a geographical detector model to reveal key factors influencing WEF Nexus coupling coordination and the nonlinear interactive effects between influencing factors. The research findings indicate: (1) China's 30 provinces show an overall uncoordinated trend in their WEF Nexus, with regional development disparities continuing to intensify. Provinces in the northeastern region demonstrate significantly better coupling coordination levels compared to those in the central and western regions. Additionally, the proportion of provinces with low coupling coordination has increased, while the concentration of provinces with high coupling coordination has decreased, indicating a weakening polarization effect. (2) Effective irrigation area, agricultural fertilizer application, and total agricultural machinery power are the dominant factors affecting provincial WEF Nexus coupling coordination. This highlights the core role of the food subsystem in coordinated nexus development. (3) There are widespread bilateral enhancement and nonlinear enhancement effects between influencing factors. However, these synergistic effects show a continuous weakening trend, leading to an increasing number of uncoordinated provinces and posing serious challenges to system stability. Future policies should focus on strengthening inter-regional resource allocation and cross-departmental collaborative management to maximize the synergistic effects of influencing factors.

Paper ID: 212

Decoupling relationship between electricity CO2 emissions and economic growth: Evidence from urban agglomerations, China

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Abstract:

Power sector emissions reduction is a crucial pathway for China to achieve its carbon neutrality goals. Decoupling economic growth from CO2 emissions is one strategy for reducing power sector carbon emissions. However, research on China's power industry in this context remains limited. This study quantifies the contributions of various drivers to power sector CO2 emissions using the LMDI model and analyzes the relationship between power sector CO2 emissions and economic growth using the Tapio model, then quantitatively assesses the efforts made by various factors to achieve decoupling. The results show that the CO2 emissions of China and the six urban agglomerations initially increased, then decreased, and increased again, with a stable growth rate of around 3% during the 2016-2020. The impact of different factors on power sector CO2 emissions varied significantly across the six urban agglomerations. Economic scale and population size were the main factors driving increased emissions, while conversion efficiency was the primary factor mitigating the rise in emissions. Electricity consumption intensity held significant potential for future emission reductions. The decoupling index for the six urban agglomerations showed an overall trend of declining and then increasing, with some degree of decoupling achieved in all of them. The driving factors of power sector CO2 emissions in urban agglomerations exhibited varying degrees of decoupling efforts. Among them, the Yangtze River Delta urban agglomeration showed the most significant decoupling efforts, with a decoupling effort value of 3.313 in 2011-2015. Conversion efficiency and electricity consumption intensity are the dominant factors influencing the decoupling efforts of the six urban agglomerations' power sector CO2 emissions. Given that urban agglomerations present different carbon emission characteristics, differentiated and diversified emission reduction paths should be explored in the future to promote CO2 emission reduction urban agglomerations.

Paper ID: 213

Does digital infrastructure promote regional inclusive green growth? An empirical study from China

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Abstract:

Inclusive Green Growth (IGG) embodies a sustainable development paradigm that integrates economic growth, social equity, and environmental protection as its foundational pillars. The advent of digital infrastructure has unveiled novel avenues for the realization of IGG. This study investigates the impact of digital infrastructure on IGG within the Chinese context, utilizing provincial panel data spanning from 2003 to 2020. This study has devised a composite methodology that amalgamates the capital stock approach with the physical quantity method to establish a theoretical construct for quantifying the digital infrastructure stock . Subsequently, by employing a novel efficiency measurement model that synthesizes the notion of the comprehensive technology frontier with a non-oriented, non-radial directional distance function within the Data Envelopment Analysis (DEA) framework, this article quantifies IGG efficiency. The findings reveal a transition in IGG efficiency from a state of equilibrium to one of disparity. Building upon these analyses, the study extensively examines the mediating influence of technological innovation and industrial structure, alongside the heterogeneous effects of economic development, human capital, and traditional infrastructure on the relationship between digital infrastructure and IGG. The insights garnered from this research empower policymakers to discern and surmount potential impediments in the construction of digital infrastructure, thereby facilitating the advancement of IGG.

Paper ID: 214

Production of granular planting soil using construction waste mud cake

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Abstract:

Granular planting soil was produced using the mud cake obtained from the resource disposal of construction waste soil at a construction waste treatment plant in Shenzhen, its performance of the granular planting soil was studied, and environmental benefit was analyzed in order to realize the resource utilization of construction waste mud cake, reduces the environmental pollution and economic cost brought by landfill residue mud cake, and promote the construction of waste free city. The main findings are 1) The soil infiltration rate of the construction waste mud cake can be greatly improved by granulation, and the soil infiltration rate of the produced granular planting soil far exceeds the lower limit of the soil infiltration rate of planting soil ≥ 5mm/h of the Planting soil for greening (CJ/T 340-2016). The infiltration rate of planting soil increased with the increase of planting soil particle diameter; 2) The organic matter content of planting soil can be significantly increased by adding biochar, and the increase of organic matter increases with the increase of biochar. Three kinds of biochar used in this study significantly increase organic matter content of the planting soil, in which, the charcoal biochar has the most significant effect on organic matter content, followed by bamboo biochar and corn stalk biochar. Biochar can effectively increase the contents of hydrolyzed nitrogen, available phosphorus and available potassium in granular planting soil, and biochar can release more hydrolyzed nitrogen, available phosphorus and available potassium to planting soil as time goes on; and 3) The calculation results by life cycle assessment show that compared with traditional landfill disposal, the resource disposal of granular planting soil prepared by 1t construction waste mud cake can reduce 103.7 kg CO2 eq., 21.0 kg solid waste, 0.12m2 land occupation and 4.878 Yuan environmental cost.

Paper ID: 215

Development of movable modular ecological system

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Abstract:

Combining the existing ecological roof and rainwater parterre, a movable modular ecological system applicable to greening transformation of buildings and sponge city was developed. The movable modular ecological system is composed of drought-resistant plants, medium soil layer, permeable geotextile, permeable layer, slotted pipe, waterproof geotextile, outflow control device, anticorrosive wooden box and pulley. The basic specifications of the system are set as 800-1000mm in length, 600-800mm in width and 350-600mm in height. When the movable modular ecological system is installed on the roof, it can be called as the movable modular ecological roof and its height shall be taken as 350mm to reduce its weight. When the system is placed in the courtyard, it can be called as movable modular rainwater parterre and its height shall be taken as 600mm to detain more rainwater. The movable modular ecological system not only has ecological functions such as reducing rainwater runoff, staggering peak and reducing urban heat island effect, but also has the characteristics of being light in mass, movable and not requiring fertilization and watering. The medium soil can remove phosphorus and nitrogen from rainwater, and the rainwater treated by this ecological system can not only meet the requirements of GB3838 Class II water of the Surface Water Environmental Quality Standard, but also reduce the rainwater runoff by 30%-50%, delay the peak for 10-20 minutes, and reduce the peak by 1/3-1/2. The system is easy to install and meet landscape need, so it saves operation cost greatly. Without changing the roof structure and ground surface, it can be easy to arrange on the roof and in the courtyard, replacing constructing sponge city facilities such as green roof, raingarden, rainwater parterre and sunken green area.

Paper ID: 216

Sustainable valorization of End-of-life Tires for Hydrogen Production: Process design, modelling, and techno-economic analysis

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Abstract:

The number of end-of-life tires (ELTs) is steadily increasing, resulting in severe environmental problems. Turning ELTs to energy through gasification provides a sustainable solution to the emerging issues of waste management. This study has proposed a novel system based on plasma gasification to convert ELTs to hydrogen. Considering the advantages of plasma gasification including less hazardous pollutants and higher syngas yield, it has been integrated into the proposed system. However, the significant energy consumption caused by the plasma torch cannot be ignored. Therefore, a multi-stage power cycle consisting of supercritical CO2 cycle and Organic Rankine cycle has been designed to recover waste heat from high-temperature syngas after plasma gasifier to generate electricity and improve energy efficiency. Additionally, MEA-based CO2 capture has been integrated to minimize the carbon emission of the system. The techno-economic analysis has been conducted to assess the performance of the integrated system comprehensively. The performed studies pointed out that the main contributors to energy and exergy destruction are the plasma gasifier and the CO2 capture unit. Moreover, the CO2 capture unit has significantly minimized the CO2 concentration in the syngas. Compared with other gasification technologies, higher H2 yield can be obtained through this novel plasma gasification process with a reasonable levelized cost of hydrogen. In sum, the technical and economic feasibility of the developed system can be verified, showing its potential to achieve sustainable hydrogen production and demonstrating a superior pathway of ELTs valorization over conventional treatments.

Acknowledgement: The work was supported by the Research Committee of The Hong Kong Polytechnic University under the student account code RNAA, and Research Grants Council of the Hong Kong, China-General Research Fund (Project ID: P0046940, Funding Body Ref. No: 15305823, Project No. B-QC83), and Environment and Conservation Fund (Project ID: P0043333, Funding Body Ref. No: ECF 51/2022, Project No. K-ZB5Z).

Paper ID: 217

Integrated carbon capture and methanation for valorisation of sludge: process optimization and performance evaluation

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Abstract:

The rapid growth of populations has led to a continuous increase in sludge generation, making the effective management of urban domestic waste crucial for promoting sustainable urban development. Due to its high heating value, sludge holds potential as an alternative energy source to replace fossil fuels. However, while methods such as combustion for electricity generation can enable value-added utilization of sludge, they result in carbon emissions. Therefore, integrating carbon capture and utilization is necessary to mitigate this issue. The emergence of integrated carbon capture and methanation (ICCM) technology offers a promising solution by combining both capture and conversion processes in a single reactor using bifunctional catalysts, thereby reducing costs and energy consumption. However, comprehensive simulations and evaluations of the integrated sludge combustion and ICCM process are lack, particularly in terms of its economic and environmental performance. To address this gap, we aim to design an integrated process for the two technologies and conduct a thorough assessment of energy efficiency, product costs, and carbon emissions. Furthermore, given the significant heat generated by sludge combustion and ICCM processes, process optimization based on machine learning and work and heat exchange network (WHEN) synthesis will be applied to optimize the process and design an effective heat exchange network, ensuring efficient utilization of system heat. The proposed system will achieve higher energy efficiency and excellent economic and environmental performance. (Acknowledgement: The first author - Wang Nuo is a PhD student financially supported by the Research Institute for Advanced Manufacturing (RIAM), The Hong Kong Polytechnic University, and the authors thank the Research Committee of PolyU for the support of the project through a PhD studentship (project account code: RMWP). We also thank financial support from a grant from the Environment and Conservation Fund (ECF) (Project ID: P0047715, Funding Body Ref. No: ECF 81/2023, Project No. K-ZB7V)).

Paper ID: 218

Multi-objective optimization for eco-industrial park transformation: Balancing economic growth, carbon reduction, and industrial structure adjustment

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Abstract:

While stimulating economic growth, industrial parks also encounter substantial challenges related to energy consumption and environmental degradation. To address the environmental issues caused by traditional industrial parks, the Eco-Industrial Park (EIP) model has emerged. This model promotes the green transformation of industrial parks through resource recycling and inter-industry symbiosis. However, existing research lacks systematic optimization methods for balancing the complex relationships between economic benefits, environmental benefits, and industrial structure adjustment in eco-industrial parks. Therefore, this study proposes a multi-objective optimization-based solution to optimize the industrial structure of the entire park, considering the energy consumption and waste structures of different industries within the industrial park. By constructing an optimization model with multiple objectives, including economic growth, carbon reduction, and industrial independence, and combining it with a genetic algorithm (NSGA-II), the feasibility and superiority of different industrial structure adjustment paths are evaluated. The results show that the optimized paths reduce resource consumption and environmental pollution while ensuring economic development in the park. Compared to the baseline scenario, carbon emission intensity decreases by 27.29% and 45.64% in 2025 and 2030, respectively, while the final treatment volume of solid waste is reduced by 72.13% and 91.59%. At the same time, the introduction of clean energy and waste recycling not only significantly reduces greenhouse gas emissions but also dramatically enhances the synergistic benefits of pollutant reduction, particularly for key pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM). This study provides a highly actionable model framework, offering theoretical support and practical reference for high-tech industrial parks' green and low-carbon transformation. It also suggests that future research should further deepen the development of cross-industry symbiotic networks and explore other potential low-carbon development pathways.

Paper ID: 219

Managing stakeholder trust dynamics in industrial symbiosis

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Abstract:

The prevailing linear economic model, characterized by its ‘extract, use, and discard’ approach, has led to significant environmental and resource challenges, necessitating a shift towards more sustainable systems. Industrial Symbiosis (IS), a key component of the circular economy, offers a promising solution by facilitating the exchange of resources, repurposing waste streams, and enhancing operational efficiency. IS has been shown to contribute to multiple United Nations Sustainable Development Goals (SDGs) by promoting resource efficiency and sustainable industrial practices.

Despite its benefits, IS adoption faces several barriers, with social challenges—particularly trust—emerging as a critical factor for long-term success. Trust plays a fundamental role in fostering inter-firm collaboration, ensuring effective information sharing, and overcoming coordination challenges. However, research indicates a persistent lack of trust in IS networks, which hinders collaboration and limits the scalability of symbiotic initiatives. Trust is inherently fragile and volatile, influenced by dynamic inter-firm relationships, evolving market conditions, and external environmental factors. Although some studies have explored trust development in IS, the equally crucial aspect of trust maintenance remains underexamined.

This study addresses these gaps by conducting a Systematic Literature Review (SLR) to examine how trust is developed and sustained in IS partnerships. The research integrates insights from stakeholder theory and trust theory to propose a conceptual framework for understanding and managing trust in IS collaborations. By clarifying the concept of trust in the IS context and identifying mechanisms for its long-term maintenance, this study contributes to both theoretical advancements and practical applications.

Future research will focus on empirically testing the proposed framework through multi-region case studies, analyzing trust dynamics across different geographical contexts to provide deeper insights into fostering enduring IS partnerships.

Paper ID: 220

Hydrogen potential in China's aviation sector: A techno-economic supply chain perspective

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Abstract:

The aviation industry, contributing 3.6% of global GDP in 2019, is projected to more than double in air transportation volume by 2050. However, as it accounts for 2.4% of global CO_2 emissions, decarbonization remains a significant challenge. China's aviation industry is in a period of post-pandemic recovery and rapid growth with rising per capita incomes and the improvements in air transportation facilities. Meeting national dual-carbon target necessitates alternative fuels, with hydrogen emerging as a promising but uncertain solution due to technological, economic, and infrastructural challenges.

This study presents a techno-economic analysis of hydrogen adoption in China's aviation sector, evaluating its demand potential, infrastructure requirements, and cost feasibility. First, hydrogen demand is modeled based on commercial aircraft availability, domestic flight distances, and constraints of alternative fuels. Second, a comprehensive hydrogen airport hub is designed, integrating on-site renewable hydrogen production, storage, and liquefaction. A mixed-integer linear program (MILP) is designed to minimize the levelized cost of delivered hydrogen across China's 39 largest airports, utilizing high-resolution geospatial meteorological data (2019–2024). Finally, a spatial and temporal hydrogen deployment strategy is proposed, accounting for airport-specific hydrogen costs and flight network coverage potential.

Findings suggest that while hydrogen adoption requires substantial investment, it offers significant carbon reduction potential. Key challenges include infrastructure scalability, production costs, and regulatory frameworks. Given the long development timelines for hydrogen aircraft and uncertainties in alternative fuels, early progress is essential. Decarbonization will demand high capital expenditure and policy support, but immediate emissions reductions will yield cumulative long-term benefits. Additionally, alternative transport modes such as rail and shipping should be considered, though they may not always be viable substitutes. This study provides insights into hydrogen's role in aviation decarbonization and the economic feasibility of hydrogen airport hubs, offering guidance for policymakers in shaping a sustainable future for air travel.

Paper ID: 221

A comprehensive energy-material-carbon accounting framework for decarbonizing China's hydrogen sector

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Abstract:

As a rapidly evolving sector with increasing demand, the hydrogen industry requires a comprehensive decarbonization strategy that integrates both generation-side energy structure optimization and consumption-side demand development. However, fragmented approaches across these dimensions often hinder a holistic perspective in policy design, limiting the long-term vision for a sustainable hydrogen economy.

This study introduces a comprehensive energy-material-carbon accounting method to enhance transparency in carbon emission responsibilities throughout the hydrogen supply chain. By integrating material-energy-carbon flow analysis with an extended input-output framework, the method systematically traces emissions from hydrogen production, distribution, and utilization to final demand. It further decomposes emission contributions into economic, material, and energy factors.

Applying this method to China's hydrogen industry from 2014 to 2024 reveals a significant rise in carbon emissions, primarily driven by economic demand growth of 6.8% per year, while mitigation efforts, such as renewable energy integration, had only a limited impact. In 2024, industrial activities accounted for the majority of emissions, with the transportation and chemical sectors as key contributors to embodied consumption emissions. Based on net-zero emission scenarios for clean hydrogen development until 2060, the study models sector-specific carbon reduction potential along with water and energy resource demands. Additionally, for the scale-up of water electrolysis, it quantitatively forecasts demand for stainless steel, critical raw materials (e.g., nickel, cobalt, titanium, platinum, iridium, ruthenium), and rare earth elements (e.g., yttrium, lanthanum, neodymium, dysprosium).

The findings suggest that China's hydrogen economy should prioritize renewable energy integration, energy efficiency improvements, and distributed generation to reduce reliance on fossil fuel imports while ensuring energy security and the sustainable decarbonization of hard-to-abate sectors. By enhancing transparency, this approach facilitates better coordination between top-down national targets and bottom-up regional implementation, enabling a more effective and aligned hydrogen decarbonization strategy.

Paper ID: 222

Retrieval augmented generation enhanced large language model life cycle sustainability assessment for renewable ammonia generation

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Abstract:

This study evaluates the energy, chemicals, and agri-food policies of the United States (USA), European Union (EU), and People's Republic of China (PRC) targeting 2030, 2050, and 2060 goals, as they relate to the development of renewable ammonia generation. By analysing these policies through the lens of Life Cycle Sustainability Assessment (LCSA), the research identifies policy-driven shifts in assumptions impacting technologies' economic, environmental, and social dimensions, thereby influencing technology rankings across regions and timelines. Methodologically, the study utilizes a Social Life Cycle Assessment (SLCA) with a large language model (LLM) retrieval-augmented generation pipeline to analyse relevant literature representing emerging green technologies. This mixed-method approach enables the extraction and analysis of extensive, machine-readable data to rank technologies on social indicators, providing a nuanced understanding of how international policies might shape the future technology landscape. U.S. policy fluctuates with administration changes, impacting renewable and carbon capture technologies. The EU is committed to sustainable design, targeting net-zero emissions by 2050, which favours non-CO2 emitting and circular economy technologies. China's policies focus on reducing coal dependence and enhancing renewable energy and hydrogen technologies, aiming for carbon neutrality by 2060.

Paper ID: 223

Design specifications and Life Cycle Assessment (ISO 14067) for a pyrolizer economically optimal for moderate flows (500 to 1000 tons per annum) of waste biomass

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Abstract:

Biochar production technologies tend to either be highly advanced state of the art machines or, at the other end of spectrum, highly artisanal ovens like the kontiki flame curtain kiln. Lacking are technological options in the mid-range. This is sub optimal because the generation of waste biomass is highly heterogeneous and, in many cases, a mid-range option would be ideal. Here we present the design specifications and a life cycle assessment (LCA) for an oven that fills this mid-range requirement. The LCA focuses specifically on the carbon footprint and uses the methodology and guidelines of the ISO Standard 14067. With this oven it is possible to produce over 150 tons of biochar per annum with every ton of biochar from municipal green waste generating 1.7 to 2.0 tons of negative emissions of CO2 equivalent.

Paper ID: 224

Multiscale optimization of China's power battery recycling: city-level pathways for pollution and carbon reduction in sustainable systems

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Abstract:

As the world's largest electric vehicle market for over a decade, with a share exceeding 70% of global sales, China faces increasing pressure to achieve sustainable battery circularity. However, macro-scale predictions are often disconnected from decision-making needs, and spatially heterogeneous environmental impacts remain underexplored. We develop a multi-scale framework integrating machine learning with city-level traffic insurance data, province-specific LCA, and regional policy simulations, covering 364 cities, 24 battery types, 6 recycling technologies, and ~200 capacity datasets. Results show that: 1) By 2030, retired battery volumes will surge to between 4.07 and 4.82 million tons, exhibiting a "south-to-west" gradient migration pattern. 2) Planned recycling capacity exceeds projected demand by 2.2 times, concentrating high pollution footprints in coal-dependent central regions. Potential recoverable quantities of lithium, cobalt, nickel, and manganese are estimated at 157,000, 53,000, 250,000, and 55,000 tons, respectively. 3) Informal recyclers dominate regional emission disparities; formalization could enhance emission reduction by 53%, achieving a 47-million-ton GWP reduction. We propose a spatially-integrated battery recycling roadmap, emphasizing the importance of regional technology gradient strategies in achieving a circular system. The study demonstrates that large-scale recycling combined with technology zoning can effectively alleviate overcapacity, promote resource circulation, and significantly reduce environmental footprints. These approaches provide transferable solutions for emerging economies, countries with decentralized energy grids, or those with fragmented industrial systems, particularly those facing similar industrialization dynamics.

Paper ID: 225

Exploring global railway technology evolution and SDG alignment via large language model-driven patent analysis

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Abstract:

The global railway industry's transition toward sustainability demands innovative approaches to map technological trajectories and assess their alignment with the United Nations Sustainable Development Goals (SDGs). This ongoing study proposes a data-driven framework integrating domain expertise, patent analytics, and large language models (LLMs) to explore innovation pathways and their societal implications. A structured knowledge repository is built using railway standards, technical documentation, and global patent data filtered via IPC codes (B61, G08G, H02J) and CPC sustainability codes (Y02/Y04S). High-quality patents are prioritized through citation networks and family size. Then, we use APIs and employed to analyze patent texts, including abstracts, claims, and diagrams. Detailed prompts guide the LLM to extract technological components at the system, subsystem, and component levels, alongside SDG alignment scores for each technology. The results are cross-validated with International Union of Railways (UIC) standards to ensure accuracy.

Technology evolution is mapped by analyzing patent timelines, citation networks, and adoption rates, classifying innovations into four stages: emerging (e.g., hydrogen-powered trains), growth (AI-driven predictive maintenance), maturity (energy-efficient propulsion), and decline. Visualizations reveal interactions between technologies, such as smart infrastructure's role in enhancing energy systems. Long Short-Term Memory (LSTM) models process historical patent trends (filing volumes, citations) to forecast future trajectories, predicting a 3–5-year surge in connected railway systems and renewable energy integration. Preliminary findings indicate that mature technologies like energy-efficient propulsion may align closely with SDG 7 (affordable energy) and SDG 9 (industry, innovation and infrastructure), while emerging AI-driven innovations show rapid patent growth.

By combining domain knowledge with LLM, this work-in-progress aims to equip stakeholders with adaptable tools for R&D prioritization and SDG-oriented decision-making. The framework's interdisciplinary design seeks to advance replicable methodologies for aligning industrial innovation with SDGs, positioning railways as potential catalysts for climate resilience and resource-efficient mobility.

Paper ID: 226

Water resource dispatching strategy considering resources conservation for dust suppression in dry bulk ports

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Abstract:

Effective dust suppression is crucial for environmental management in dry bulk ports (DBPs), but conventional methods rely heavily on freshwater, exacerbating regional water scarcity and increasing operational costs. Meanwhile, the discharge of ballast water and rainwater runoff introduces environmental risks, including invasive species and marine pollution. Despite the potential for recycling ballast water and rainwater to mitigate these challenges, current water resource dispatching in DBPs primarily depends on experience-based decision-making, leading to inefficient water dispatching, excessive consumption, and elevated costs. To address these issues, this study develops a water resource dispatching model that integrates water reuse, pumping station efficiency, and operational cost minimization. Using real-world data from a large DBP in northern China, numerical experiments demonstrate that the proposed model outperforms conventional rule-based scheduling methods, achieving a 25.51% reduction in total costs, saving approximately 26,369 kWh of electricity, and cutting carbon emissions by around 15 tons. Additionally, the utilization rate of rainwater and ballast water reaches approximately 20%, highlighting the model's effectiveness in enhancing sustainability. Furthermore, this study examines the impact of seasonal fluctuations and municipal water pricing on dispatching strategies, providing port managers with a practical decision-support tool for adaptive water resource management. The proposed model offers a cost-effective and environmentally sustainable solution for DBP operations, contributing to long-term resource conservation and pollution mitigation.

Paper ID: 227

Study on environmental impacts and emission reduction potential of Chinese white tea production in Fujian Province

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Abstract:

China, the birthplace of the tea plant (Camellia sinensis L.), has cultivated tea for over 4,000 years. However, modern tea production faces significant sustainability challenges. Approximately 30% of tea plantations in China overapply fertilizers (N-P2O5-K2O = 450-150-150), leading to environmental degradation. Additionally, coal-dependent processing exacerbates the industry's carbon footprint. As a labor-intensive and economically vital crop, tea production must balance resource efficiency with ecological and economic benefits. Despite its importance, quantitative research on the environmental impacts of China's tea production system remains limited, hindering efforts to achieve sustainable development and implement green supply chain management practices.

This study employs life cycle assessment (LCA) to evaluate the environmental footprint of white tea production in Fujian Province, a major tea-producing region. The findings reveal significant regional variations in environmental costs across 13 counties. Tongcheng County and Bailin City exhibited higher area-based environmental impacts, while Guanyang and Xiamen County showed higher yield-based impacts. The study identifies substantial potential to reduce fertilizer use and associated environmental impacts, particularly in regions with intensive farming practices. Key environmental hotspots include global warming potential (GWP), reactive nitrogen (Nr) emissions, acidification, and eutrophication. Nitrogen fertilizer application was the primary contributor to GWP, followed by N2O emissions. NH3 and NO3- emissions were the dominant drivers of Nr emissions and acidification, while NO3- and NH3 significantly influenced eutrophication.

By quantifying these impacts, this research provides a scientific foundation for promoting sustainable tea production practices and informed decision-making. It highlights the need for targeted interventions, such as optimizing fertilizer use and adopting cleaner energy sources, to reduce the environmental footprint of tea production. This work supports the green transformation of China's tea industry, contributing to global efforts toward sustainable agriculture.

Paper ID: 228

Mapping the European Green Deal: a RAG-based knowledge graph analysis

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Abstract:

The European Green Deal (EGD) is the European Union's central framework for tackling climate change, mitigating environmental degradation, and fostering economic sustainability. This study employs Retrieval-Augmented Generation (RAG) to analyze EGD-related documents and develop a comprehensive knowledge graph. Embedding techniques first build a detailed knowledge base of regulations, policies, and directives. RAG then retrieves relevant information, while large language models annotate the content, extracting key entities and relationships. The resulting knowledge graph reveals intricate connections across policy domains—energy, transportation, and manufacturing—within the EGD framework.

The analysis may expose significant gaps in policy coherence, potentially leading to fragmented or conflicting implementations. It could also reveal barriers such as inadequate funding, bureaucratic hurdles, and limited stakeholder engagement, along with inequities in resource allocation that leave certain regions or communities underrepresented in EGD benefits. Integrating multiple policy tools aimed at climate neutrality might likewise uncover coordination and effectiveness gaps, raising concerns about the robustness of these mechanisms.

Building on knowledge graph insights, predictive analytics forecast future policy developments and trends, guiding policymakers toward more informed, long-term sustainable decisions. This approach underscores the EGD's role as a blueprint for decarbonization and industrial transformation, providing data-driven strategies to address critiques related to feasibility and equity.

Finally, this interdisciplinary work presents actionable strategies for policymakers, researchers, and industry leaders, emphasizing adaptive and scalable methods to extend the EGD's global influence. By situating the EGD within broader contexts—planetary boundaries and key UN Sustainable Development Goals—the study highlights its importance in shaping the future of industrial ecology and sustainability science. Ultimately, the research demonstrates how embedding, RAG, and knowledge graph visualization can enhance policy analysis and prediction, fostering more resilient and sustainable policymaking processes. For example, it reveals interdependencies among policies crucial for achieving Europe's ambitious climate targets.

Paper ID: 229

Resource recovery potential of municipal solid waste from a city corporation area in Bangladesh

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Abstract:

Municipal solid waste (MSW) management practices are very much traditional and unscientific in Bangladesh, the waste mostly is collected and transported outside of cities for dumping. Recently, integrated solid waste management (ISWM) based on 3R approach has been initiated in many cities in Bangladesh. However, local government authority responsible for MSW management are not aware of the economic and environmental benefits of ISWM. This study was conducted in Gazipur City Corporation (GCC) area, the largest city corporation in Bangladesh to explore the resource recovery potential, economic and environmental benefits of 3R at household levels. A total of 206 waste samples were collected from households from 5 zones of GCC and analyzed for waste composition and per capita waste generation. The household's waste mostly comprised of organic materials (83.4%) followed by plastic (6.34%), paper (5.75%), glass (0.91%), leather & rubber (0.66%), metal (0.62%) and others (2.32%), which reveals a resource recovery potential of about 14.28%. The per capital waste generation rate in GCC is about 0.36 kg/capita/day. The current MSW generation from the households in GCC is about 718 tons/day, of which about 130 tons/day can be recycled as resource materials if segregations are practiced in household levels. Considering the current market prices of the recyclable materials, it was estimated that revenue potential of the recoverable materials about 154 million BDT/yr for 100% recovery, and in case of 70% recovery, the revenue potential is about 108 million BDT/yr. Resource recovery also potentially reduces the waste volume to about 298 m3/day, which is about 14.5% of the total waste volume. Considering the vehicles trips required for daily waste disposal to the designated landfill site at GCC, a total of 38 trips can be reduced per day and a land of 6.9 acres can be saved annually for 100% resource recovery.

Paper ID: 230

Reliability and economic analysis of urban rainwater harvesting for non-potable water demand: cases of commercial buildings with large catchment

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Abstract:

This study investigated the reliability of urban rainwater harvesting (RWH) for commercial buildings with large catchment and high non-portable water demand along with volume of water captured, spillage and economic feasibility. Three different types of commercial buildings (i) educational institute (Ahsanullah University of Science and Technology-AUST), (ii) health care facility (Ibn Sina Specialized Hospital-ISSH) and (iii) Corporate Office Building (Times Media Building-TMB) were analyzed. MATLAB programming environment was used to simulate daily water balance using daily rainfall input data for 30-year continuous time series (1986-2015) to generate time-based reliability (TBR), volumetric reliability (VR), annual average water savings (WS), and overflow ratio (OR). Economic analysis evaluated benefit-cost ratio (B/C ratio), net present value (NPV) and payback period for project life cycle of 30 years for three scenarios involving different investment costs: (1) RWH when utilizing existing underground reservoir (UGR), (2) separate storage at ground level not using UGR and (3) separate storage just below rooftop catchment and not using UGR. Regardless of storage size, 100% TBR or VR can never be achieved for selected commercial buildings. Achieving 0% OR requires absurdly large storage tanks, and not economically feasible. However, using the UGR for RWH can improve storm water stagnation issues. For scenario one, best economic outcomes can be achieved with payback period of only 11 months for AUST, 10 months for both ISSH and TMB. Without using UGRs, new storage tanks of maximum capacity of 1100m3 are economically feasible for both scenario two and three for AUST and IBH. For TMB, economically feasible largest possible new storage is 400 m3. In all the mentioned scenario two and three cases, payback period is very high. This study’s findings may provide a useful directive in understanding the policy makers of the resent directives of mandatory requirements of RWH in new buildings in Dhaka City.

Paper ID: 231

Flowing revenue: The role of water resource taxation in China's water stewardship

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Abstract:

Does pricing water lead to an increase in water resources? This article provides quasi-experimental estimates of the impact of taxing water on water resources by leveraging a unique natural experiment: the staggered introduction of water resource tax across China. In a difference-in-differences (DiD) paradigm, I find that the rollout of water resource taxation in China had a positive impact on water conservation, with a pronounced increase in surface water of at least 14.45%. However, there was no significant decrease in over-quota water and ground water within over-extracted aquifer area. Interestingly, the moderating effect of tax intensity yielded seemingly divergent effects on surface and ground water, which may somehow account for the policy's less discernible influence on the latter. This study sheds fresh light on the optimization of water resource taxation and the promotion of sustainable water stewardship.

Paper ID: 232

Comprehensive life-cycle assessment of oily sludge treatment technologies incorporating cyclone desorption technology

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Abstract:

The surge in petroleum demand has driven global generation of hazardous oily sludge exceeded 60 million tons annually, necessitating development of environmentally sustainable management protocols. However, comprehensive environmental assessment and economic viability analysis of oily sludge treatment technologies remain limited. This research employs the life cycle assessment (LCA) to quantitatively compare four treatment technologies: incineration, solvent extraction, pyrolysis, and cyclone desorption. All energy and material flows were established in the life cycle inventories. The results show that cyclone desorption technology has the least environmental impact, the direct contribution rate is 65.36%, pyrolysis technology followed at 84.35%. The incineration and solvent extraction technologies exhibited substantially greater impacts at 92.52% and 96.08%, respectively. Techno-economic analysis identified cyclone desorption as the most cost-efficient technology at $165.62 per metric ton. The research can help oil extraction and refining sectors manage oily sludge more effectively and minimize environmental impacts.

Paper ID: 233

Dynamic simulation of energy optimisation pathways in Yellow River Basin based on regionally coordinated decarbonization strategies

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Abstract:

The Yellow River Basin (YRB) is known as China's "energy basin" and the core region for achieving China's energy transition and "dual carbon" goals. However, minimal research explores the energy optimization pathways in YRB based on regionally coordinated decarbonization strategies.

This study adopts material flow analysis to elucidate energy-carbon footprint patterns in the nine provinces of the YRB from 2005 to 2020, initially develops a multi-regional dynamic synergistic development model to explore energy transition pathways based on regional industrial production characteristics from 2020 to 2035. The sophisticated model is constructed and simulated by integrating input-output modeling, system dynamics, and multi-objective programming. By employing a policy mix that encompasses industrial structure adjustment, enhancement of environmental efficiency, and collaborative development, this study compares multiple scenarios to identify the optimal energy pathway for the YRB, especially the energy transition pathways of key industries in each region, while maintaining overall control over multi-regional energy and carbon targets.

The findings provide guidance in formulating effective environmental policies and economic strategies aligned with energy transition development goals, which can also provide the methodologies and pathways needed for regional development holistically.

Paper ID: 234

The Effect of Pre-Swelling and Alkali Loading on the Debromination of Pyrolysis Oil from Waste Circuit Boards

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Abstract:

To achieve efficient suppression of brominated organic compounds during the pyrolysis of waste printed circuit boards (WPCBs) under low-additive conditions and obtain debrominated pyrolysis oil, this study proposes a combined approach involving swelling pretreatment, alkali impregnation, and co-pyrolysis debromination. The thermal degradation characteristics and debromination efficiency of pyrolysis oil derived from WPCBs impregnated with KOH, NaOH, and a KOH/NaOH mixture are systematically investigated. The results reveal that swelling pretreatment combined with alkali impregnation significantly reduces the initial pyrolysis temperature from 300°C to 275°C and broadens the temperature range of thermal decomposition. Under comparable loading conditions, the KOH impregnation exhibits superior debromination performance compared to the NaOH impregnation, while the KOH/NaOH mixture demonstrates a synergistic effect, achieving the highest debromination efficiency. Notably, when the KOH to NaOH ratio is 2:1 and the total alkali loading is only 5.68% of the WPCB weight, no brominated organic compounds are detected in the pyrolysis oil. This study highlights that the proposed method—swelling pretreatment followed by alkali impregnation and pyrolysis—enables efficient debromination with a significant reduction in alkali additive usage, offering a promising strategy for sustainable WPCB recycling.

Paper ID: 235

Dodecylamine-mediated indium recovery from spent liquid crystal display panels towards high value-added electrocatalysts

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Abstract:

Converting electronic wastes into high value-added catalytic materials is an effective way for reducing dependence on rare resources and enhancing sustainability of our society. Herein, we report an effective strategy that combines a dodecylamine (DDA)-mediated indium (In) recovery from spent liquid crystal display panels with a hydrothermal method for facile synthesis of In-based electrocatalysts towards high-efficiency electrochemical CO2 reduction reaction (eCO2RR). In this strategy, the rapid formation of coordinating compounds between the -NH2 group of DDA and metal ions enables the extraction of In3+ cations from the acidic LCDPs leach solution to an organic phase, which are then converted into InOOH nanoparticles with abundant oxygen vacancies (denoted as In-LCDPs and hereafter) through a low-temperature hydrothermal process. The eCO2RR evaluations confirm the superior electrocatalytic performance of the In-based nanoparticles produced from the LCDPs. In specific, within a broad potential range (-0.77 to -1.17 V vs RHE), the In-LCDPs show a Faradaic efficiency for formate (FEformate) of 85%, with the highest FEformate of 90.23% at -0.97 V vs RHE, which is comparable to the FEformate (93.8% at -0.97 V vs RHE) of In-based catalyst prepared from pure In precursors using the same method. Further investigations reveal that the Sn and Al impurities have minimal impact on the catalytic performance of In-LCDPs, while the presence of Fe3+ impurities significantly enhance the production of hydrogen during the eCO2RR. This work might have provided a scalable pathway to transform LCDPs into value-added electrocatalysts for eCO2RR.

Paper ID: 236

Pathways towards improved waste management: Integrating the roles of government, market, and society

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Abstract:

Government, market, and social forces can all influence municipal solid waste (MSW) management efficiency. However, the impact of synergies among government, market, and society on MSW management efficiency remains unclear. To address this gap, this study analyzes panel data from 30 Chinese provinces spanning 2015 to 2022 and employs a super–efficiency Slacks–Based Measure (SBM) model, treating carbon emissions as an unexpected output, to estimate MSW management efficiency. Subsequently, the study utilizes a government–market–society framework to identify determinants of MSW management efficiency and applies a multi–period fuzzy–set Qualitative Comparative Analysis (fsQCA) to examine pathways for enhancing efficiency. The findings reveal that no single condition is indispensable for achieving high MSW management efficiency; rather, various effective configurations emerge from the combinations of governmental, market, and societal conditions. For period 1 (2015–2018), pathways include market–society driven, government–society driven, and government–market driven; for period 2 (2019–2022), they involve society–driven, market–society driven, and government–market driven configurations. Market–society and government–market synergies have stabilized, while the role of social entities is increasing. This study deepens the understanding of the complex interactions among various determinants of MSW management efficiency.

Paper ID: 237

Industrial solid waste managementsystem: model development and strategies from a machine learning perspective

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Abstract:

Industrial solid waste (ISW) poses a severe threat to the natural ecology and human health, representing one of the significant constraints on sustainable development. Therefore, strengthening ISW management is crucial for advancing clean production processes and facilitating the transition of industrial structures towards eco-friendliness. Motivated by this, the present study developed a management system encompassing ISW influencing factors, generation prediction, and disposal characteristics to establish interconnections among various sub-domains of ISW management. Machine learning (ML) methods were employed to predict the generation characteristics and disposal scenarios of ISW in China, with model evaluations conducted using mean absolute percentage error (MAPE), root mean square error (RMSE), mean absolute error (MAE), and the coefficient of determination (R2). The research findings indicate that total energy consumption, completed floor area of buildings, industrial value added, and the number of enterprises in high-tech industries are the four primary indicators influencing ISW production. The extremely randomized trees (ET) model is deemed the most acceptable for predicting ISW in China. Across different scenario settings, the predictions reveal a trend of "continuous increase—gradual decrease—stabilization" in ISW generation in China from 2023 to 2060, with volumes ranging from 4 billion tons to 5 billion tons. Meanwhile, ISW utilization, disposal, and storage quantities all exhibit notable growth trends. Based on these predictions, the constructed ISW management system can enhance waste recycling and reuse efficiency, converting ISW into renewable resources. Furthermore, the study underscores the importance of safeguard mechanisms, including government policy guidance, industry-academia-research collaboration, green technological innovation, and the circulation of green products. These mechanisms collectively facilitate efficient waste recycling management, creating additional value for ISW materials.

Paper ID: 238

Leveraging knowledge graphs for key technologies in intelligent non-coal mines construction and operation

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Abstract:

The digitalization of mining is essential for enhancing mineral resource efficiency and ensuring sustainable development. With the evolution from digital to intelligent mines, new technologies and methodologies are being introduced, yet their complexity and interdisciplinary nature present challenges in synthesizing the fragmented knowledge scattered across academic literature, patents, and reports. This fragmentation impedes the systematic understanding and application of technologies in intelligent non-coal mining and operation. In this context, knowledge graphs have the potential to overcome the bottlenecks in technological innovation and systematic application in intelligent mining by extracting, integrating, processing, and utilizing the numerous entities and relationships embedded in key technologies. This study proposes a three-tier ontology model for intelligent non-coal mining, comprising "key technologies - application scenarios - physical foundation." Utilizing the bidirectional encoder representations from transformers (BERT) pre-trained language model, an enhanced Lattice-LSTM model is developed, integrating and improving bidirectional long short-term memory (BiLSTM) and Conditional Random Fields (CRF) to efficiently extract domain-specific knowledge from unstructured textual data. The model enables the identification of entities and relationships, systematically structuring the complex technological knowledge of intelligent mining, which is then stored in a Neo4j graph database. By advancing the integration of knowledge graph technologies with intelligent mining, this study contributes to addressing the challenges of knowledge fragmentation, the constructed knowledge graph optimizes the current key technology framework, and reveals the developmental pathways of key technologies in intelligent mining. With its targeted applications, uncovers potential directions for technological advancement, providing valuable insights into the technological evolution of the field. This research not only facilitates the intelligent transformation and upgrading of traditional mining operations but also offers theoretical foundations and technical support for the sustainable development of the mining industry, to promote more efficient decision-making and innovation in mining practices.

Paper ID: 239

Closed-loop recycling of cathode material from spent lithium-ion batteries via collaborative leaching and direct regeneration approach

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Abstract:

The efficient recycling of valuable metals in spent lithium-ion batteries is extremely important to alleviate the imblance between supply and demand of key metals. This article focuses on the direct regeneration mechanism of ternary cathode materials, with the objectives of pretreatment, valuable metal leaching, and in-situ recombination of waste lithium-ion batteries. Results show that the transition metals of cathode materials were reduced to metal oxides including CoO, NiO and MnO after reduction roasting,. The leaching efficiency of Ni, Mn, and Co were, 91.27%, 87.45%, and 88.57% respectively at a reaction time of 40 minutes and a reaction temperature of 80°C. Subsequently, in-situ regeneration research of motor materials was conducted. The regenerated cathode material presents high sphericity and uniform particle size distribution and a complete layered α-NaFeO2 crystal structure with a low cation mixing degree and layered structure. Besides, the crystal structure of the material assumes clear lattice fringes and a good crystallization degree. The electrochemical results show that the regenerated materials exhibit excellent reversible discharge capacity and cyclic stability of 143.7 mAh/g first discharge capacity, and the reversible capacity remained at 137.2 mAh/g after 50 cycles, with a retention rate of 94.8%, which has the application prospect of commercial electrode materials. The proposed recycling process in this paper lays a theoretical foundation for developing a short-range, clean, and green recycling process for spent lithium-ion batteries.

Paper ID: 240

A comprehensive study on the influence of pH for dewatering performance and filter cake characteristics in solid-liquid separation of clean coal

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Abstract:

The pH of solution significantly influences the interplay between polymer flocculants and clean coal, thereby affecting dewatering performance. Herein, a comprehensive study on the influence of pH for dewatering performance of clean coal was investigated from the perspectives of particle interaction and filter cake structure. The results reveal that as the solution transitions from acidic to alkaline, the filtration rate diminishes and the cake moisture content elevates, regardless of flocculant presence. Atomic Force Microscope (AFM) measurements indicated a reduction in the adhesion force of particles as the pH increases. CT analysis demonstrated that the filter cake porosity at pH 4 is markedly greater than those at pH 7 and 10. Upon reaching a pH of 10, the cake porosity further decreases to 5.41%, while the ratio of isolated pores to total pores increases to 17.15%. In acidic environments, the development of pore space in filter cake is more uniform and well connected, which indicates a substantially lower capillary pressure compared to that at pH 7 and pH 10. The Lattice Boltzmann Method (LBM) simulation results indicate that the permeability of the cake formed at pH 10 is notably lower than that of pH7 and pH4.

Paper ID: 241

Mapping Chinese plastic flows from 2001 to 2040 based on dynamic probabilistic material flow analysis and scenario projection

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Abstract:

Plastic waste management, deeply intertwined with our economy, presents a global challenge. Plastic pollution pervades both aquatic and terrestrial ecosystems worldwide. In a vast country like China, establishing a comprehensive plastic flow regime that accounts for socioeconomic disparities between urban and rural areas is essential for effectively reducing s plastic waste. This study aims to map the life-cycle of China's plastic flows from 2001 to 2040, distinguishing between urban and rural sources, through integrating dynamic probabilistic material flow analysis with scenario analysis. The results indicate that from 2001 to 2020, cumulative plastic waste generation was 1001 ± 14.6 million tonnes (Mt), with a higher proportion originating from urban areas (706 ± 10.3 Mt) compared to rural areas (218 ± 3.2 Mt). The rate of increase in mismanaged plastic wastes (MPWs) in rural areas outpaced that in urban areas, peaking in 2016, five years after the peak in urban areas. Consequently, the cumulative total of rural MPWs, including littering (103.5 ± 2.0 Mt) and open dumping (74.8 ± 1.5 Mt), was higher than that in urban areas (littering: 83.0 ± 4.0 Mt; open dumping: 70.3 ± 1.4 Mt). The scenario analysis forecasts a reduction of 96.5 ± 0.4 % and an 83.0 ± 2.1 % in MPW generations in urban and rural areas by 2040, respectively, if all interventions are implemented. However, strategies like reuse&recycling and reduce&substitute are less effective in rural areas compared to urban areas. Therefore, we recommend establishing a collection system with both penalties and incentives to reduce rural MPWs.

Paper ID: 243

Life cycle assessment and life cycle costing of solid oxide fuel cells: a systematic review

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Abstract:

Solid oxide fuel cells (SOFCs) have emerged as a highly promising technology for clean and efficient energy conversion, offering significant potential to reduce greenhouse gas emissions and enhance energy security. However, their environmental and economic performance must be comprehensively evaluated to guide their widespread commercialization and deployment. Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) methods are indispensable tools for understanding these implications and identifying opportunities for optimization. This study conducts a systematic review of 48 peer-reviewed articles extracted from authoritative databases, including Web of Science (WoS), Scopus, and ScienceDirect, to assess the state-of-the-art in LCA and LCC research applied to SOFCs. Through a rigorous analysis of the literature, we identify key trends, methodological approaches, and critical findings related to the environmental and economic performance of SOFCs in diverse applications, such as stationary power generation, combined heat and power (CHP) systems, auxiliary power units (APUs), and transportation. The results reveal substantial variability in environmental and economic impacts, primarily influenced by factors such as system boundaries, operational conditions, fuel sources, and end-user applications. Notably, the environmental benefits of SOFCs are strongly contingent on the energy source used for hydrogen production, with renewable-based systems demonstrating significantly lower greenhouse gas emissions compared to fossil fuel-based alternatives. Economically, while SOFCs face challenges due to high initial capital costs, ongoing advancements in materials science and manufacturing technologies are progressively driving cost reductions. Furthermore, the review highlights critical gaps in the existing literature, including the lack of standardized LCA methods and limited studies on end-of-life management and recycling strategies. These findings underscore the urgent need for harmonized and transparent LCA and LCC frameworks to enhance the comparability and reliability of results. The review provides actionable insights for policymakers, researchers, and industry stakeholders, offering a foundation for optimizing SOFC technology and advancing sustainable energy systems.

Paper ID: 244

Enhancing water resource sustainability: Accurate algal bloom forecasting through integrating machine learning and process-based modeling

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Abstract:

Accurate prediction of algal blooms is vital for water resource sustainability, as these blooms can severely impact water quality and the health of aquatic ecosystems. However, achieving reliable predictions using machine learning (ML) models typically requires high-frequency observational data, which is often scarce in real-world scenarios. While previous approaches have frequently relied on linear interpolation to fill gaps in low temporal-resolution data, this method may fail to accurately reflect true variations in water quality, potentially compromising sustainability efforts. To overcome this limitation, we propose a novel framework that integrates the process-based Soil and Water Assessment Tool (SWAT) with an ML predictor, explicitly considering the mechanisms underlying water quality changes. By leveraging SWAT's capability to simulate hydrological processes and nutrient dynamics, we generated daily estimates of key water quality parameters from monthly monitoring data in the Lam Tsuen River, Hong Kong, achieving a percentage of bias (PBIAS) below 20%. These reconstructed data were then utilized to train a random forest model for high temporal-resolution chlorophyll-a predictions, matching the accuracy of traditional biogeochemical models used for algal bloom assessments. By integrating process-based simulations with ML techniques, our framework not only aligns with the fundamental physical mechanisms affecting water quality but also provides timely forecasts essential for managing water resources sustainably. This approach ensures that stakeholders can make informed decisions to mitigate the impacts of algal blooms, thereby protecting aquatic ecosystems and supporting long-term water resource sustainability.

Paper ID: 245

Evaluating losses from water scarcity and the benefits of water resource management measures to intercity supply chains in china based on water quantity and quality

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Abstract:

In addition to insufficient per capita water resources and uneven spatiotemporal distribution, water pollution in China further exacerbates the risk of water scarcity. Existing studies typically rely on annual data for water quality and usage, overlooking significant monthly fluctuations and the potential dampening effect of annual averages on extreme monthly water quality. To date, no comprehensive, three-dimensional assessment of water scarcity has been conducted in Chinese cities that integrates water quantity, quality, and ecological factors. Furthermore, the current Water Scarcity Risk (WSR) methodology relies on subjective functions and parameter settings, failing to capture the adaptive behaviors of economies to water scarcity, which undermines the reliability of quantified water scarcity losses.This study uses monthly average water quality monitoring data from 3,414 national surface water sites across China to calculate monthly quality-adjusted water usage for each site and prefecture-level city. We develop an agent-based complex network model to estimate the interregional and intersectoral impacts of water scarcity based on both water quantity and quality. The study also evaluates the supply chain-wide economic benefits of three water resource management measures: improving water quality, increasing the use of reclaimed water, and implementing the South-to-North Water Diversion Project (SNWD).The findings show that regional water quality issues significantly exacerbate water scarcity in China, particularly in northern cities, leading to an additional RMB 42 billion in loss. At the urban level, 8% of the losses are directly due to reduced yields, with cities like Yinchuan, Xuzhou, and Karamay experiencing particularly severe direct losses due to regional water resource constraints. The remaining 92% of losses, totaling RMB 280.2 billion, are indirect. Improving surface water quality has the broadest impact, while the SNWD generates the greatest economic benefits. These findings provide valuable insights for mitigating water scarcity, fostering cross-regional cooperation, and reducing losses.

Paper ID: 246

Mix design and dynamic stability of Stone Mastic Asphalt Pavement surfacing with Recycled Concrete Aggregate

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Abstract:

This paper is an attempt to investigate the mix design and dynamic stability of Stone Mastic Asphalt (SMA) containing different amounts of Recycled Concrete Aggregates (RCA) for pavement surfacing. Utilisation of RCA in asphalt mixtures as a sustainable alternative to natural aggregates can be justified after a comprehensive mix design and assessment of dynamic stability. The mix designs of the RCA based SMA mixtures were conducted using Marshall method of design, the dynamic stability was evaluated using loaded wheel tracking experiment. The replacement levels adopted for coarse aggregate replacement were 0%, 20%, 40%, 60%, 80%, and 100%. One more replacement level of 100% utilisation of both fine and coarse RCA was also included in the study. The Optimum Binder Contents (OBCs) of the mixtures increased with increase in the amounts of RCA. The mixtures containing RCA achieved higher stability values than the control. Only the mixtures containing coarse RCA exhibited better dynamic stability than the control. The mixture containing both fine and coarse RCA is the only mix that violated the 6 mm maximum rut depth requirement at the test temperature of 60 oC. There was a strong correlation between coarse RCA content and rut depth with R2 of 0.96. It was concluded that utilisation of coarse RCA in SMA offers a better dynamic stability due to the interlocking and adhesive properties of RCA. Implementation of RCA based asphalt mixture will help to achieve circular economy in construction industry. Inclusion of fines from demolition wastes to SMA is discouraged as it would lead to loss of dynamic stability.

Paper ID: 247

Synergistic application of remote sensing technology and artificial intelligence for water quality monitoring in inland water bodies

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Abstract:

Accurate quantification remains a critical yet technically demanding aspect of water quality assessment. The synergistic application of remote sensing technology and artificial intelligence (AI) is increasingly demonstrating its potential to address the challenges faced in water quality monitoring. Remote sensing technology enables large-scale coverage and efficient, real-time acquisition of the distribution characteristics of water quality, compensating for the shortcomings of traditional monitoring methods. The advent of AI architectures provides unprecedented opportunities to decode complex spectral-water quality interconnections, particularly resolving high-dimensional nonlinear correlations between multispectral scattering characteristics and aquatic biogeochemical parameters. The study provides a detailed overview of the application of AI and remote sensing technology in the retrieval of concentrations for seven water quality parameters, and compares these AI-based retrieval models with those constructed with traditional methods. These parameters include chlorophyll-a (Chl-a), phycocyanin (PC) and five non-optically active constituents (NOACs). Besides, the study elaborates on the broad prospects of AI in the fusion techniques of multi-source remote sensing data in the preprocessing of remote sensing images. Finally, it discusses major issues that need further research in the application of remote sensing technology and AI in water quality monitoring. This study endeavors to equip academic and regulatory stakeholders with a strategic framework and evidence-based guidance to catalyze technological breakthroughs in AI-driven remote sensing for water quality surveillance.

Paper ID: 248

Material and leaching properties of recycled crushed stone from ash from wood biomass power plants

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Abstract:

Currently, the number of biomass power plants that can contribute to carbon neutrality is increasing. As a result, the volume of biomass ash generated from these plants is also rising, making it urgent to explore effective ways to utilize this ash. However, it is difficult to control the generation of ash due to the presence of heavy metals and variations in physical properties such as particle size. Therefore, it is essential to clarify the characteristics of biomass ash and promote its effective utilization.

The purpose of this study is to understand the properties of recycled crushed stone made from biomass ash. In particular, the effect of the amount of water mixed into the initially solidified soil before crushing on the strength of the recycled stone is determined through unconfined compression tests, and the characteristics of the recycled stone are evaluated using cone index tests. Additionally, leaching tests are conducted to assess the environmental safety of the recycled material when applied to surrounding soil.

The results suggest that both the strength of the initially solidified ground and the strength characteristics of the recycled crushed stone are significantly influenced by factors such as curing duration, type of ash, and the amount of mixing water. Furthermore, the leaching tests conducted to evaluate the environmental safety of the recycled crushed stone indicate that the amount of harmful substances leached is greatly affected by the type of ash and the combustion materials.

These findings suggest the need to focus on the mixing conditions during the initial soil solidification process.

Paper ID: 249

Cost and environmental impact evaluation of perovskite photovoltaics based on prospective life cycle assessment

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Abstract:

Perovskite photovoltaics (PVs) have emerged as a leading next-generation solar technology due to their exceptional photoelectric conversion efficiency. Accelerated commercialization of perovskite PVs offers diverse pathways for building sustainable power systems and achieving climate mitigation targets. However, their large-scale deployment remains constrained by unresolved challenges in lifecycle costs and environmental impacts. This study employs a prospective analysis to develop a dynamic lifecycle cost (LCC) and lifecycle assessment (LCA) framework for perovskite PVs. The framework integrates technology learning curves for cost and environmental impact and material flow analysis, quantitatively evaluating the levelized cost of electricity (LCOE), carbon footprint, and other environmental impacts of large-scale perovskite PV applications. It systematically identifies commercialization barriers and pinpoints key material and process bottlenecks. Through multi-criteria decision analysis, threshold models for efficiency-lifetime-cost and efficiency-lifetime-environmental impact relationships are established. Comparative analyses with traditional technologies (crystalline silicon PV) estimate performance benchmarks for market entry. The study further proposes a phase industrialization roadmap for perovskite PVs, providing quantitative decision support for strategic optimization of perovskite PV development, scaling deployment potential, and evidence-based policy guidance for renewable energy standardization.

Paper ID: 250

How does climate policy uncertainty affect urban green innovation?

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Abstract:

Green innovation is a key strategy for balancing environmental and economic benefits, driving regional green transitions, and achieving dual carbon goals. Governments influence urban green innovation both directly and indirectly through the formulation and implementation of climate policies. However, due to inherent differences among policymakers in terms of interests, objectives, and capacities—as well as the complexity of coordinating multiple climate policy tools—uncertainty often arises throughout the policymaking and implementation process, thereby hindering sustainable urban development. This study empirically examines the differential impacts of climate policy uncertainty on heterogeneous urban green innovation using regional activity data from 154 Chinese prefecture-level cities between 2000 and 2022. The results indicate that climate policy uncertainty significantly enhances urban green innovation performance, primarily by stimulating technological innovations to reduce carbon emissions from fossil energy sources. In cities with high levels of climate policy uncertainty, green innovation related to fossil energy decarbonization is particularly active. Moreover, this effect varies depending on the mode of innovation: collaborative innovation significantly amplifies the positive impact of climate policy uncertainty on urban green innovation. Overall, the findings suggest that when promoting the green transformation of urban industries, policymakers should carefully consider the uncertainty stemming from policy ambiguity and fluctuations. Furthermore, they should leverage the positive effects of policy uncertainty on heterogeneous urban green innovation. This study contributes to the micro-level analytical framework of urban green transformation from the perspective of policy uncertainty. It offers new insights for policymakers to better understand climate policy uncertainty risks and implement sustainable development strategies.

Paper ID: 252

Carbon footprint of different classes of roads in China: an up-to-date case study from a life-cycle perspective

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Abstract:

Each stage of road construction, including material production, construction, and maintenance, consumes resources and energy, resulting in carbon emissions. Assessing the life-cycle carbon footprint of road of different classes will facilitate the development of low-carbon roads. This study developed a comprehensive carbon emission calculating model for China's roads based on a process-based Life Cycle Analysis (LCA) framework, which encompassed all stages from material production to road demolition. Using Beijing as a case study, we quantified carbon emissions across the life cycle stages of multiple classes of roads. Additionally, we conduct a sensitivity analysis on key energy and carbon emission factors and evaluates the impact of three mitigation scenarios: the use of recycled asphalt, optimized cement production processes, and the electrification of non-road mobile machinery. The results indicate that the material production contributes over 40% of the life-cycle carbon emissions, while the mixture production phase contributes more than 35%. As road classification upgrades, the carbon emission share from asphalt-related processes rises from 43.2% for tertiary roads to 55.5% for highways, while the emission contribution from cement-related processes declines from 28.1% to 15.8%. Factors related to heavy oil, modified asphalt, diesel, coal, and cement show sensitivities ranging from 54.2% to 13.3%. The use of recycled asphalt and low-carbon cement can reduce the road carbon footprint by 8.9% to 37.4%, while electrification of non-road mobile machinery can achieve similar reductions. To reduce the use of fossil energy-intensive materials and technologies, the use of low-carbon materials and the electrification of construction machinery should be encouraged in future road construction and management.

Paper ID: 253

Risk characteristics, transmission pathways and regulatory strategies in secondary land market

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Abstract:

Establishing a competitive, open, and unified secondary land market is essential for efficient land resource allocation and economic development. However, deficiencies in the regulatory system impede market flow, reducing resource allocation efficiency. To address this, this study investigates secondary land market risks by creating a nationwide dispute database using adjudication documents from China Judgments Online. Through text analysis and Interpretive Structural Modeling (ISM), it identifies key risk factors and transmission pathways, ultimately offering regulatory strategies. The research findings highlight the following: (1) The secondary land market encompasses seventeen risk factors classified into seven major categories, including transaction rules, entity behavior, entity integrity, entity capacity, transaction subjects, contract effectiveness, and market environment. These factors encompass risks such as incomplete transaction rules, land-related illegal activities, economic misconduct, official malfeasance, procedural non-compliance, contract fraud, entity default, infringement of national or collective interests, infringement of legitimate rights of land users, improper enforcement, inadequate financial capacity, irregular registration, defective land transactions, non-standard contract texts, contract invalidity, land price bubbles, and insufficient transaction liquidity. (2) The secondary land market features six risk transmission pathways, primarily involving the transmission of market environmental risks and policy institutional risks to entity-related risks. (3) Guided by the principles of an "active government" and an "efficient market," a regulatory framework for the secondary land market is established, focusing on the entire transaction process and covering institutional environment, market order, regulatory subjects, regulatory bodies, and regulatory targets. This research contributes to the expansion and enhancement of the knowledge system of risk research in the secondary land market, supplements paradigms and methods in land market risk management research, and holds significant practical value for enhancing risk prevention capabilities and promoting the flow and allocation of land resources in the secondary land market.

Paper ID: 254

Carbon and cost implications of integrating green hydrogen with coal chemical production in China

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Abstract:

China's coal chemical sector uses coal as both a fuel and feedstock and its increasing greenhouse gas (GHG)emissions are hard to abate by electrification alone. Here we explore the GHG mitigation potential and costs for onsite deployment of green H2 and O2 in China's coal chemical sector, using a lifecycle assessment and techno-economic analyses.We estimate thatChina's coal chemical production resulted in GHG emissions of 1.1 gigaton CO2 equivalent (GtCO2eq) in 2020, equal to 9% of national emissions. We project GHG emissions from China's coal chemical production in 2030 to be 1.3 GtCO2eq, ~50% of which can be reduced by using solar or wind power-based electrolytic H2 and O2 to replace coal-based H2 and air separation-based O2 at a cost of 10 or 153 Chinese Yuan (CNY)/tCO2eq, respectively. We suggest that provincial regions determine whether to use solar or wind power for water electrolysis based on lowest cost options, which collectively reduce 53% of the 2030 baseline GHG emissions at a cost of 9 CNY/tCO2eq. Inner Mongolia, Shaanxi, Ningxia, and Xinjiang collectively account for 52% of total GHGmitigation with net cost reductions. These regions are well suited for pilot policies to advance demonstration projects.

Paper ID: 255

Sustainability of nature-based tourism in the Sundarban, India: an emergy analysis approach

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Abstract:

Nature-based tourism destinations, including national parks, wildlife reserves, and ecologically sensitive areas, have experienced significant global surge in tourist footfall. Thus, sustainable tourism development has received extensive attention, emphasizing the need for a system-based perspective and an interdisciplinary approach to effectively evaluate its sustainability. This study aims to assess sustainability of nature-based tourism system in the Sundarban, a UNESCO world heritage site, through emergy analysis (EmA), a holistic method that quantifies all energy inputs to evaluate environmental and economic impacts. Data from various field surveys, GPS-based surveys, GIS-based modelling, ARIMA modelling, government sources, and existing literature were used for the EmA. In 2023, the Sundarban has received nearly one million tourists, exerting significant pressure on local resources, with tourist consumption nearly 3.5 times than that of the average local residents. Tourism generated $46.33 million in income, but the relatively high Emergy-to-Earn Ratio (ENR) (Sej year-1 $-1) highlights the resource-intensive nature of tourism, raising concerns about the long-term economic viability of current tourism practices in the region. The Environmental Sustainability Index (ESI) of 0.591 indicates a moderate level of environmental sustainability, while the system's low Environmental Loading Ratio (ELR) of 0.183, contrasts with a low Emergy Yield Ratio (EYR) of 0.108, which undermine overall sustainability. The EmA findings indicate that without significant changes, the system may not be sustainable in the long term. Sobol' sensitivity analysis revealed that imported emergy (Si = 0.429 and STi = 0.329) has the greatest impact on the region's sustainability. Scenario analysis clearly pinpoints that sustainable tourism practices could be ensured by reducing per capita resource consumption by tourists, promoting a resource-efficient and environmentally conscious tourism model to accommodate emergent tourism traffic in this region. Finally, policy recommendations were proposed as an exit strategy to transit towards a higher level of environmental sustainability and well-being.

Paper ID: 256

Quantitating and decomposing driving factors of carbon emissions in the China's iron and steel industry from the perspective of energy-material-economy nexus

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Abstract:

A deep understanding of the driving factors of carbon emissions is the foundation for formulating effective carbon reduction policies in the iron and steel industry (ISI). These driving factors involve multiple aspects, presenting a complex nexus throughout the entire process from economic demand, material production to energy consumption and carbon emissions. As a result, it is difficult to quantify and decompose these factors comprehensively at the same time. To fill this gap, we established a carbon emission calculation formula for ISI based on energy-material-economy nexus (CISEME) by combining material flow analysis, energy and carbon flow analysis and the input-output model. The CISEME involves multiple factors from the energy-side (such as energy intensity, energy structure, and carbon emission factor), the material-side (such as steel consumption intensity, production efficiency, and process structure), and the economy-side (such as economic scale, industrial structure, and input-output structure). Based on the CISEME, we further applied the Logarithmic Mean Divisia Index (LMDI) decomposition method to reveal the coupled impacts of these driving factors on carbon emissions, with a case study of China's ISI (CISI) from 2007 to 2022. The results indicate that the impact of the demand-side factors was greater than that of production-side factors over all periods. The final demand has the greatest impact on carbon emission growth in CISI. While the steel consumption intensity effectively curbed carbon emissions from 2007 to 2017, but showed a rebound since 2017, indicating an increasing dependence of secondary industry on steel for economic output. Additionally, energy efficiency became more important for carbon reduction recently. It is suggested that policymakers attach great importance to coordinating economic, steel, and energy policies when formulating emission reduction policies, and should continuously promote economic structure optimization, reduce steel consumption intensity, as well as provide policy support for the development of energy-efficient technologies.

Paper ID: 257

Multifaceted benefits of magnesium hydroxide dosing in sewer systems: Impacts on downstream wastewater treatment processes

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Abstract:

Magnesium hydroxide [Mg(OH)2] is a non-hazardous chemical widely applied in sewer systems for managing odour and corrosion. Despite its proven effectiveness in mitigating these issues, the impacts of dosing Mg(OH)2 in sewrs on downstream wastewater treatment plants have not been comprehensively investigated. Through a one-year operation of laboratory-scale urban wastewater systems, including sewer reactors, sequencing batch reactors, and anaerobic digesters, the findings indicated that Mg(OH)2 dosing in sewer systems had multifacted benefits on downstream treatment processes. Compared to the control, the Mg(OH)2-dosed experimental system displayed elevated sewage pH (to 8.8±0.1), reduced sulfide concentration by 35.1±4.9% (6.7±0.9 mg S/L), and lower methane concentration by 58.0±4.9% (19.1±3.6 mg COD/L). Additionally, it increased alkalinity by 16.3±2.2% (51.9±5.4 mg CaCO3/L), and volatile fatty acids concentration by 207.4±2.2% (56.6±9.0 mg COD/L) in sewer effluent. While these changes offered limited advantages for downstream nitrogen removal in systems with sufficient alkalinity and carbon sources, significant improvements in ammonium oxidation rate and NOx reduction rate were observed in cases with limited alkalinity and carbon sources availability. Moreover, Mg(OH)2 dosing in upstream did not have any detrimental effects on anaerobic digesters. Magnesium-phosphate precipitation led to a 31.7±4.1% reduction in phospahte concentration in anaerobic digester sludge supernatant (56.1±10.4 mg P/L). The retention of magnesium in lsudge increased settleability by 13.9±1.6% and improved digested sludge dewaterability by 10.7±5.3%. Consequently, the use of Mg(OH)2 dosing in sewers could potentially reduce downstream chemical demand and costs for carbon sources (e.g., acetate), pH adjustment and sludge dewatering.

Paper ID: 258

Heavy metal concentrations in rice that meet safety standards can still pose a risk to human health

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Abstract:

Long-term consumption of rice containing heavy metal(loid)s poses significant risks to public health, which can be scientifically evaluated through food safety assessment. However, spatial variability and uncertainty in exposure parameters are generally neglected in existing food safety assessment standards. This study focused on rice consumption in 32 provinces ofChina, and extracted 3376 data points of five heavy metal(loid)s (cadmium, arsenic, mercury,lead, and chromium) and two nutrient elements (copper and zinc) from 408 articles. Probability and fuzzy methods were integrated to cope with the spatial variability or uncertainty and more accurately evaluate the risk. The results demonstrated that long-term consumption of rice that meets the national food safety standards still can cause non-negligible health risks, particularly for children and toddlers with chronical exposure. Arsenic and Cd were found to be the most critical elements, which contribute to 64.57% and 22.38% of the overall human health risk, respectively. Fuzzy assessment indicated that the score in northern China is approximately eight folds of that in southern China, indicating that northern rice has lower risks and better nutrition. Our results demonstrate that the food safety standards need to be tailored according to local conditions with more specific receptor parameters and risk acceptance.

Paper ID: 261

Modelling the impact of anthropogenic wastes on greenhouse gas emissions from the enigmatic mangroves of Indian Sundarban

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Abstract:

The greenhouse gas (GHG) emissions from the mangrove ecosystem due to climate change have become a significant environmental concern in the present scenario. However, the GHGs, emitted through anthropogenic activities in these vulnerable regions are often overlooked. The level of soil pollution has escalated due to the uncontrolled disposal of wastes from ports, ferry services, plastics, and metals, contributing to substantial GHG emission. In this study, a novel process based dynamic model was developed using R programming language to simulate the emission of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), incorporating both anthropogenic and environmental drivers. R “deSolve” package was used for model stimulation and “ecolmod” was used for model calibration. GHGs were estimated using Multiple Gas Analyzer (HORIBA JAPAN, VA-VS 5000). The content of heavy metal and microplastic in the soil was estimated using Atomic Absorption Spectrometer, Fourier transform infrared spectroscopy respectively. Identification of soil microbial communities was carried out through phylogenetic analysis using DADA2 methodology and R package “Phyloseq” and “ampvis2”. The CO2 emission was sensitive to HMeff2 (impact rate of heavy metals on microbial respiration process) and MPeff3 (impact rate of microplastics on microbial respiration process). The CH4 dynamics was sensitive to HMeff1 (impact rate of heavy metal on methanogenesis process) and MPeff1 (impact rate of microplastics on methanogenesis process) and the N2O pool was sensitive to N2O dif rt. (N2O diffusion rate). Key contributor to GHG emissions in the Sundarban includes fish waste, heavy metals, and microplastics. Effective monitoring and control of plastics, fish wastes, and heavy metals contaminations along with strategic implementation of no-plastic or no-waste zones in line with the Sustainable Development Goals (SDGs) could provide viable solutions to mitigate this environmental challenge.

Paper ID: 262

Carbon emissions implications of energy infrastructure investments in Belt and Road Initiative host countries

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Abstract:

Energy infrastructure investments are crucial in shaping carbon emissions trajectories, particularly in developing countries striving to balance growing energy demands with sustainability goals. Under the Belt and Road Initiative (BRI), China's large-scale energy investments present a unique opportunity to assess their environmental impact across host nations. This study evaluates the effects of carbon emissions on BRI energy infrastructure investments, examining a range of power sources—including coal, hydropower, solar, wind, and nuclear energy. We analyze these impacts under three distinct scenarios using the GTAP-E-Power model and project-level data from BRI countries. The findings reveal three key insights. First, significant substitution effects among different energy sources alter the overall emissions landscape. While coal-fired power plants raise environmental concerns, their deployment under BRI reduces net emissions in lower-middle-income and upper-middle-income countries by displacing less efficient fossil fuel sources. Second, host developing countries can simultaneously achieve economic growth and carbon reduction by leveraging foreign investments to access cleaner and more efficient energy technologies. Third, a comparative scenario analysis underscores the importance of prioritizing clean energy investments once immediate electricity shortages are addressed. This research offers actionable insights for BRI host nations, emphasizing the need for strategic energy planning to align economic development with carbon mitigation efforts. By adopting carbon-conscious infrastructure strategies, these countries can enhance energy security, accelerate the transition to cleaner energy, and contribute to a more sustainable global energy landscape.

Paper ID: 263

Evaluating manure management strategies on material flow of agricultural system at the field-village-township level in China

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Abstract:

The agro-pastoral ecotone in northern China confronts prominent issues, including water shortage, worsening soil desertification, decreasing farmland organic matter, and decoupling of crop-livestock system. These not only heightened the risk of agricultural non-point source pollution but also reduce the ecosystem's carbon sequestration capacity. The integrated crop-livestock system could mitigate these issues. However, circularity is a scale - specific issue, and how to establish this system at different scales remains unclear. This study aimed to elucidate how different manure management methods affect nutrient flow and substance cycling in fields, villages, and townships in typical areas of the agro-pastoral ecotone. Determine whether the region can achieve circular agriculture (planting - breeding integration) by regulating manure management methods. We chose Liangzhou District in Gansu, China, which consists of 39 towns and 436 villages, as a case study. By applying conservation of mass law to calculate substance utilization efficiency and recycling rate. The results demonstrated that the system substance utilization efficiency (SUE) at different scales hinges on the material cycling degree within the systems and the level of exogenous material supplementation. The nitrogen recycling rates (NRR) at the field, village, and township scales were 76%, 77.4%, and 74.7% respectively. This indicates the integrated crop-livestock system has the highest self-sufficiency rate of various substances at the village scale, with the least exogenous demand. Carbon, phosphorus, and potassium trends were overall consistent with that of nitrogen. The nitrogen use efficiencies (NUE) of the crop, livestock, and manure management systems were 48.3-60.9%, 83.9-86.9%, and 54.0-78% respectively. In the crop system, leaching was the main loss pathway, mainly due to local extensive flood irrigation. Therefore, more emphasis should be placed on reducing nitrogen losses from fertilizers in the crop system, a key strategy for efficient substance cycling in the integrated crop-livestock system.

Paper ID: 264

Remote sensing perception model of farmland landscape complexity and its application in crop remote sensing classification

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Abstract:

Cropland plays an important role in the food system, being essential for food provision, carbon fixation, soil protection, and water resource management. Mapping data based on remote sensing imagery is fundamental for cropland monitoring and food security. Some studies have found that farmland landscape information such as crop number, aggregation degree, fragmentation degree, plot shape, and plot size in the monitoring area have a significant impact on crop remote sensing recognition features and classification algorithms. However, the scale of remote sensing data used to describe the landscape in current research is coarse. Moreover, the understanding of the complexity of farmland landscape is relatively general and lacks systematic induction. In addition, research often summarizes the law between farmland landscape and classification accuracy through prior knowledge such as historical crop distribution maps, and the model transferability is poor. In our study, the real scene of the farmland landscape was described based on the high-resolution UAV images of the field survey. In the case of prior knowledge, realize the division of farmland landscape complexity, explore the influence of landscape factors on crop remote sensing classification under different landscape complexity divisions, and summarize the indicative role of farmland landscape information on crop remote sensing classification. The farmland landscape is partitioned by evaluating the complexity of the farmland landscape, and the classification features and classifiers are optimized for different partitions. The optimal crop remote sensing classification features and classification algorithms in different complexity partitions are excavated in the experimental area, and compared with traditional classification methods. Perform comparative performance evaluations. The research confirms that the model method in this paper has the ability of large-scale remote sensing classification and mapping of crops with high accuracy, and provides method exploration and application demonstration for using farmland landscape information to guide crop remote sensing classification.

Paper ID: 265

An implementation framework for utilizing smart technologies in construction and demolition waste management

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Abstract:

Effective management of construction and demolition waste (CDW) could yield substantial economic and environmental benefits for projects. Smart technologies provide solutions in this field, promoting sustainable development within the construction industry. However, significant gaps remain in current research regarding the integration of smart technologies within a unified framework. Therefore, the aim of this research is to establish an implementation framework for CDW management (CDWM) that integrates smart technologies and enhances the intelligence and efficiency of CDWM. This study was conducted by searching the Web of Science core database for literature related to CDW and smart technologies. A total of 214 articles were obtained through manual screening. The articles were then categorized according to seven technologies—Artificial Intelligence (AI), Building Information Modelling (BIM), Geographic Information Systems (GIS), Big Data, Internet of Things (IoT), Remote Sensing, and Blockchain—with three to five representative papers selected for each technology for a comprehensive review. It was found that the most mature technologies currently applied in the field include AI, BIM, GIS, and Big Data. Based on the application scenarios of these technologies and their limitations, this study classifies them into five categories: (1) spatial technologies, (2) recognition technologies, (3) data communication and collection technologies, (4) data management and processing technologies, (5) data exchange and transaction technologies. The specific application scenarios of these technologies are further categorized according to the five phases of the CDW life cycle: design, construction, demolition, transportation and disposal /recycling. Accordingly, this study proposes an implementation and application framework based on these considerations. The framework guides practitioners in integrating technologies, conducting full life cycle research, and bridging the gap between mature and emerging technologies. It also provides a solid foundation for future academic research on specific categories of smart technologies, enabling comparative analyses and the optimization of strategic choices.

Paper ID: 266

Cross-modal modelling of infrared spectra and photo image towards fast characterization of municipal solid waste

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Abstract:

Efficient characterization of municipal solid waste (MSW) serves as a critical prerequisite for automated sorting systems, which enables optimized energy recovery through targeted material processing. While existing machine learning models utilizing spectral or photographic data achieve rapid property identification within seconds, single-sensor models suffer from limited informational scope and environmental adaptability. To overcome these issues, we developed multi-modal characterization models integrating spectral and photographic data, proposed an innovative sorting system based on chemical characteristics, and explored the economic and environmental potential of the system in the downstream energy recovery. To solve the compatibility challenges arising from structural, representational and correlational differences between heterogeneous datasets, a cross-modal fusion framework was developed. The relative weights of spectral and photographic inputs on the predictive accuracies were discussed. The optimized hybrid model demonstrated accuracies of 99.49%-99.78% in predicting thermal, physical and kinetic properties. It outperformed relevant unimodal models in both property coverage and prediction accuracy. Mechanistic analysis through feature mapping revealed spectra-particularly C-H bend vibrations-as the primary discriminative factor, while photographic data provided auxiliary support. Building upon the multi-modal characterization model, a new sorting system prioritizing thermokinetic characteristics over conventional source/density-based criteria. Implementation simulations projected 10% enhancement in energy conversion efficiency, translating to potential economic gains of 320668.40 RMB/day and carbon mitigation of 603.95 tCO_2/day across Chinese MSW facilities. This work establishes a sensor-fusion framework that redefines smart waste management strategies, and explores the influence mechanism of multi-modal models that provides data-model-theory basis, advancing both fundamental characterization methodologies and industrial-scale circular economy practices.

Paper ID: 268

Investigation on permeability of filter cake with different particle sizes: experimental and simulation study

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Abstract:

Cake permeability is a crucial macroscopic physical property in characterizing filtration behavior for coal slurry. However, there is still no appropriate model derived to establish the essential relationship between the cake permeability and complex particle property. In this study, the three-dimensional microstructures with different particle gradation and porosity were generated using particle discrete element software. The permeability of each constructed model was calculated utilizing Lattice Boltzmann Method (LBM). Simulation result shows that the Kozeny–Carman (KC) model is proper to predict the permeability of porous media with different gradations. When the gradation parameters are not considered, it shows that d30 can best represent the particle size characteristics of the particle systems. When the porosity and average particle size remain unchanged, the permeability increases with the increasing of the non-uniformity coefficient (Cu) and the curvature coefficient (Cc). Moreover, we proposed an analytical expression for the permeability estimation with different gradation characteristics, which contains the parameters that can be easily measured in engineering. Then a set of coal slurry samples with different particle size distributions were selected to conduct the filtration test, the permeability of each sample was measured to compare with the predicted results of the gradation permeability model. It is clear that the KC equation in this case can not calculate the cake permeability effectively. Although the gradation model is relatively appropriate to estimate the cake permeability, its accuracy still needs to be improved by considering the pore structure property to eliminate the effect of constant terms.

Paper ID: 269

ESG Policy Mismatch: Evidence from the Difference in ESG Perceptions based on China Social Media: Public VS. Private

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Abstract:

Environmental, Social, and Governance (ESG) is a strategic tool used by the government to measure companies' performances and mitigate relevant risks. The attention on studying SDGs and ESG is increasing to better utilize strategic tools in reaching sustainability. The impediment of the promotion of ESG regulations and the achievement of various sustainable development goals caused the policy mismatch of ESG. Academic contributions to the better integration of SDGS and ESG are lacking. This study aims to apply the value-belief-norms theory to develop one theoretical model to reveal the policy mismatch problem of ESG by exploring the public and private sectors' focus on SDGs and ESG in China. This study uses a natural language processing technique to generate topic clustering and trend evolution by capturing qualitative data from Weibo, which is a popular social media in China. The results show that the public focus on ESG is more SDG-oriented; conversely, the private sectors focus more on specific ESG regulations.

Paper ID: 270

Investigating the influence of stakeholder pressure on environmental proactivity in the construction industry using structural equation modeling (sem)

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Abstract:

As the construction industry faces mounting pressure to adopt sustainable practices, understanding the mechanisms through which stakeholder influence drives environmental proactivity is critical. While prior research has established the significance of stakeholder pressure in shaping corporate sustainability efforts, existing studies often overlook the distinct ways in which different stakeholder groups—regulatory bodies, clients, and social actors—affect firms' environmental motivations and strategic responses. This study aims to address this gap by applying Structural Equation Modeling (SEM) to examine how diverse forms of stakeholder pressure translate into proactive environmental practices within the construction sector in Hong Kong and Mainland China.

Drawing on survey data from 120 construction-related organizations, this research categorizes stakeholder pressure into regulatory, economic, and social dimensions and explores their impact on firms' proactive motivations, including reason-to, can-do, and energized-to motivations. The study further investigates how these motivations influence distinct environmental practices, namely planning and organizational, operational, and communicational strategies. Through SEM analysis, the study reveals the differential pathways through which stakeholder expectations shape corporate environmental behavior, providing a nuanced understanding of how firms navigate sustainability challenges under varying external pressures.

By integrating stakeholder theory with proactive motivation frameworks, this study offers practical implications for construction firms seeking to align their sustainability efforts with stakeholder demands. The findings also provide policy insights, guiding regulators in designing more effective incentives and enforcement mechanisms to enhance environmental performance in the industry.

Paper ID: 271

Assessing Resource Benefit and carbon mitigation potential of China’s Electronic Waste Recycling

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Abstract:

The majority of discarded electronic waste were idled or disposed informally especially in developing countries. Recycling and reuse of electronic waste not only helps alleviate China’s heavy reliance on mineral resources but also contributes to carbon emission reduction and achieving carbon neutrality. In this regard, we have showcased the future potential for utilizing ten types valuable bulk materials and rare metals under three recycling scenarios, as well as the corresponding carbon emission reduction outcomes, through developing an integrated assessment model towards waste recycling. The results indicate that with an increase in recycling rates, these materials can be formed into loops-closed increasingly. By 2060, under the low recycling scenario, recycled resources can provide an average of 85% of raw materials for production. Under the medium recovery scenario, platinum and vanadium will form a closed production loop, while under the high recycling scenario, recycled resources can provide over 95% of raw materials for production, and in addition, plastics and palladium can also form closed loops. Further, 479.65 million, 538.64 million, and 586.08 million tons CO2 can be reduced by 2060 in the three recycling scenarios. This study provides policy implications of improving the recycling rate of electronic waste especially in developing countries, in order to promote their sustainable economic development and resource supply.

Paper ID: 272

Impact of Energy Resources Mismatch on the Green Growth Performance of the "the Belt and Road" Countries

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Abstract:

Green development is a key feature of high-quality progress in the Belt and Road Initiative (BRI), yet energy and resource mismatches hinder green growth in BRI countries. This study analyzes panel data from 2011 to 2023 for these countries. First, It uses DEA-EBM model to to measure the green total factor productivity (GTFP) of these countries. Next, it examines how energy and resource mismatches affect GTFP and explores the underlying mechanisms from the perspectives of factor-biased and output-biased technological changes. Finally, it compares Asia and Europe and estimates GTFP gains from correcting these distortions using counterfactual analysis.The findings reveal the following:1) A higher degree of energy and resource mismatch, exemplified by subsidies for non-renewable energy prices, correlates with lower GTFP in BRI countries, a conclusion that holds firm across various robustness tests. 2) Energy and resource mismatches primarily affect a country's green growth performance through two effects: an "enhanced energy use bias" and an "enhanced undesirable output bias." 3) Subsidies for non-renewable energy prices amplify the energy use bias in energy-driven countries, reduce capital input in capital-driven countries, but have no significant substitution effect in labor-driven countries. 4) Compared to European countries, Asian countries exhibit a higher degree of energy and resource distortion, with a greater negative impact on GTFP. 5) Eliminating energy and resource mismatches could boost GTFP by 26.91% across all BRI countries, with increases of 23.93% for European countries and 29.89% for Asian countries, based on their current levels.

Paper ID: 273

Research on the optimization path of gaseous pollutants and CO2 emissions reduction in Inner Mongolia from the perspective of energy

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Abstract:

As an important energy base in China, it is urgent to explore the scientific path of CO2 emissions and gaseous pollutants reduction for Inner Mongolia.

In this study,the Energy Flow Analysis(EFA),Material Flow Analysis(MFA) and Input Output Model(IO) multiple methods were used to build a complex path model of Inner Mongolia pollution reduction and carbon reduction synergistic effect, analyze the difference between Inner Mongolia's pollution and carbon emissions in the past 20 years and the endogenous development effect and measure effect of Energy,Economy and Environment(3E) system under different scenarios, and explore the optimal path of Inner Mongolia pollution reduction and carbon reduction. The main conclusions of this study are as follows:(1) Gaseous pollutants will reach the peak in 2027 at the earliest. (2) The optimization measures of power generation structure in the region can effectively promote the clean transformation of energy structure.(3) The proportion of electricity in the future energy structure has been greatly improved, with an increase of about 6% to 12%.(4) Thermal power generation still accounts for a large proportion in the current and future energy structure, which cannot be completely replaced by clean power.

This study uses simulation analysis method to make forward-looking guidance for the future policy planning of resource-based regions represented by Inner Mongolia.

Paper ID: 274

Decarbonization and equalization: The dual effects of supply chain restructuring within China

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Abstract:

The supply chain restructuring within China could result in CO2 emission change of provinces, how to develop an effective reduction strategy is of great importance, and whether “side effects” on environmental-economy inequality across provinces exist while reducing emissions remains unknown. To investigate the dual effects on decarbonization and equalization of domestic supply chain restructuring (SCR), we first identify the critical provincial-sector for low-carbon SCR targeting the sector with a large carbon footprint based on the environmentally-extended multiregional input-output model with hypothetical extraction method, and reveal the CO2 reduction effect of marginal restructuring. A regional environmental inequality index is utilized to examine the impacts of low-carbon SCR on the interprovincial inequality that results from the unequal exchange between embodied value-added and CO2 emissions in interprovincial trade within China. Results show that in 2017, the 1% decrease of intermediate inputs from Other Services in Beijing to Construction in Jiangsu while the decrease is replenished by Other Services in other provinces could reduce the CO2 footprint of Construction in Jiangsu by 65.8 kilotonnes (kt). We also identify Nonmetal Mineral Products in Inner Mongolia and Smelting Metals in Hebei, respectively, as the critical sectors for low-carbon SCR targeting Construction in Hebei and Electrical Machinery in Jiangsu, with the largest reduction effects of 73.2 and 35.0 kt under marginal restructurings. These three low-carbon SCR modes can significantly improve the environmental-economy inequalities across provinces, and exhibit great reduction potentials with 1.65, 5.49, and 0.88 million tonnes under their respectively reasonable SCR scales. The marginal restructuring of Smelting of Metals in Xinjiang targeting both Construction and Electrical Machinery in Jiangsu could reduce their CO2 footprints by 29.2 and 31.0 kt, respectively, but they will significantly deteriorate the interprovincial inequalities, which are inadvisable. This study provides references for formulating SCR trading policies toward decarbonization and equalization.

Paper ID: 275

Advancing the UN plastics treaty: the potential of blockchain and digital passports for plastic circular economics

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Abstract:

The resolution of plastic pollution has been widely debated, with recycling seen as a key strategy to mitigate plastic waste. However, current waste management systems struggle to efficiently process plastic waste, revealing the limitations of global recycling efforts. The fragmentation of the recycled plastic market stems from low demand and supply challenges, driven by price considerations, insufficient traceability and transparency, and design flaws in recycled products.

Information asymmetry, first introduced by Akerlof (1978) to explain market failure, remains a major barrier to plastic recycling. Limited access to information on supply, quality, and material suitability leads to a preference for virgin plastics, further hindering circular economy efforts. While qualitative studies (Milios et al., 2018; Nicolli et al., 2012) have explored this issue, quantitative research remains scarce.

The global plastics treaty, initiated by UNEP in 2022, provides a timely opportunity to address these challenges. With 175 countries committing to quantitative recycling targets, material traceability, and market incentives. As its implementation is expected in 2025, this presents a critical window to assess how policy interventions can enhance transparency, trust, and efficiency in plastic recycling systems.

Given this context, this study aims to comprehensively analyze the current application, challenges and impact of information technologies in secondary plastics market. We will first conduct a comprehensive horizontal review of various information technologies and their global applications on plastic recycling. Then, we will take a vertical approach by analyzing specific technologies (blockchain and digital passports) in the context of plastic packaging recycling in China by case study and principal-agent (P-A) model, aiming to clarify the impact of information technology on the recycled plastics market. Finally, the study aims to bridge gap by exploring how policy instruments can support the adoption of blockchain and DPPs within the framework of UNEP’s policy goals.

Paper ID: 276

A versatile direct recycling approach for Ni-rich Li-ion batteries degraded under various conditions via thermal treatment and solid-state reaction

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Abstract:

Direct recycling is an emerging and sustainable method for recovering cathode active materials from spent lithium-ion batteries (LIBs). This process involves separating the degraded cathode material and directly restoring its structure and chemical composition. However, recycling Ni-rich NMC cathodes, such as LiNi0.8Mn0.1Co0.1O2 (NMC811), presents challenges due to their increased structural degradation at high temperatures compared to lower-Ni formulations. In this study, we develop a direct recycling method using thermal treatment and solid-state reaction to regenerate spent NMC811. Additionally, we demonstrate the versatility of this process by applying it to NMC811 degraded under various conditions (cycled at 25°C or 45°C until 80% or 60% capacity retention). Spent NMC811 cathodes were thermally treated at 600°C to remove PVDF and conductive carbon. XRD analysis confirmed that all thermally treated NMC811 samples exhibited a consistent c/a ratio of 4.93633 and a Ni/Li mixing degree of 13.28%, with spinel phase transformation observed. ICP-OES analysis indicated similar elemental composition across samples, with Li, Ni, and Mn losses after thermal treatment. This uniform phase transformation through the thermal treatment process provided a stable and consistent starting point for regeneration, regardless of the degradation condition of the NMC811 sources. The thermally treated NMC811 was mixed via hand-grinding and regenerated at 750°C for 15 hours under an oxygen atmosphere using a solid-state reaction. XRD analysis of regenerated NMC811 showed an increase in c/a ratio to 4.94842 and a reduction in Ni/Li mixing to 4.79%, restoring the layered phase structure consistent with pristine NMC811. Electrochemical testing in a Li-ion half-cell demonstrated that the regenerated NMC811 delivered a discharge capacity of 162 mAh/g at 0.25C, with voltage profiles and dQ/dV characteristics comparable to pristine materials. These findings highlight the feasibility of a scalable, closed-loop direct recycling process for NMC811, offering a robust solution for industrial LIB recycling across diverse degradation scenarios.

Paper ID: 277

Challenges of C&D waste recycling with regards to the public opposition: A case study of Victoria, Australia

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Abstract:

Over the past few years, the increase of population in urban areas of Victoria, Australia has led to a growth in construction activities to meet public needs. Consequently, these developments have caused the generation of more construction and demolition (C&D) waste, whose management has been challenging due to its unusual size and negative impacts. Therefore, there has been a rise in C&D waste recycling, while these activities can create concerns among local communities, contributing to the public opposition. This study aims to investigate the challenges of C&D waste recycling in relation to the public opposition in Victoria, Australia. A qualitative approach has been adopted as a basis for methodology and the data has been collected through interviews with different stakeholders involved in C&D waste recycling. Results indicate that 9 different types of challenges exist during the C&D waste recycling process, all associated with public concerns. These challenges are categorised in 4 main groups, including financial, stakeholder management, project management, and Regulatory framework. Therefore, a fairly public opposition management may lead to the decrease of the abovementioned challenges in the C&D waste recycling industry. Finally, this research provides a framework to show how public opposition can lead to these challenges and how they can be addressed. The findings of this study can be helpful for the C&D waste industry and government agencies, fostering mutual understanding and encouraging more engagement to mitigate the challenges.

Paper ID: 278

Characterisation and recycling potential of glass fibre reinforced nylon 6 sucker rod guides

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Abstract:

Australia generates over 300 metric tonnes of waste each year from composite rod guides, predominantly composed of high performing thermoplastics such as glass fibre-reinforced Nylon6. These composite guides are essential in oil and gas exploration, but are subjected to extreme downhole temperatures, pressures, and abrasive forces that can affect their material properties over time. However, the degradation mechanisms and recycling viability of Nylon6 in this application remain largely unexplored. This study aims to characterise the physical, thermal, and chemical properties of used Nylon6 composite guides to evaluate their potential for recycling.

25% glass fibre reinforced Nylon6 guides were collected from two wells in Australia, with samples taken from the top, middle, and bottom sections of each well. SEM exhibited substantial surface degradation across all samples, with sand and silt deposits and fragmented glass fibres. Burn-off tests indicated mean fibre content of 24.34% and 23.80%. In contrast, fibre length distribution showed mean fibre lengths of 458 μm for well 1 and 399 μm for well 2. FTIR indicated no alterations in chemical composition of used samples. DSC analysis supported this finding, showing a consistent mean melting temperature across all samples (223.1°C for well 1 and 222.8°C for well 2). The lack of thermal or chemical changes indicates that it retains its molecular integrity despite high downhole stressors, though physical wear was apparent. These findings suggest that used composite guides primarily suffer from physical rather than chemical or thermal degradation. With the retention of its critical properties, recycling composite guides by mixing with virgin material is feasible providing sustainable solution for waste management within the petroleum industry.

Paper ID: 279

Bridging space and activity: ontology-based insights into urban park engagement

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Abstract:

As urban areas become increasingly dense and built environments expand, urban parks play a vital role in facilitating physical activity, social interaction, and psychological restoration. However, existing frameworks often fail to adequately capture the intricate interactions between human activities, spatial characteristics, and temporal patterns within these green spaces.

This study proposed an ontology that integrates various dimensions of urban park usage through seven classes: ActivityPattern, Activity, TimeRelated, Trip, Place, ParkUser, and UserPerception. By positioning ActivityPattern as the central concept, the study establishes relationships between the spatiotemporal aspects of park visits, the demographic characteristics of users, users' transport modes, and subjective perceptions of spaces. This ontology linked heterogeneous data, including survey data and open data from public platforms such as open street map.

Preliminary validation through case studies in Shanghai demonstrates the ontology's effectiveness in identifying activity, temporal trends, and correlations between user perceptions and activity choices. This ontology enables researchers and urban planners to examine how user groups interact with park environments across various temporal scales, from daily routines to seasonal fluctuations. It contributes to formalising the relationships between urban residents and spaces through the lens of activity patterns. This work offers a foundational framework for urban researchers exploring the role of parks in fostering health, social cohesion, and environmental justice in contemporary cities.

Paper ID: 280

Sustainable extraction of pectin and insoluble dietary fibre from apple pomace

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Abstract:

We report a green extraction method for extracting pectin from apple pomace (AP), followed by valorising the residual apple pomace into insoluble dietary fibres. The hydrothermally derived pectin was characterised by FTIR, 1H NMR, degree of esterification (DE) and molecular weight. It was found to closely resemble the properties of conventional acid-derived and commercial apple pectin. The leftover apple pomace after pectin extraction, which is generally considered waste, was then processed using mechanical and chemical treatments to recover insoluble dietary fibres with improved functional properties. Recovered fibres were characterised for chemical composition, functional groups, SEM and functional properties including water-holding capacity (WHC), water-swelling capacity (WSC), oil-holding capacity (OHC), glucose-adsorption capacity (GAC), and emulsifying activity. In contrast to mechanical treatment, the chemical treatments were able to damage the microstructure and resulted in the loose and large structure, which was the basis for the strong water, oil or glucose absorption properties. The water contact angle (of hydrophilic nature) and zeta potential supported the findings for strong correlation of microstructure to the dietary fibre properties. Overall, this approach provides an opportunity to extract high-value pectin from AP while simultaneously enhancing the utility of the remaining AP residue as a source of dietary fibre, thus allowing complete utilization of fruit processing waste, contributing to sustainability. The described process of hierarchical utilization of fruit waste biomass could be a viable option for fruit processing industries to improve their economics and diversify their product portfolio.

Paper ID: 281

Site selection assessment of PV-CSP power plants in China based on resource conditions and techno-economic performance

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Abstract:

The PV-CSP hybrid plants integrate the cost-effectiveness of photovoltaics (PV) and flexibility of concentrated solar power (CSP) and have great potential to be applied in western and northern China which are rich in solar resources and land availability. This study aims to develop a site selection method for PV-CSP plants based on the assessment of resource conditions and techno-economic performance sequentially. Feasible areas are first identified through climate, geography, and infrastructure criterias using Geographic Information System (GIS). On the basis, these areas are divided into distinct climate-geographical regions, with representative points selected within each, and their annual power generation and levelized cost of electricity (LCOE) are then calculated using the System Advisor Model (SAM) software and mathematical methods, enabling the evaluation of techno-economic performance, ultimately determining site suitability. Results indicate the total suitable land area in China is approximately 420,000 km², about 4.4% of China's total land area, primarily in Tibet, Qinghai, Xinjiang, Gansu, and Inner Mongolia. The annual power generation of a 100 MW PV+100 MW CSP hybrid system ranges from 484,065 to 593,370 MWh, with a LCOE between 9.57-11.26 ¢/kWh. Western regions show better theoretical techno-economic performance compared to eastern and central regions, ranked as follows: Tibet > Qinghai > Central and Eastern Inner Mongolia > Xinjiang and Gansu > Northeastern Inner Mongolia. For example, in Tibet, power generation is approximately 18% higher, while LCOE is around 17% lower than in northeastern Inner Mongolia. Our findings provide a qunatified framework for assessing spatial variations in resources and technical-economic performance. Based on this, we recommend focusing on PV-CSP industrial clusters in Qinghai, accelerating renewable energy assessments in Eastern Inner Mongolia due to its resource potential and proximity to load centers, and conducting pilot projects in Tibet to address infrastructure limitations and leverage its resource potential.

Paper ID: 282

The contribution and contradiction of two wheeled electric vehicles using new energy power batteries to carbon neutrality in China's transportation sector

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Abstract:

This study conducts a quantitative assessment of the life cycle carbon footprint of lead-acid batteries, ternary batteries, and lithium iron phosphate batteries used in electric bicycles, which are at a critical period of transformation and development under the "dual carbon" target background. The aim is to analyze the carbon footprint of these battery technologies throughout their life cycle and to explore their potential contributions to achieving carbon neutrality goals. The results show that during the production phase, the carbon footprint of LFP batteries is 82.75 kgCO2eq, slightly higher than that of NCM batteries at 77.96 kgCO2eq, while the carbon footprint of lead-acid batteries is 83.03 kgCO2eq, comparable to LFP batteries but slightly higher than NCM batteries. Although the carbon footprint of LFP batteries is slightly higher in the production of positive and negative electrode materials, it is lower than that of NCM batteries in the production of electrolytes and separators. In the production process of lead-acid batteries, electricity consumption and lead material production are the main sources of carbon emissions, contributing 35.11 kgCO2eq and 34.77 kgCO2eq, respectively. This study proposes recommendations such as extending battery life, improving the stability and safety of NCM batteries, enhancing resource utilization efficiency, reducing the use of toxic materials, expanding the scope of battery carbon footprint assessment, and optimizing low-carbon supply chain logistics to promote the green transformation and sustainable development of the electric bicycle industry.

Paper ID: 283

Beyond data silos: A knowledge graph architecture for enhanced community photovoltaic intelligence

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Abstract:

With the rapid growth in renewable energy demand, distributed energy resources, particularly community-level photovoltaic systems, have become crucial for enhancing energy independence and reducing carbon emissions. However, building community energy resilience faces data interoperability challenges, primarily stemming from difficulties in integrating multidimensional heterogeneous data sources (such as community environment, geospatial information, and meteorological data). This research proposes an innovative community photovoltaic knowledge graph framework designed to enhance semantic data interoperability and support community energy resilience assessment. Through a systematic literature review, we first identify the key parameters required for photovoltaic power generation estimation and their semantic relationships. Based on this, the study then develops an ontology model that formalises complex relationships between entities as a knowledge graph, enabling semantic integration and reasoning across heterogeneous data. The knowledge graph employs RDF triple storage patterns and supports complex cross-data source queries through the CYPHER query language. The study validates the framework's effectiveness using a real community case study in Eindhoven, Netherlands. Our results demonstrate that the ontology model successfully integrated heterogeneous data from five postal code areas, including meteorological data, building information, and photovoltaic module specifications. Through query rules, the model achieved precise analysis of spatiotemporal patterns in community photovoltaic power generation. This research not only provides data-driven decision support for community energy system planning but also establishes a technical foundation for enhancing community energy resilience, including grid flexibility, stability, and capacity to respond to emergencies and extreme weather events.

Paper ID: 284

The impact of external shocks on the global natural gas trade network: a perspective based on network dependency

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Abstract:

With the increasing intensity of geopolitical tensions, natural gas trade has become one of the most important economic and trade activities among global nations, significantly influencing the world's energy economy and security. Therefore, it is necessary to reveal the impact of external shocks on the natural gas trade network from the perspective of network structure dependency. Firstly, this study selects global natural gas trade data from 2010 to 2023 to construct the liquefied natural gas (LNG) and pipeline natural gas trade networks (LNGTN and PNGTN, respectively). Secondly, we employ the Temporal Exponential Random Graph Model (TERGM) to conduct an in-depth study of the dynamic evolution of the global natural gas trade structure. Finally, to further understand the stability of natural gas trade network dependency, we combine the improved cascading failure model with the TERGM model to simulate the impact of external factors on the structural dependency relationships of the natural gas trade network. The research results show that: firstly, reciprocity plays a crucial role in establishing trade relationships, and factors such as national distance and economic scale have a significant impact on the natural gas trade network. Secondly, with the increasing complexity of the global trade pattern, the stability and resilience of the natural gas trade network structure have significantly decreased. Thirdly, to cope with external shocks, countries tend to diversify their natural gas trade relationships, and the global natural gas trade network is gradually evolving from a structure dominated by a few core exporters (such as Russia, Qatar, and Australia) to a more diversified structure.

Paper ID: 285

Assessing climate hazards and risks to transition mineral production in Australia

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Abstract:

Ensuring a consistent supply of transition minerals is vital for meeting the growing demand for green energy technologies, however the effect of future climate change on these supply chains has yet to be comprehensively assessed. The increasing frequency and magnitude of climate hazards introduce a range of environmental risks to mining supply chains, potentially disrupting operations and threatening the long-term resource availability needed to manufacture green energy technologies.

This study applies comprehensive GIS analyses to identify and evaluate climate hazards to transition mineral supply chains in Australia. The climate hazards analysed reflect key risks identified by the mining industry, such as water scarcity (e.g. drought), flooding (e.g. changes in precipitation), and bushfire risk (e.g. increases in temperature). Our spatial models incorporate public data to create a transferable and scalable method of climate hazard analysis.

To contextualise future risks, the study examines historical climate events and their impacts on transition mineral production. By analysing past production data in regions that have experienced significant climate hazards, the research identifies patterns of disruption and quantifies production losses associated with specific climate events. These insights are then compared with projected climate scenarios to evaluate how future environmental hazards might impact transition mineral production.

Our research estimates that by 2040, at least 20% of copper, nickel, and lithium mine sites in Australia will experience an increase in climate hazards. This has implications at multiple levels, including the operation of individual mine sites, the sustainability of current mining supply chains and practices, and the global availability of minerals for green energy technologies. The climate hazards analysed here highlight broader risks to the supply of transition minerals, and our research approach can be replicated for mine sites worldwide.

Paper ID: 286

Research on the governance mechanism for supply security of China’s strategic critical mineral resources in short supply: A case study of copper, cobalt, lithium, and nickel

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Abstract:

Strategic critical mineral resources (SCMRs)—such as copper, cobalt, nickel, lithium, rare earth elements, aluminum, tungsten, and beryllium—serve as foundational materials for safeguarding national economic security, defense capabilities, and the development of strategic emerging industries. Their supply security has become a geopolitical priority for major economies, with governance mechanisms evolving into a focal point of international competition. This study focuses on copper, cobalt, lithium, and nickel, which face surging global demand and acute supply shortages in China. By constructing a theoretical framework for SCMR supply risk governance and vulnerability-resilience analysis, we evaluate China’s supply risks and global trade dynamics through quantitative assessments of resource demand, trade networks, and market interdependencies. Empirical findings reveal systemic vulnerabilities in China’s SCMR supply chains and propose actionable policy pathways.

The research integrates an improved supply risk governance framework with a vulnerability-resilience analytical model to identify risk sources, assess systemic fragility, and analyze global supply network resilience. Key innovations include: (1) A novel theoretical framework linking geopolitical dynamics, resource security, and adaptive governance mechanisms; (2) Application of complex network models and wavelet analysis to quantify global trade patterns and market correlations, addressing interdependencies among co-occurring minerals; (3) Cascading failure simulations to map risk propagation pathways under supply disruptions, offering insights into resilience-building strategies.

Policy recommendations emphasize institutional innovation and international collaboration. At the institutional level, China should enhance its global governance influence through high-standard institutional openness and multilateral cooperation under the Belt and Road Initiative (BRI), fostering resource security partnerships with Central Asia, Africa, and the Americas. Strategically, a four-pillar synergistic mechanism is proposed to optimize industrial organization, drive technological innovation, reposition global value chains, and strengthen international bargaining power. These measures aim to mitigate supply risks, advance China’s SCMR governance capabilities, and contribute to sustainable global resource security frameworks.

Paper ID: 287

Spatiotemporal assessment of sustainable development in China's cold chain logistics for agricultural products: A dual-perspective approach

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Abstract:

Cold chain logistics for agricultural products (CCLAP) is crucial for ensuring food security and reducing post-harvest losses. However, its rapid development has raised concerns regarding environmental, cost, and social issues, prompting increasing attention to exploring sustainable development for the industry. This study constructs a dual-perspective framework that integrates the Triple Bottom Line (TBL) model and stakeholder theory to dynamically assess the sustainability of CCLAP in China. The framework combines the three dimensions (social, economic, and environmental) with the four main stakeholders (government, logistics enterprises, farmers, and consumers) involved in the CCLAP process, resulting in a comprehensive evaluation indicator system. Spatiotemporal analysis was conducted using the Boston Matrix method. The results indicate: (1) The CCLAP sustainability level in China demonstrated an increasing trend, with the eastern and central regions exhibit higher development levels and faster growth rates. (2) Social and economic sustainability in China's CCLAP reveal an upward trend, while environmental sustainability has not shown significant improvement. (3) The roles of government, enterprises, and consumers in promoting CCLAP sustainability have gradually improved, while farmers' contributions remain largely unchanged. This study offers valuable strategies for improving CCLAP sustainability, and contributes empirical insights to emerging countries.

Paper ID: 288

Public attention and attitudes towards green express packaging in China: A text mining approach

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Abstract:

Green express packaging offers a promising pathway to reduce pollutant and greenhouse gas emissions, thereby supporting the achievement of sustainable development goals. However, despite active promotion by governments worldwide, progress in its adoption remains slow in China, largely due to limited public engagement. To better understand public attitudes and concerns, this study analyzes social media data collected from Weibo, one of China's most widely used microblogging platforms. A multi-dimensional analytical framework is developed that integrates spatial and temporal analyses, sentiment classification, and topic modeling. Findings reveal significant variations in public concern over time and across regions. While overall sentiment is generally positive, notable differences exist among provinces. Thematic analysis highlights three dominant discussion themes: waste management, environmental protection, and customer service experiences. These insights provide policymakers with an empirical basis for refining strategies and improving governance frameworks for green logistics in China.

Paper ID: 289

Advanced frugal innovation for sustainable food packaging: A design of experiments framework

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Abstract:

In a world where the distance in time and space between the farm and the consumer is expanding, packaging solutions are essential for preserving, transporting, and storing fresh produce. There has been a push to create sustainable and practical packaging to maintain quality throughout the supply chain while lowering post-harvest loss and carbon emissions. This study aligns with the principles of frugal engineering by offering a sustainable packaging solution that minimises material consumption and waste, decreases transportation energy through lightweight design, and offers end-of-life environmental advantages. This solution is a sophisticated, cost-effective invention.

This study aims to balance five essential attributes: mechanical strength (including barrier properties), transport friendliness, biodegradability, recyclability, and light-weighting to provide an economical, sustainable packaging solution for fresh food supply chains. A Taguchi L9 orthogonal array covering several packaging design elements (such as material type, thickness, structural reinforcement, and barrier coating) is used in the study to effectively investigate ideal combinations using a Design of Experiments (DOE) methodology. Here, three key factors are varied: material composition, additive or nanofiller content (to enhance barrier properties), and coating thickness.

Gas permeability measurements and standardised tensile testing are used to confirm mechanical strength and barrier qualities using a gas analyser. The packaging's capacity to endure mechanical shocks and retain dimensional stability while in transit is evaluated by simplified vibration and stacking tests replicating actual handling and logistics situations. Accelerated composting tests are used to assess biodegradability by measuring the rate of deterioration over a predetermined time period in a controlled environment. Recyclability is assessed by putting the material through several reprocessing cycles and testing to see if its essential mechanical and barrier qualities are retained. The goal of using less material without sacrificing overall functionality validates light-weighting.

Paper ID: 290

Quantitative evaluation method for carbon reduction potential of spent lithium-ion battery recycling process coupled with multi-dimensional parameters

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Abstract:

The assessment of carbon emissions from resource cycle is crucial to the low carbon and efficient resource recovery of spent lithium ion batteries (LIBs). However, current assessment of carbon emissions from the resource cycle has problems such as complex influencing factors and multiple parameter dimensions, which makes it difficult to accurately quantify the carbon reduction potential. In this research, a quantitative multi-dimensional parameter evaluation is proposed for the whole industrial chain of spent LIBs to analyses the carbon reduction potential. The main researches include: ① In the technical dimension, four resource cycle models has been built, and the key technical links that affect the carbon reduction potential was identified based on the material flow analysis and carbon footprint assessment; ② In the resource dimension, the metal resource recycling rate was introduced to construct the material cycle-carbon footprint (MCCF) index by coupling the whole industrial chain and resource loss chain carbon emissions , so as to accurately quantify the carbon reduction potential under different resource recycling rates in different LIBs recycling technologies; ③ In the time dimension, the conservative scenario, mild scenario and radical scenario based on the coexistence of multiple resource recycling technologies was constructed according to MCCF index, and the carbon emission impact of LIBs industry was predicted under the coexistence of multiple resource recycling technologies. Finally, a multi-objective optimization model was builted to realize multi-dimensional and multi-parameter coupling, comprehensively quantify and screen efficient carbon reduction technology paths, and promote the theoretical innovation system development of the carbon reduction for LIBs resource recycling.

Paper ID: 291

Material flow analysis for sustainable resource management: insights from the automotive plastics

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Abstract:

This study analyses the current state and challenges of polypropylene (PP) recycling in the automotive sector. Material flow analysis reveals that while interior components contain three times more PP than bumpers, their recycling rate is lower due to contaminants and adhesives requiring costly manual sorting. Bumper recycling faces obstacles from coatings, with high-cost removal processes limiting efficiency. Scenario analysis indicates that restricting end-of-life vehicle (ELV) exports significantly increases domestic recycling volumes but poses economic trade-offs. Enhancing automated sorting, developing coating-removal technologies, and implementing “Car-to-Car” recycling could improve recycling efficiency and market value. However, small- and medium-sized enterprises (SMEs) struggle with the adoption of advanced technologies. Strengthening domestic resource circulation requires policy support, financial incentives, and industry collaboration. To enhance global competitiveness, Japan should reform recycling policies, expand supply chains, and integrate recycled materials into vehicle manufacturing. These findings provide a framework for advancing sustainable automotive recycling.

Paper ID: 293

Assessing the environmental impact of energy mix adjustments in construction and demolition waste recycling

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Abstract:

The management of demolition waste recycling is one of the main trends currently being researched in the global transition to low-carbon energy systems and circular economies. This study conducts a comprehensive life cycle assessment (LCA) of a demolition waste recycling facility in Australia, specifically investigating the impacts of transitioning its energy mix from predominantly fossil energy use to an increased proportion of renewable energy. A detailed base case model was developed to represent the facility's current operations, incorporating energy use, material flow and emissions data. Three substitution scenarios were modeled, including partial substitution, where 30% of conventional energy is replaced with renewable energy; moderate substitution, where 60% of conventional energy is replaced with renewable energy; and full substitution, where conventional energy is almost completely replaced with renewable energy.

Environmental performance is assessed through the ReCiPe and TRACI methodologies using key indicators such as greenhouse gas emissions, primary energy consumption and acidification potential. Our findings suggest that while increasing the share of renewable energy typically reduces direct operational emissions, these benefits are somewhat offset by upstream impacts associated with the production, installation, and maintenance of renewable energy infrastructure. In addition, sensitivity analyses indicate that uncertainty in emission factors and the intermittent nature of renewable energy can have a significant impact on overall environmental outcomes.

Paper ID: 294

Delineating the dual boundaries of agri-food systems

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Abstract:

Achieving food security within planetary boundaries is a critical global challenge. While the Belt and Road Initiative (BRI) has promoted food security, it has also intensified environmental pressures. This study incorporates the doughnut economics framework into the agri-food system and employs a multi-regional input-output (MRIO) model to calculate the environmental pressures (water, land, carbon and nitrogen) associated with agri-food production and consumption within the BRI. The coupling coordination degree (CCD) model is used to assess the relationship between food security and environmental performance. The results indicate that most BRI countries cannot achieve food security within environmental boundaries, with the livestock sector being the main contributor to boundary transgressions. Trade-offs between food security and environmental performance are widespread, highlighting the need for sustainable agricultural transitions. These findings provide valuable insights to support policies that balance food security and environmental sustainability, fostering a green transformation in agriculture within the BRI.

Paper ID: 295

Recycling waste concrete for full-solid waste concrete production: an effective strategy for greenhouse gas mitigation and circular economy

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Abstract:

The widespread use of carbon-intensive materials in construction, combined with the growing generation of construction and demolition waste (CDW), has intensified global concerns over greenhouse gas (GHG) emissions and material conservation. Rapidly growing cities like Shenzhen, with limited land and high material turnover, urgently require sustainable concrete alternatives. This study evaluates the potential of Full-Solid Waste Concrete (FSWC), produced from recycled concrete and industrial by-products, as a low-carbon substitute for traditional Portland Cement (PC). Three groups of FSWC samples were optimized by adjusting the ratio of fly ash (FA) to slag in the raw material mix, thereby ensuring comparable compressive strengths to those of conventional PC. A Life Cycle Assessment (LCA) is conducted to assess its environmental performance across five impact categories: Global Warming Potential (GWP), Terrestrial Acidification Potential (TAP), Freshwater Eutrophication Potential (FEP), Human Toxicity Potential (HTP), and Fossil Depletion Potential (FDP). The results indicate that material consumption is the predominant contributor to environmental impacts across all categories, with alkali activators and superplasticizers (SPS) being the primary contributors to toxicity and fossil depletion impacts. Substituting FSWC for PC at equivalent strength significantly reduces GWP, achieving a reduction of up to 60%. Notably, the GHG mitigation potential increases with the strength of the concrete, underscoring the efficacy of FSWC in high-performance applications. Sensitivity analysis highlights the significant impact of transportation distances between landfill sites and CDW sources, suggesting that optimizing transportation logistics is crucial for maximizing the environmental benefits of FSWC. Results from this study demonstrates that FSWC presents a promising, low-carbon alternative for the construction industry, offering significant potential for both GHG mitigation and enhanced CDW utilization, particularly in rapidly developing cities with constrained land resources.

Paper ID: 296

PET plastic recycling policies and sustainable construction: a mixed-methods study from a circular economy perspective

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Abstract:

With global resources becoming scarcer and environmental issues worsening, the idea of a circular economy has become an important way to support green change in industry. The construction industry uses many resources and creates significant waste and pollution, making sustainable development a major challenge that needs new management methods and policy support. This paper examines the impact of Polyethylene Terephthalate (PET) plastic recycling policies on the sustainable development of the construction industry from a circular economy perspective. First, an analysis framework based on circular economy, sustainable development, and green supply chain theories is built to compare the design, rewards, and supervision of current PET plastic recycling policies at home and abroad. Then, by reviewing literature, analyzing typical cases, conducting surveys, and holding interviews, the study evaluates how these policies improve resource use, reduce environmental impact, and increase economic benefits throughout a construction project. The results show that while current policies have made some progress in promoting the recycling of construction waste, problems in technical support, market rewards, and management coordination still limit their overall effectiveness. Based on these findings, the paper offers suggestions for improving policy design, technology research, market incentives, and supervision methods to help both government and industry make better decisions and promote a green change in the construction industry.

Paper ID: 297

Preparation of a new CO2 capture-mineralization integrated material based on coal fly ash: modification method, properties and mechanism

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Abstract:

Carbon capture, utilization, and storage (CCUS) technologies are pivotal in mitigating climate change. These technologies, especially CO2 mineralization using industrial solid wastes, have garnered considerable attention. This process not only mineralizes CO2 effectively, producing high-value byproducts such as calcium carbonate, but also enhances the resource utilization of industrial solid wastes. The substantial potential of coal fly ash (CFA) in CO2 mineralization is widely acknowledged. Nonetheless, direct use of CFA for CO2 mineralization often leads to the formation of a carbonation product membrane, which hinders CO2 diffusion and reduces mineralization efficiency. In this study, through alkali-sulfur activation modification, a novel integrated CO2 capture-mineralization material (ICCM) with a flower-cluster-like structure was successfully prepared using CFA. It was observed that the smooth glassy structure of CFA was disrupted, forming a porous microstructure that increased its specific surface area. Concurrently, active aluminum and silicon were released from the glassy phase, generating a plethora of easily mineralizable minerals like ettringite and C-S-H gel, which collectively contributed to the flower-cluster-like structure. This study systematically investigated the impact of CFA content, mineralizers (MA), and alkaline substances on ICCM properties. Subsequent CO2 capture-mineralization experiments delved into the specific effects of temperature, humidity, and ICCM structure on the process. Humidity emerged as the decisive factor influencing the CO2 capture-mineralization performance of ICCM. Under optimal conditions, each gram of ICCM could capture and mineralize 48 mg of CO2, primarily forming calcite with minor amounts of aragonite and nano-scale calcium carbonate, positioning it as a potential additive for cementitious materials. In summary, this study successfully developed a new type of efficient CO2 mineralization material by modifying CFA. The findings provide a theoretical foundation and practical pathway for integrated CO2 capture-mineralization technology, contributing a novel technological approach to CCUS.

Paper ID: 298

Role of virtual water under the framework of generalized trade: a case study of macau

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Abstract:

Macao, characterized by its compact urban area, dense population, and limited precipitation utilization, was an extremely water-scarce city that relied heavily on the importation of water resources from mainland China to sustain its daily consumption and urban development. Under the framework of generalized trade, both physical and virtual water played important roles in alleviating Macao's water scarcity, and it was necessary to explore the state of its imported water resources. This paper indicated that Macao's dependence on mainland China for water resources far exceeded expectations. On one hand, Macao imported over 96% of its physical water from the mainland to meet daily needs. On the other hand, a huge amount of virtual water was transferred to Macao through agricultural products, industrial goods, and energy, supporting its urban development in a virtual sense. In practice, virtual water contributed more than physical water to the alleviation of Macao's water scarcity. This paper aimed to propose new perspectives and methods for mitigating urban water resource pressures under the generalized trade framework. By analyzing the synergies between physical and virtual water trade, this paper offered innovative insights into alleviating water scarcity in urban areas.

Paper ID: 299

Policy frameworks for managing end-of-life cross-laminated timber in the built environment: Comparative analysis and implementation pathways

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Abstract:

In the context of accelerating climate action and the transition toward a circular economy, cross-laminated timber (CLT) has emerged as a sustainable alternative in the built environment due to its inherent capacity for carbon sequestration, high prefabrication efficiency, and structural strength. However, the end-of-life (EoL) phase of CLT buildings presents a policy challenge: ensuring that EoL processes effectively preserve the stored biogenic carbon rather than inadvertently releasing it. This study explored the existing policy framework regarding the EoL management of CLT, with a focus on regulatory mechanisms, economic incentives, environmental impacts, and international practices. The research also incorporates an analysis of upstream forest management practices, which significantly influence the sustainability and quality of the sequestered carbon in CLT. Through systematic examination of policy approaches in regions including Australia, Sweden, Austria, Germany, and the U.S., this research identifies how these frameworks shape the adoption of sustainable EoL strategies such as direct reuse, cascade recycling, energy recovery, landfill gas generation, and landfilling. Our findings reveal that reuse of CLT components substantially enhances material efficiency by extending lifespan, reducing waste and maintaining carbon storage. While energy recovery strategies reduce emissions by replacing fossil fuels, these approaches demonstrate different carbon retention profiles. These findings highlight the need for targeted policy interventions that align waste management with sustainable forest practices. Based on our analysis, we propose evidence-based reforms designed to incentivize adaptive reuse, standardize recycling protocols, and promote strategic investments in building deconstruction and sustainable forest management. Additionally, incorporating design-for-deconstruction principles into CLT building design is essential for facilitating the future adaptive reuse of CLT components. The implementation of these policy frameworks would significantly advance sustainable material cycles in the construction sector while optimizing environmental impacts across the full lifecycle of timber products.

Paper ID: 300

Educational trials to promote life cycle thinking for environmentally sustainable dietary transitions in China

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Abstract:

The transition towards environmentally sustainable diet plays a vital role to alleviate food related environmental burdens. For example, plant-based diets, alternative proteins, organic food, local seasonal food, unpackaged food, efficient cooking, food waste reduction are popular dietary choices that could reduce environmental impacts from different life cycle stages of foods. To nudge people towards dietary transitions, education is a promising way through informing people the environmental impacts of different dietary choices. In this study, to enhance people's life cycle thinking and environmental awareness of dietary choices, we developed a structural educational framework by combing card game with short lecture, and conducted trials among 115 university students. To testify the efficiency of the educational materials, we conducted questionnaire surveys before and after the trails. The card game was designed based on the life cycle assessment (LCA) results, in which scenario analysis were conducted on 61 representative dishes to estimate greenhouse gas (GHG) emission and water consumption of 8 life cycle stages. During the card game, players collect LCA cards of 8 stages, and they have 1-4 choices on each stage. The final scores are decided by GHG emissions or water consumptions of the dish that players have, and the LCA dietary alternatives that they choose. The questionnaire results showed that students who showed low acceptance of meat reduction dietary transition before were more willing to reduce meat consumption after the trial, with 11% increases on the acceptance level. Besides, the environmental literacy of foods increased significantly after the trial, especially among students who showed low environmental literacy before, with 290% and 345% growth in the right answer ratios for the first and second trials, separately. Since the trials was conducted among university students, the educational materials are expected to be more efficient when applied to populations with lower environmental literacy.

Paper ID: 302

Can cross-regional energy supply alleviate energy poverty? - The perspective of Ultra-high voltage transmission project

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Abstract:

Resource and environmental management is critical for sustainable development, and energy poverty, a major cause and consequence of economic poverty, hampers high-quality economic progress. To address energy poverty, driven by imbalanced energy supply and demand, the Chinese government promotes trans-regional energy transmission projects, with the UHV (Ultra High Voltage) transmission project serving as a key example.

Based on the macro data of 30 provinces in China from 2003 to 2019 and the micro data of 12450 samples in China in 2014, 2016, and 2018, this research uses quasi-natural experiment method to explore the effect and mechanism path of UHV transmission projects on energy poverty.The findings show that UHV transmission projects reduce energy poverty by 1.87%. The main mechanisms include optimizing the energy structure and improving energy efficiency. Specifically, UHV transmission supports the regional transfer and consumption of clean energy, shifts away from fossil fuels, and enhances overall energy supply stability. It also reduces energy loss during transmission, increasing efficiency and better utilizing limited energy resources, thus easing energy poverty. However, the study notes that UHV transmission does not significantly improve energy poverty by reducing power instability or enhancing public power services, likely due to challenges in infrastructure and service quality. Interestingly, within a 500km radius, UHV projects have a positive spillover effect, alleviating energy poverty in surrounding areas.

In conclusion, this study offers valuable insights for academic research and provides empirical evidence for policymaking on cross-regional energy transmission, contributing to resource optimization, environmental management, and sustainable economic development in China.

Paper ID: 303

Data-driven modeling and validation of building-integrated photovoltaic facade power generation under multi-factor influences

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Abstract:

With the accelerated global energy transition, Building-Integrated Photovoltaic (BIPV) technology has become a key approach to achieving efficient use of renewable energy in urban areas. However, the power generation performance of BIPV facade systems is influenced by various external environmental factors, making it challenging to describe their power generation characteristics accurately. This paper proposes a data-driven modeling approach by scientifically classifying the two main factors—solar energy capture and heat gain/loss characteristics of building-integrated photovoltaics—to develop a power generation model for BIPV facade systems under the influence of multiple factors. First, the types and contributions of the influencing factors are categorized, and the main factors and their impact features are extracted. Next, an optimal power generation model is obtained through data selection and interpolation iteration. Finally, the model is validated by comparison with simulation methods of high recognition and field experimental measurements. The results indicate that the power generation model obtained through pure data iteration improves accuracy by 12% compared to the single-diode equivalent circuit models used by existing commercial software, with a controllable deviation from the experimental results. This model provides a reference for the power generation efficiency of BIPV facade systems during the building design phase.

Paper ID: 304

Heterogeneous Variations on Historical of Mercury, Dioxins, and CO2 emissions from Medical Waste Incineration Process in China: Emission Inventory, Driving Factors, and the Impact of COVID-19

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Abstract:

Medical waste incineration (MWI) is one of the important sources of carbon dioxide (CO_2) and hazardous air pollutants (HAPs), threatening the triple planetary environmental crisis of climate change, biodiversity loss, and environmental pollution. Utilizing the EMEP/EEA air pollutant emission inventory and the IPCC 2006 guidelines, this study develops a comprehensive inventory of anthropogenic mercury (Hg), dioxins (PCDD/Fs), and CO_2 emissions from the MWI process in China among 2014-2023, employing a bottom-up approach at the plant level. The findings indicate that national MWI emissions of Hg, PCDD/Fs, and CO_2 increased by 1.33, 2.23, and 1.17 times, respectively, across Chinese mainland from 2014 to 2023. Notably, the response to the COVID-19 pandemic has led to a sudden increase of both Hg and PCDD/Fs emissions in the MW incineration process in China, particularly in 2022. Random forest model analysis identifies GDP and total population as key determinants of MWI, with feature importance values of 0.617 ($P < 0.05$) and 0.100 ($P < 0.05$), respectively. Additionally, a geographical detector analysis reveals that GDP, openness, and urbanization significantly influence pollutant and CO_2 emissions, with temporal variations in significance. These results provide critical insights for formulating medical waste disposal policies, promoting sustainable management practices in China, and enhancing preparedness for future health emergencies.

Paper ID: 305

Decoupling industrial development from carbon emissions in resource-based cities -based on 90 cities in China

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Abstract:

This study examines the sustainable development of resource-based cities in the context of global climate change and resource scarcity. Focusing on 90 resource-based cities in China, the research employs the Tapio decoupling index and the Log Mean Divisia Index (LMDI) to analyze the decoupling relationship, dynamic pathways, and driving factors between industrial development and carbon emissions during the transition toward carbon peaking and carbon neutrality. The findings indicate that: (1) Decoupling between industrial growth and carbon emissions was prevalent in resource-based cities from 2009 to 2019, with weak decoupling and expansive negative decoupling being the most frequent states. The dominant dynamic pathway followed a sequence of weak decoupling → expansive negative decoupling → strong decoupling. (2) Significant heterogeneity in decoupling performance was observed across different types of resource-based cities. Mature and regenerative cities exhibited more stable and favorable decoupling outcomes, while declining and growing cities experienced higher volatility and more frequent negative decoupling phenomena. (3) Energy carbon intensity was identified as the primary positive driver of decoupling, whereas economic energy intensity, per capita GDP, and population growth were the key negative factors impeding the decoupling process. (4) The decoupling pathways were characterized by a positive interaction chain of "economic energy intensity → energy carbon intensity" and a negative transmission mechanism of "per capita GDP and population → economic energy intensity." These results provide valuable insights for formulating targeted green industrial transformation and sustainable development strategies tailored to different types of resource-based cities.

Paper ID: 306

Using causal loop diagrams in a systems approach to improve Indonesia's plastics value chain

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Abstract:

Despite ongoing efforts to improve resource recovery from waste, progress has been hindered by fragmented approaches that overlook systemic inefficiencies. A systems-based approach that integrates environmental, economic, social, technical, and political factors is crucial for providing a holistic understanding of the complex interrelationships and promoting resource sustainability. Complex Value Optimization for Resource Recovery (CVORR) is a systems-based approach designed to assess the complex value of resource and waste management systems across environmental, economic, social, and technical dimensions. CVORR examines how complex value is created, distributed, and diminished to identify drivers, barriers, and potential interventions, ultimately aiming to optimise value retention and creation in alignment with circular economy principles. A key advancement of the CVORR's baseline analysis is the incorporation of Causal Loop Diagrams (CLDs), which map reinforcing and balancing feedback loops that influence system dynamics. These loops facilitate the identification of system inefficiencies and interdependencies, revealing feedback mechanisms that can either perpetuate or mitigate barriers to circularity. In this study, CLD was used to map the dynamics of the Indonesian plastics value chain as part of the PISCES project, focusing on identifying systemic lock-ins that impede effective plastics resource recovery, highlighting critical points of intervention, including policy-, social-, material and technological-based. The originality of this study lies in the integration of CLD with a systems-based methodology within a real-world context, demonstrating its effectiveness in tackling plastic pollution challenges. The findings provide valuable insights for stakeholders, informing targeted interventions that enhance sustainability outcomes and facilitate the transition toward a circular economy. The impact of this research extends beyond Indonesia, offering a framework that can be adapted globally to optimise resource recovery systems, support research and innovation and inform policy strategies.

Paper ID: 307

Dynamic lifecycle emission assessment of photovoltaic technology in Australia based on AI-driven climate forecasting

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Abstract:

The sustainable transition to renewable energy demands a comprehensive evaluation of environmental impacts throughout the lifecycle of photovoltaic (PV) systems. This study introduces a dynamic lifecycle emission assessment model for PV installations in Australia by integrating artificial intelligence (AI)-powered climate forecasting with lifecycle assessment (LCA) and scenario analysis. Machine learning and deep learning techniques are applied to predict key climatic variables—such as solar irradiance, temperature, and wind speed—to capture temporal fluctuations and uncertainties under future climate change scenarios. The dynamic LCA model quantifies emissions from PV system manufacturing, operational electricity generation, and end-of-life processes. A special focus is placed on the impact of various recycling technologies at the end-of-life stage. Scenario analyses compare conventional recycling methods with advanced recovery processes, offering insights into how different end-of-life strategies influence the overall carbon footprint. Preliminary findings suggest that incorporating AI-driven climate predictions enhances the accuracy of emission estimates by accounting for dynamic environmental conditions, which in turn refines energy yield calculations and emission profiles. This novel framework not only provides a robust tool for assessing the full lifecycle emissions of PV systems but also informs policymakers and industry stakeholders about the environmental trade-offs associated with evolving recycling practices and climate variability. By merging advanced AI techniques with traditional LCA methodologies, the study contributes to the interdisciplinary dialogue on resource sustainability and offers practical guidance for optimizing PV technology performance in a complex, changing climate.

Paper ID: 308

Revealing iron and carbon transfer characteristics among global multi-regional steel industry chain: an energy-material-economic integrated analysis

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Abstract:

As a hard-to-abate sector with large carbon emissions, realizing the low-carbon development of iron and steel industry is crucial for global carbon neutrality, which needs coordinated efforts from multiple regions along the entire steel industry chain (SIC). These efforts can benefit from revealing the overall iron and carbon transfer characteristics and clarifying the steel-related carbon emission responsibilities (SRCERs) of various regions in different stages along SIC. By integrating trade-linked energy and material flow analysis, environmental extended multi-regional input-output model, and energy consumption and carbon emission accounting, this study traced the intertwined iron and carbon transfer from multi-regional energy and mineral supply to steel production and finally to economic final demand among global 13 regions. The results showed that the main lines of iron and carbon transfer were from iron ore supply in Oceania to steel production in China, and from China's intermediate product supply to local and other regions' final demand, separately. The findings indicated that China's gross capital formation, mainly led by construction, accounting for the largest final demand in the world, drove about 40% of global steel production and SRCERs. Furthermore, the results call for integrating this regional iron and carbon transfer relationship into the design of steel mitigation strategies.

Paper ID: 309

Developing an activity-based framework for community energy management: a case in guangzhou, china

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Abstract:

Forecasting energy demand is important for effective neighbourhood energy management. However, existing tools struggle to comprehensively capture cross-sectoral energy implications resulting from shifts in activity patterns of residents, such as the popularity of remote working and e-commerce. This study presents a novel activity-based aggregated urban energy and carbon management model. The framework integrates residential activity chains as the critical link between domestic and workplace environments. Residential and workplace energy demand are estimated based on time allocation choices. Based on a case in Guangzhou, China, this paper reports findings on community-scale energy impacts during the COVID-19 pandemic when remote working practices became prevalent. The research establishes a model grounded in utility maximisation theory to capture residents' time use and activity choices. A survey data collected during the pandemic is employed for model calibration and validation. A typical neighbourhood comprising both residential and office buildings serves as the analytical case for energy assessment. This research contributes to sustainable communities by revealing how activity-based energy modelling can optimise resource allocation and reduce overall energy consumption when activity patterns shift, particularly through remote working. Moreover, it enhances energy resilience by providing policymakers with a framework to anticipate and adapt to energy demand distributions, thereby enabling more robust neighbourhood-level energy planning.

Paper ID: 310

Assessing the spillover effects of carbon emissions trading policy on green innovation: evidence from China's export enterprises

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Abstract:

Green innovation is essential for achieving sustainable development, particularly for China's export enterprises, which face strict environmental standards and high demand for low-carbon products. Despite its importance, green innovation in export enterprises remains stagnated and needs a breakthrough. Although carbon emissions trading policy is recognized as a formal environmental regulation tool, its impact on green innovation capacity, especially among export enterprises, is underexplored. The existing studies also neglect the importance of export enterprises, the theoretical mathematical derivation of the relationship, and the broader externality spillover effects on other forms of innovation. This study investigates the impact of carbon emissions trading policy on green innovation in China's export enterprises, using a mathematical economic model and quasi-natural experiment. Our findings reveal that the policy effectively stimulates green innovation in export enterprises without detracting from other innovative activities. And the spillover effect of this policy as market-based environmental regulation is more substantial than that of mandatory environmental regulations. This supports the view that the policy provides positive incentives to break through green barriers, and does not lead to R&D resource misallocation in these enterprises. Additionally, R&D investment and human capital play a key role in the policy-innovation relationship. State-owned enterprises experience a notable boost in green innovation, while private enterprises show minimal effects, likely due to an unequal allocation of carbon quotas. This research offers both theoretical and empirical insights for optimizing future carbon emissions trading policies.

Paper ID: 311

A critical review of energy-material-economic flow analysis in low-carbon transition

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Abstract:

The root cause of climate change lies in the increasing consumption of materials brought about by economic development, which in turn leads to more energy consumption, which is the main source of carbon emissions. The production and consumption of energy, the production and consumption of materials, and the production and consumption of other sectors of the economy all involve their own complex networks. A reasonable carbon reduction policy must be based on a clear understanding of these networks, and the interaction between the three networks is a research challenge. Due to their suitability for network analysis and the ability to achieve visual display, energy flow analysis, material flow analysis, and economic flow analysis based on input-output structure have gradually become popular. The problem is that these three different disciplinary methods need to be integrated in order to provide a more complete system overview. This paper attempt to provide a critical review of the energy-material-economic flow analysis, including basic concepts and principles, method development and integration attempts, and the research frontiers. The results indicate that, on the basis of extensive previous studies combining three methods in pairs, the combination of the three has become possible and some early attempts have emerged. Among various ways to integrate the three, integrating energy flow analysis forward and economic flow analysis backward based on material flow analysis, which has more obvious dynamic characteristics, may provide better assistance in understanding the network evolution of carbon emission source. However, this method needs to be further applied to multi-regional levels and further explored on how to integrate information from various aspects, including nature, technology, data, and society, to increase research support for policy making for low-carbon transition.

Paper ID: 312

Carbon pricing potential in industrial fisheries: Global challenges and opportunities

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Abstract:

The depletion of fish stocks and the rising greenhouse gas emissions associated with industrial fishing have become pressing global concerns, exacerbated by harmful subsidies that encourage overcapacity and profit maximization. Despite longstanding efforts by the World Trade Organization to eliminate these subsidies, progress has been slow due to persistent challenges in policy reform. This study explores the potential for fisheries policy transformation through the lens of carbon pricing, situating the issue within a broader climate policy framework. By analyzing emissions profiles, political landscapes, and economic conditions across the 19 largest fishing nations, the findings reveal that developing countries with weaker climate policies have limited incentives for reform and face significant administrative barriers. Furthermore, this study highlights the role of fisheries sector heterogeneity in shaping policy outcomes and proposes a downstream carbon pricing framework that integrates emissions trading and individual transferable quotas. This novel approach aims to support the gradual elimination of harmful subsidies while promoting sustainable fisheries management.

Paper ID: 313

Determining causality in sustainability transitions: Identifying drivers of sustainable consumption using DEMATEL

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Abstract:

The combined consumption to satisfy the needs of 8.2 billion individual consumers result in substantial impact on the environment. The cumulative effect of these purchases lead to unprecedented environmental challenges that require global attention. Current consumption patterns tainted with materialism, excessive purchases, and "throwaway" culture lead to unsustainable consumer behavior. It is important to shift current consumption patterns to sustainable practices by identifying the factors that drive consumer behavior towards sustainability transitions. There is a need to identify the most influential drivers in this transition, so interventions and strategies can be shifted to where it matters.

This paper identifies the drivers of transitioning to sustainable consumption through a comprehensive analysis of causal mechanisms and interrelationships using DEMATEL. These include consumer-centric values (environmental concern, sense of personal responsibility, sense of fulfillment, peer influence, social validation), government-initiated strategies (policy on SDGs, consumer education, tax relief/incentives for businesses), and manufacturer-centric characteristics (sustainability mindset, sustainable product development, consumer demands, cost efficiency).

DEMATEL is a decision analysis method that can depict causal relationships between drivers and/or barriers. DEMATEL can determine the top influential drivers that may trigger a domino-like effect towards sustainable consumption. The top influential drivers can be the focus of sustainability strategies for efficient intervention. This identification and mapping offer valuable insights for policymakers, industry practitioners, and academic researchers.

Paper ID: 315

Energy-Environment-Economy evaluation of photovoltaic module recycling and disposal

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Abstract:

Driven by the global energy transition and the "dual-carbon" goals, China's photovoltaic installed capacity has ranked first in the world for consecutive years. However, early large-scale deployments of photovoltaic modules are approaching their end-of-life cycle, posing urgent challenges of resource waste, environmental risks, and industrial recycling bottlenecks. To address these issues, this study integrates a dynamic material flow prediction framework for silicon-based and thin-film photovoltaic modules, grounded in the evolutionary trajectory of photovoltaic technology. This framework predicts module retirement patterns across different development stages and technological generations, providing a scientific basis for accurately predicting resource recovery windows. Further integrating life cycle assessment and multi-criteria decision analysis, the research quantifies the trade-offs among energy consumption intensity, unit recycling economic costs, carbon footprints, and toxic emissions in mechanical, thermal, and chemical treatment processes for end-of-life photovoltaic modules. Special emphasis is placed on optimizing the closed-loop recovery efficiency of high-value materials like silicon and silver, while establishing coordinated mechanisms to mitigate diverse environmental impacts. By transcending the limitations of static forecasting and single-dimensional evaluation in traditional photovoltaic waste management studies, this research offers actionable pathways to overcome bottlenecks in large-scale recycling. It presents a Chinese approach to sustainable global photovoltaic industry management, balancing technological innovation, environmental responsibility, and circular economy principles. This work not only advances methodologies for predicting and evaluating photovoltaic waste but also provides critical insights for policymakers and industry stakeholders to align recycling infrastructure planning with climate goals and resource security imperatives.

Paper ID: 316

Impacts of supply chain on provincial forest carbon sink pressure: analysis of embodied timber carbon stock in china's interprovincial trade

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Abstract:

Forest carbon sinks represent a critical natural pathway toward achieving carbon neutrality goals, while forest products, as extensions of forest resources, serve dual functions in long-term carbon storage and emissions reduction through substitution, becoming key strategic measures for addressing global climate change. As the world's largest trader, producer, and consumer of forest products, China's trade pattern highly reliant on international markets and limits traditional timber carbon accounting methods from comprehensively assessing how consumption regions exert resource and environmental pressure on timber-producing regions through trade and supply chains, while failing to consider ecological value and carbon offset contributions embodied in global trade flows. With China's formal establishment of carbon peaking and carbon neutrality targets, studying embodied timber carbon in interprovincial timber trade has become a critical component in evaluating forestry resource management efficiency and achieving sustainable development goals. This research aims to quantify the embodied timber carbon stock across China's provinces and systematically analyze the network and characteristics of embodied timber carbon flows in interprovincial trade. Based on data from "Ninth National Forest Resources Report" and using the single-tree biomass equations and biomass carbon content tables for major Chinese tree species, differentiated biomass estimation models were constructed. The study integrates nationwide forest inventory data, spatial tree species distribution information, calculating provincial timber carbon stock based on tree species differences through a multi-regional input-output model. Additionally, high-precision above-ground biomass estimation was conducted using stand height and density parameters extracted from airborne LiDAR data, yielding provincial forest above-ground biomass subsequently converted to forest carbon sink values. A Forest Carbon Sink Pressure Index (FCSPI) is developed to measure each province's demand pressure on forestry carbon sinks and its impact on regional forest management. The findings provide a scientific basis and policy recommendations for optimizing trade structures, promoting sustainable forestry, and achieving carbon neutrality goals.

Paper ID: 317

Spatial dynamics and decoupling of building material stock and economic development in the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract:

Building material stock (MS) influences urban sustainability by affecting resource use efficiency and carbon emissions. This study investigates the spatial patterns and dynamics of MS in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) from 2000 to 2020, using nighttime light index and building data. Following the "cradle to gate" stage of Life Cycle Assessment, we assess MS and its associated carbon emissions, spatially mapping these trends across the region. Spatial analysis reveals the concentration and agglomeration of MS, with significant clustering patterns across cities in the GBA. The study explores the decoupling between economic growth and MS, using material productivity (MP) to evaluate resource efficiency. While some cities show decoupling trends, such as Shenzhen and Dongguan, with rising GDP and declining MS per capita, others maintain a linear relationship. Notably, Macao and Hong Kong exhibit higher MP levels, while Dongguan and Zhongshan have lower values. Over the period from 2000 to 2020, the GBA's average MP declined, with Shenzhen and Dongguan seeing improvements, while cities like Zhaoqing, Huizhou, and Macao experienced sharp declines. We also discuss the factors influencing these patterns through a framework considering industrial structure, locational advantages, and institutional factors. This study emphasizes balancing economic growth and resource efficiency for sustainable urban development in rapidly urbanizing regions.

Paper ID: 318

Estimating Construction and Demolition Waste through automated Detection of Building Changes: a Building Inventory Approach

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Abstract:

The escalation of urban development and infrastructure projects has necessitated a comprehensive understanding of construction and demolition (C&D) waste volumes, which pose significant environmental challenges. This study presents a novel framework designed to estimate C&D waste volumes through an integrated approach that combines the automatic detection of building changes in the inventory and field assessments of building material compositions in Wallonia, Belgium. By leveraging geospatial data from over two million buildings, we classify them into four groups: demolished, new, modified, and unmodified. Initially, we identify 37,317 demolished buildings, a figure that is comparable to the demolition records available over the past ten years. Subsequently, we employ a logistic regression model to analyze the relationship among building characteristics, land parcels, and patterns of building demolition. The findings reveal critical insights into factors influencing C&D waste volumes. Furthermore, we set up a sampling strategy to analyze the composition of residential building materials, with a focus on calculating material intensities. The material intensities are cross-referenced with the gross volumes of the buildings to obtain an estimate of the materials present in the residential building stock. Based on the validated demolition rate, we estimate the volume of waste generated from the demolition of buildings that can be recycled or reused. Finally, we evaluate the derived C&D waste using the data from the recycling and demolition centers in Wallonia.

Paper ID: 319

Water scarcity assessment of provincial energy production in China

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Abstract:

The geographical distribution of energy and water resources in China is reversed, leading to the severe challenge of water shortage in energy production. Some studies have measured the water resource use of energy production through water footprint and virtual water, but they cannot fully reflect the water resource vulnerability of energy production. Based on the input-output analysis method and regional water stress index, this study develops the scarce water footprint assessment model and virtual scarce water trade estimation model to comprehensively assess water scarcity for production activities of different energy types at the provincial level in China. The results show that although the water use for energy production in regions like Ningxia Hui Autonomous Region is not large, its energy production faces a serious water shortage problem due to high water stress. To effectively alleviate the vulnerability of water resources in energy production in the above regions, at the regional level, attention should be focused on virtual scarce water transfer from net outflow areas like Ningxia Hui Autonomous Region to net inflow areas like Shaanxi Province. At the sectoral level, attention should be focused on virtual scarce water transfer from energy industries and agriculture to sectors like petroleum, coking products and nuclear fuel processing products. In addition, the scarce water footprint of different types of energy production varies greatly. It is necessary to develop targeted water management measures for production activities of different energy types. This study calls for incorporating water scarcity into energy production planning in China and strengthening cooperation between energy and water management departments to promote the sustainable development of energy and water resources in China.

Paper ID: 320

The benefits of solar PV systems in reaching China's renewable energy and carbon reduction goals: Implications from the systems assessment of late-model commercial solar power system

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Abstract:

Recognizing the climate benefits of solar energy by reducing combustion-based electricity generation, Chinese government vigorously develops solar PV technology and expands its capacity. This trend receives further impetus from its carbon-neutral promise before 2060. However, there is still a lack of quantitative analysis on the nonrenewable costs and benefits of state-of-the-art commercial solar PV systems in China within a factory-scale comprehensive boundary. By compiling a high-resolution inventory that includes previously overlooked equipment, material and service inputs, this study evaluates all-round benefits of a representative solar PV plant newly constructed in Tibet from climate and economic perspectives, and scales up results at a factory level to a national level by integrating operating plant-specific data across China. The results show that, driven primarily by reductions in cost and intensity, nonrenewable energy consumption and carbon emissions induced by solar PV systems have decreased by nearly 90% during the past decade. Generating 1 kWh of electricity with late-model commercial solar PV system requires only 0.36 MJ of nonrenewable energy and results in 29.47 g of carbon emissions. This demonstrates extremely high levels of renewability (96.54%) and carbon-neutrality (97.02%) compared to coal-fired power systems. The cumulative climate benefits from the planned deployment of solar PV systems by the end of 2050 are projected to reach 112.89 Gt, accounting for around 27.48%-69.34% of the national carbon neutral goal. Correspondingly, the avoided climate-driven economic damages can be comparable to government's investment in solar PV related incentive policies. These results can help us understand how to make full use of the benefits obtained by solar PV systems in planning carbon neutralization roadmap, illustrating policy implications to achieve environmental sustainability, economic viability and the trade-offs between them.

Paper ID: 321

Sustainable pathway to circularity via slag chemistry in recovery of valuable metals from secondary resources such as copper sludge and spent petrochemical catalysts

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Abstract:

The recycling of electronic-wastes and recovery of precious and rare metals from various industrial wastes such as catalysts, sludges, slags, etc. is highly important to achieve the mitigation of CO2 emissions in metallurgical sector. Due to the conflicts of limited natural resources and increasing demands, as well as their economic values, it is essential to recover valuable metals from secondary resources. The current study aims to recover valuable metals from petrochemical spent catalysts and copper sludge containing valuable metals such as gold, silver, palladium, etc. through the pyrometallurgical smelting process. The smelting reduction experiment was conducted at 1500oC using a high frequency induction furnace. It was found that silver and palladium concentrated in copper, but a significant amount of copper and matte droplet was lost in the slag. The loss of silver and palladium occurs when copper droplets containing these elements were entrapped into the slag phase. Loss of valuable metals due to physical entrainment means that copper droplets were not settled down completely but rather dispersed in the slag layer. This is called physical loss. To quantitatively evaluate the physicochemical behavior of slag-metal interfacial phenomena, the interfacial tension of the slag-metal system and settling velocity of copper droplets was estimated. Consequently, the thermophysical properties such as slag viscosity, surface or interfacial tensions in conjunction with thermochemical solubility of target elements in the slag (this is called chemical loss) contribute to the recovery rate of valuable metals. To maximize the recovery of target metals, the lower slag viscosity, resulting in the higher terminal velocity of metal droplets, as well as the removal of sulfur, resulting in a higher surface or interfacial tension, are necessary by minimizing a physical loss. Alternatively, the lower solubility of target metals in the slag is required to minimize a chemical loss.

Paper ID: 322

Modeling urban vulnerability to flooding using GeoAI: A multi-hyper graph approach to independent urban systems

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Abstract:

The intensification of flooding risks, driven by climate change, necessitates advanced approaches to evaluate urban vulnerability. This study proposes a novel framework that integrates GeoAI with multi-hyper graph modeling to examine the interdependencies between urban infrastructure systems during flood events. By utilizing Graph Neural Network (GNN) and hypergraph structures, the model captures both pair-wise connections and higher-order dependencies among key urban components, such as land use patterns, transportation networks, and urban function zones. The framework explicitly incorporates natural geographic factors, critical infrastructure, and social service systems, offering a holistic view of urban resilience. A core contribution of this approach is its capacity to model spatial dependencies and system interconnections, enabling the identification of urban vulnerability hotspots. Moreover, proposed approach is transferable across diverse urban environments, which enhances the applicability and allows for its adaptation to different cities, regional contexts, and varying infrastructure configurations. By employing explainable artificial intelligence (XAI) techniques, the model will further help to understand which features or hyperedges play a decisive role in complex urban systems. This research offers valuable contributions for urban planners and policymakers in developing scalable, effective strategies to address flood risks in the context of climate adaptation.

Paper ID: 323

Do hotels and tourists share the same preferences for circular economy measures?

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Abstract:

Hotels in tourism destinations are investing in circular economy measures that are costly and require a large amount of resources to be accomplished on time and efficiently. The question addressed in this paper is to what extent the preferences for circular economy measures are aligned between hotel managers and tourist demand. The answer this question could be useful to ascertain the optimal amount of investment in circular economy measures taking into account its potential impact tourists decision making and choices. The paper utilizes the methodology of discrete choice experiments to analyse the preferences of both tourists and hotel managers. Discrete choice experiments consist of posing individuals with alternative options of circular economy efforts at hotels involving different costs or prices to pay for them. Circular economy policies at hotels that a tourist can choose are disaggregated into the components of managing energy, water, and waste segments within a hotel organization at different levels of effort and investment. Two different samples, one of tourists and one of hotels were interviewed utilizing discrete choice questionnaires in Spain. The responses are analysed separately and jointly to robustly compare the statistical differences in preferences between both groups. Results show that there is a gap between tourists and hoteliers, with the former willing to pay more for circular economy measures than what hotel managers are willing to invest. The results raise the need for hotels to adjust to the preferences of tourists in their investment decisions on circular economy actions.

Paper ID: 324

Unveiling the inequality and embodied carbon emissions of China's battery electric vehicles across life cycles by using a MRIO-based LCA model

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Abstract:

China has dominated the market for battery electric vehicles (BEVs), accounting for around 60% of global BEV sales. Simultaneously, the exponential growth of BEVs in China has drastically increased global carbon emissions via supply chain effects. This study adopted Multi-Regional Input-Output-based Life-Cycle Assessment (MRIO-based LCA) model to evaluate the BEVs' embodied carbon emissions of all life cycle phases, including manufacturing, driving, battery replacing, and scrapping phases. Furthermore, the Structural Path Analysis (SPA) was applied to trace critical transmission paths within the industrial chain. The Gini coefficient was adopted to reveal the inequality of global carbon emissions induced by each life cycle phase of BEVs in China. The results demonstrate that the total life cycle carbon emissions of BEVs reached 101 million tons, with manufacturing phase accounting for 53%. South Korea, Russia and India are the top three embodied carbon emissions countries caused by BEVs' manufacturing phase. Additionally, secondary industry contributes 17% of total carbon emissions from the perspective of final production contribution, with the mining and quarrying sector alone accounting for 10% of this share. The scrapping phase drives the main driver of global carbon emission inequality across the BEV life cycle. Countries contributing to emission imbalances are predominantly smaller economies, with characteristics of less developed nations. While BEVs eliminate tailpipe emissions, their "zero-emission" potential remains constrained by decarbonization of power supply. The findings of this study provide a scientific basis for formulating equitable emission reduction policies.

Paper ID: 325

In vitro reproduction of scaptotrigona postica bees

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Abstract:

This study explores innovative methods for in vitro queen bee reproduction, focusing on stingless bees utilized in Meliponiculture. Bees, vital for pollination and producing economically beneficial products like wax and honey, belong to the Hymenoptera order, with stingless bees categorized under the Meliponini tribe. This research raises important questions regarding the efficiency and reliability of existing queen reproduction techniques, particularly those developed by Dr. Cristiano Menezes in 2010, based on initial methods introduced by Camargo in 1974. The ecological significance of stingless bees, comprising over 300 species classified into Meliponas and Trigonas, emphasizes the necessity for effective reproduction methods to promote environmental sustainability. The methodology employs ELISA plates with U-shaped wells to mimic natural bee cells. Newly hatched Scaptotrigonapostica larvae are cultivated with an artificial larval food setup. The study initially evaluates moisture control as a critical variable, using distilled water to maintain approximately 100% relative humidity and then transitioning to sodium chloride solutions to achieve 75% humidity. Despite two initial trials resulting in unsuccessful larval development due to premature moisture reduction and drying of the larval fluid, the research aims to identify the optimal moisture levels and larval fluid volume required for producing healthy queens. These findings are crucial for improving the success rate of new nest creation through colony division. The expected outcomes include refining the in vitro reproduction method for more consistent and successful queen production. The study aims to significantly contribute to sustainable bee management and conservation practices, highlighting the broader ecological and economic implications.

Paper ID: 326

Is municipal solid waste incineration fly ash modified asphalt binder sustainable in building roadway infrastructure?

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Abstract:

Municipal solid waste (MSW) has been a growing concern for several years due to its massive generation along with its societal and environmental challenges associated with its management. Notwithstanding, the state-of-the-art incineration with energy recovery through waste-to-energy (WtE) process reduces the volume of MSW significantly, but accumulation of the hazardous residues from the incineration process apart from its handling and disposal continues to intensify the problem further. For instance, municipal solid waste incineration fly ash (MSWIFA), being a hazardous material poses significant environmental risks, particularly through leaching of heavy metals that could adversely affect the ecosystem. Therefore, in order for safe and sustainable utilization of MSWIFA, it must be contained or encapsulated or hosted in an asphalt binder medium so there is no potential leaching of heavy metals whatsoever. Further, asphalt binder has exhibited superior rheological and mechanical characteristics when modified with MSWIFA. Thus, the major objective of this study was to evaluate the suitability of repurposing MSWIFA in modified asphalt binder for roadway infrastructure through the state-of-the-art methodologies to assess the short and long-term leaching of heavy metals. Based on the findings, leaching analysis confirmed 20-60% reduction in the heavy metal leaching from the MSWIFA-modified asphalt binder. Also, finer MSWIFA particle size outperformed coarser sizes in terms of dosage utilization and superior rheological properties due to higher surface area as well as exemplary interaction between the base binder and MSWIFA. Overall, MSWIFA-modified asphalt binder exhibited outstanding material performance through better resilience and high durability. It is envisioned that this research will help promote waste-to-wealth in developing green infrastructure and contribute towards solid waste management through reducing the excessive MSWIFA stockpiles closely aligned with the United Nations Sustainable Development Goals.

Paper ID: 327

Lignin and crumb rubber as sustainable bio-asphalt binders: harnessing industrial wastes in roadway infrastructure

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Abstract:

The increasing demand for sustainable alternatives to virgin asphalt binder is majorly attributed to its energy-intensive manufacturing process while also addressing environmental concerns such as resource depletion, greenhouse gas emissions, and waste management. Globally, about 100 million tons of lignin are produced annually as byproducts from pulp & paper industry and concurrently about 1000 million waste tires are generated, both of which would be dumped in the landfill and/or incinerated if not repurposes, thereby leading to greenhouse gas emissions and groundwater contamination. Intriguingly, utilization of carbon rich materials such as lignin and crumb rubber can lower carbon footprint and its combined incorporation in asphalt binder would further promote waste valorization in concert with alleviation of virgin asphalt consumption. Therefore, the major objective was to assess the suitability of kraft lignin and CR together to develop a set of novel CR-modified lignin-asphalt binders through a comprehensive leaching study, compatibility of two industrial wastes, and rheological assessment of the modified asphalt binder blends. The scope included preparation of several different blend combinations of lignin and CR-modified asphalt binders along with rheological characterization and environmental toxicity tests. The findings indicated that CR-modified lignin-asphalt binders leached minimal heavy metals, also well below the regulatory limits. Further, the incorporation of lignin improved the mechanical and rheological performance of CR-modified lignin-asphalt binders. On a research-to-practice scale, for every 100 tons of virgin binder, about 30-35 tons of lignin and CR can be incorporated, thereby helping in utilization of approximately 5000 waste tires and allowing for clearing dry sludge derived from 2000 tons of wastepaper pulp. It is envisioned that this study will contribute to the development of sustainable and durable materials required for roadway infrastructure through the integration of two major industrial wastes, thus, aligning with circular economy principles.

Paper ID: 328

A novel engineering driven approach for Direct Air Capture process

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Abstract:

Direct Air Capture (DAC) is a promising technology to reduce atmospheric CO_2 levels by extracting it directly from ambient air. A key challenge to realizing DAC in practice is low process efficiency. This low efficiency is due to the slow adsorption kinetics caused by the relatively low concentration of CO_2 (~0.04%) in air. Adsorption rates are often increased by increasing temperature and pressure, leading to higher energy costs and reduced industrial viability.

In this study, we propose a process which improves efficiency by increasing CO_2 concentration in the inlet stream. We perform this selective enrichment by removing N_2 from the inlet air. Our engineering-driven approach increases the relative concentration of CO_2 before its capture. Preliminary results using process simulations show an improvement of around 40% in CO_2 capture per cycle by removing 80% of N_2 from the inlet stream. Additionally, the extracted N_2 stream presents an opportunity for commercial utilization, enhancing the economic feasibility of the process.

In practice, our process system utilizes at least four adsorption beds operating in parallel, employing commercially available zeolite 13X as the adsorbent. To make the process robust and more efficient, we have designed an optimized column operation strategy, adjusting adsorption-desorption cycles to maximize throughput and minimize downtime. A key innovation is the utilization of waste air from the outlet of adsorption beds to cool the saturated beds post-desorption, reducing the overall energy demand. A robust control system ensures directed flow of the process stream to improve process reliability.

By integrating nitrogen removal, optimized cycle timing, and energy-efficient processes, our novel engineering approach significantly enhances DAC performance while reducing operational costs. This study demonstrates a scalable and economically viable pathway for improving DAC efficiency and offers a practical engineering solution to accelerate carbon capture efforts for climate change mitigation.

Paper ID: 330

Sustainable urban ecosystem: the role of open data in building more resilient cities

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Abstract:

Open data plays a key role in enabling governments, citizens, and researchers to utilize structured information to improve urban planning, monitor environmental impacts, and promote a smarter and more efficient city ecosystem. The indicators of the Sustainable Development Goal 11 (SDG 11) of the United Nations 2030 Agenda propose to make cities and communities more inclusive, resilient, and sustainable.

The adoption of new technologies and the improvement of data-based urban management are key components to ensure the city's best performance in the context of the use and publication of open data. However, one of the challenges is the diversity and heterogeneity of datasets available in cities, which makes it difficult to integrate and analyze them.

This data diversification reflects cities' efforts to use open data as a strategic planning tool, adapting it to local challenges and strategic sustainable development goal 11, while exploring best practices for urban governance and innovation.

This study aims to identify the main datasets that are published and used by smart cities, listing those that are most relevant to achieving the SDG 11 indicators. Research data was collected through case studies reported in the literature and international organizations technical reports. We used approaches based on Large Language Models (LLMs) and Knowledge Graphs (KGs) to create a map of the city datasets and how they can fulfill the SGD 11 contextual needs.

SDG 11 provides a broad and coordinated framework to guide urban policies that benefit both the local reality and global society. This mapping will bring greater dataset homogeneity in cities, where local needs converge with global goals, seeking to provide insights that guide informed, sustainable, and innovative urban policies, allowing the use of open data as a strategic tool for governments and organizations to make more effective decisions aligned with SDG 11.

Paper ID: 331

Risk propagation in the copper value chain: does decentralization and fragmentation confer network resiliency?

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Abstract:

Increasing competitiveness and national security concerns are highly dependent on copper supply chains, as well as its supporting service and production industries. Global risks from US tariffs, realignment of partnerships, and mining permitting delays expose the industry to potentially systemic disruptions. This study focuses on applying a multi-tier network approach to analyze risk propagation beyond direct material flows, incorporating temporal dynamics to capture systemic vulnerabilities. Resistance metrics to disruption were captured by integrating node in-strength and out-strength into α-threshold calculations, and by assessing critical firm-level susceptibility to - and influence on - disruptions. By using firm-level relationship durations between public and private firms, the granularity of disruption modeling offers a more precise assessment of network resilience over time. Community detection and backbone filtration methods were used to examine the structural evolution of, and disruption propagation in, the copper value chain from 2011 to 2022. The results indicate that temporal shifts in sectoral interconnectivity and decentralized structures play a crucial role in preventing extreme disruptions, as cascading failures remain contained within the network communities.. Reduced key firm dominance and sparse connectivity profiles among communities result in limited avalanche sizes, thus reducing the likelihood of widespread systemic collapse. However, key firms in metal mining and industrial machinery show significant systemic influence, underscoring their importance in maintaining stability. Hence, the application of complex network theory to risk quantification within the copper value chain, generates valuable insights into how industrial networks can be strategically managed to enhance resilience to disruption.

Paper ID: 332

Key drivers of soil organic carbon fractions across climate zones and soil depths on Australian agricultural soils

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Abstract:

Soil organic carbon (SOC) fractions, such as particulate organic carbon (POC; more labile) and mineral-associated organic carbon (MAOC; more stable), play a pivotal role in soil carbon cycling, influencing soil fertility, carbon sequestration potential and long-term sustainability. However, the driving factors governing the spatial variability of these fractions across different climate zones and soil depths remain poorly understood. Based on an Australia-wide dataset, POC and MAOC observations were derived from 2256 farm paddocks with detailed climatic, topographic and pedological information. SHAP (SHapley Additive exPlanations) analysis, based on trained Extreme Gradient Boosting (XGBoost) predictive models, was then applied to identify the key drivers and their interactions with SOC fractions across various climate zones (dry, semi-dry, mediterranean, semi-humid and humid) and soil depths (0-10 cm, 10-20 cm and 20-30 cm) in Australian agricultural soils. The results reveal that the top five important factors vary significantly across SOC fractions, climate zones, and soil depths, suggesting distinct underlying mechanisms driving SOC fraction dynamics. Soil types exert a more pronounced influence on SOC fractions in semi-dry areas. Furthermore, clay content is a key determinant for POC in Mediterranean, semi-humid and humid climate zones, while SiO_2 content is more influential on MAOC. Notably, total nitrogen (TN) consistently ranks among the top two most influential factors across all conditions; however, its influence pattern differs. TN is more influential for both SOC fractions in topsoils (0-10 cm) in dry, semi-dry, and mediterranean climate zones, while it plays a more prominent role in subsoils (10-20 cm) in semi-humid and humid climate zones. Additionally, soil types and oxide minerals strongly influence subsoil SOC fractions. Our findings contribute to a deeper understanding of the interactions between climate, soil properties, land use and topography in determining SOC stability, providing valuable insights for land management and climate adaptation strategies.

Paper ID: 333

Prediction of woody biomass ash potential for utilization as fertilizer and cement material

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Abstract:

Biomass power generation has rapidly grown worldwide with the demand for renewable energy. Woody biomass combustion for energy results in ash discharge, and ash utilization is increasingly essential. In this study, the woody biomass ash (WBA) recyclable for fertilizer and cement material was estimated, considering its elemental composition, and predicted for 2050 under various scenarios in Japan. Decision tree analysis was applied to determine the parameters that decide whether the ash could be utilized or not. Waste wood combustion as fuel had the most significant impact on the availability of ash for fertilizer. The WBA appropriate for fertilizer in Japan was estimated to be 790 kt/yr, which is more than twice the annual fertilizer material import. When we looked at the distribution of the amount of ash generated in each region, northern Japan was the region with the highest amount. Bottom ash was assumed to be more favorable to cement material use than fly ash. Western Japan was considered to have a reasonable possibility of WBA utilization for cement use. The Japanese government planned to increase its annual biomass power generation to 8GW in 2030. The annual fuel consumption would be 45 Mt, resulting in the need to fully utilize domestic biomass fuel or increase the import. The WBA generation in 2030 was predicted to be about 1 Mt, and it would be kept by 2050. If the consumption of palm kernel shells, which are imported fuel, is increased, the WBA amount will be larger. If circulating fluidized beds are used less, the ash amount will be larger. The predicted WBA amount appropriate for fertilizer use was 890 kt, and the amount for cement material use was 130 kt. Ash amount was sufficient for the Japanese potassium fertilizer demand.

Paper ID: 334

A systems approach in sustainability transitions: Leading consumers towards sustainable consumption

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Abstract:

Unsustainable consumption patterns exacerbate environmental degradation. Shifts in human lifestyles, driven by rapid economic development, technological progress, and global population growth, have led to significant ecological loss and environmental harm. As waste has been a pervasive global challenge, it is imperative to establish connections between consumer behavior and the underlying factors that promote circularity within the industrial ecosystem, particularly as businesses increasingly adopt circular economy models. This study explores the causal dynamics that facilitate the transition of consumers towards sustainable consumption. Specifically, it examines how policies, incentives, and sustainability strategies implemented by governments and manufacturers influence and shape consumers' sustainable decision-making processes.

This study identifies the causal mechanisms and relationships among various actors that affect consumer behavior in transitioning to sustainable consumption. Using the systems thinking approach, causal loop diagrams (CLDs) are generated to illustrate the interactions among various stakeholders. The resulting CLD show that the GOVERNMENT remains as a strong catalyst in sustainable consumption ecosystem, as it influences the sustainability mindset of manufacturers through policy implementation. The MANUFACTURER needs to have a sustainability mindset to initiate sustainable product development. Drivers for manufacturer’s decision include enhanced company image, improved environmental concern, and consumer demands. Meanwhile, CONSUMERS consider price, product affordability, and product value as significant factors in their purchase decision. Consumer education is also an important factor in developing environmental concern and sense of personal responsibility.

Paper ID: 335

Sustainable consumption drivers and mechanisms: A critical realism approach

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Abstract:

The individual consumer, while at the receiving end of the production chain, plays a crucial role in providing solutions to current environmental problems. The current "throwaway" culture not only worsens waste problems but also propagates unsustainable practices across industries. To create lasting change, consumers need to challenge one's preference for unsustainable practices in order to shift to sustainable ways of living. This study investigated the factors influencing sustainable consumption behavior among Filipino consumers, focusing on conservation, purchasing, recycling, information seeking, and environmental activism. Using an integrated conceptual model based on the Norm Activation Model and the Theory of Planned Behavior, the research adopted a mixed-method approach under the critical realism paradigm. Quantitative data was gathered through an online survey with 217 participants, while qualitative insights were obtained from nine in-depth interviews. Findings from partial least squares – structural equation modeling revealed that the following factors: awareness of consequences, perceived responsibility, behavioral control, and social norms are key predictors of sustainable consumption. Qualitative analysis through retroduction reinforced the conceptual model, and further investigation identified intrinsic (personal values) and extrinsic (social and compliance) motivations as core drivers of sustainable consumption behavior. These results highlight the complex interplay of personal, social, and environmental factors in fostering sustainable consumption.

Paper ID: 336

Transdisciplinary integration for sustainable waste management: A review

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Abstract:

An exploratory research study was conducted to identify literature that addresses "transdisciplinary research" and "waste management." The analysis was carried out using the SCOPUS database for the period 2013-2024 with the search criterion "waste management" AND "transdisciplinary research," resulting in a total of 21 documents. These documents were examined to identify the characteristics of transdisciplinary research in the field of waste management, highlighting the presence of three driving areas: ecology, environmental economics, and environmental engineering, with an emphasis on their relationship with the economic aspect.

The keyword cloud revealed the centrality of waste management, climate change, and sustainable development in these studies, reflecting their relevance and the interconnectedness of issues in these areas. It underscores the importance of an interdisciplinary approach to addressing complex challenges with local and global implications for environmental sustainability and climate change mitigation.

The role of transdisciplinary research in waste management focuses on integrating knowledge and approaches from various disciplines to comprehensively address aspects such as water management, climate change, human health, and environmental equity. This study highlights the relevance of collaboration among environmental engineers, economists, sociologists, and ecologists to design efficient systems, evaluate costs and benefits, understand community attitudes, and assess environmental impacts.

Paper ID: 337

Regulation and management of constructed wetlands for domestic wastewater treatment in urban areas

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Abstract:

Constructed wetlands (CW) represent a sustainable and nature-based alternative for domestic wastewater treatment, reducing pollution and minimizing environmental impact. These systems mimic natural decomposition processes using aquatic vegetation, water, and substrate, effectively removing contaminants. However, their implementation in urban areas requires appropriate regulatory frameworks and governance strategies to ensure their integration into existing sanitation policies. This study analyzes the regulation and management of CWs in urban settings, aiming to assess their feasibility as a decentralized wastewater treatment strategy, a household-scale CW was designed and operated, evaluating its efficiency through physicochemical characterization with different substrate and vegetation combinations (Eichhornia crassipes, Canna indica, Zantedeschia spp., Iris spp). The system was dimensioned based on an urban community's estimated domestic wastewater generation, results demonstrated significant pollutant removal efficiencies: 90.01% for biochemical oxygen demand (BOD), 74.09% for total suspended solids (TSS), 96.91% for ammonium, and 79.90% for phosphorus, the system treated and recovered 400 L of wastewater every three days, making it suitable for non-potable reuse, such as irrigation and domestic cleaning. These findings highlight the potential of CWs as a low-cost, eco-friendly alternative for decentralized wastewater treatment in urban areas. However, their widespread adoption requires supportive regulations, institutional coordination, and public policies that promote their implementation, the study underscores the need for governance strategies that integrate CWs into urban wastewater management systems, ensuring their effectiveness and long-term sustainability. Strengthening regulatory frameworks will be essential to facilitate their scalability and encourage community participation in sustainable wastewater management.

Paper ID: 338

Evolutionary trends of responses on the Automobile Trade-In Policy among multiple participants

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Abstract:

The Automobile Trade-In Policy (ATP) aims to balance industrial growth and environmental protection, thereby promoting sustainable development in the automotive sector. Understanding the heterogeneous responses of various participants is essential for effective ATP execution and precise optimization. Based on textual data, this study analyzes the response characteristics of different participants to the ATP from multi-actor, multi-phase and multi-level perspectives, clarifying their policy focus and the evolutionary trends of information dissemination characteristics. Topic analysis reveals that, although different participants focus on varying aspects of the ATP, their discourse tendencies primarily center on four levels: policy details, implementation feedback, impact effectiveness and strategic insights. Dissemination analysis reveals significant differences in the policy dissemination influence among various participants across different phases. Spatial-temporal analysis indicates a “stable—explosive—secondary stable—secondary explosive” pattern in ATP discussions. The diffusion intensity of ATP-related information and the influence distribution of participants follow a spatial pattern of being “higher in the southeast and lower in the northwest”, consistent with regional development levels. This study provides a multi-dimensional perspective for the formulation, optimization and promotion of trade-in and other sustainable consumption policies.

Paper ID: 339

Artificial Intelligence (AI)-powered autonomous shuttles for sustainable urban mobility in Malaysia: An overview

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Abstract:

Two-thirds of the world's population will be living in urban areas by the year 2050, and an additional 2.5 billion people will be in urban areas, leading to increased road congestion and traffic demands. This surge, coupled with the environmental impact of car travel, necessitates a shift in mobility solutions. AI-powered autonomous shuttles offer a promising approach to addressing these challenges, enhancing flexibility and responsiveness by integrating seamlessly with public transportation (PT) systems and adapting to disruptions. The study aims to explore the potential of AI-based autonomous shuttle buses for first- and last-mile mobility solutions in global public transportation systems and compare them with those in the Malaysian context. This study reviews existing literature on Shared Autonomous Vehicle (SAV), especially Autonomous Shuttles, and the first- and last-mile mobility solutions in PT systems in terms of passenger perspective and traffic and Vehicle Miles/ Kilometres Travel (VMT/ VKT). Research on SAV-PT integration is predominantly based on simulations and mathematical modeling in developed countries like the United States, Italy, and Singapore, spanning urban and suburban settings under varied travel demands. Findings indicate that AI-powered predictive analytics significantly enhance autonomous shuttle efficiency by minimizing wait times and maximizing passenger service. The VMT/ VKT results are mixed, with most studies reporting reductions but one noting slight increases due to operational needs like charging trips. In the Malaysian setting, there is a lack of study of this nature. The study also explores the challenges of widespread adoption of autonomous shuttles for public transportation. Once their benefits are not only recognized but also experienced by a significant number of users, this form of transportation will revolutionize the industry. The study aligns with SDG 11 (Sustainable Cities and Communities) by advocating for safe, accessible, and sustainable transport, and SDG 13 (Climate Action) by promoting low-carbon urban mobility solutions.

Paper ID: 340

A sustainable food waste-based biogas plant integrated with organic farming: Dual role in energy security and soil health through vermicomposting using biogas slurry and agro-waste

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Abstract:

This study explores a three-phase approach to sustainable waste management and bioenergy production. Year-Round Biogas Production: A self-sustained solar photovoltaic active thermal heating floating dome biogas plant (35 m^3) is designed to optimize biogas generation from food waste. The integration of solar modules enhances thermal energy utilization, ensuring consistent operating temperatures (35 ± 2 °C), particularly in cold conditions, reducing hydraulic retention time, and increasing efficiency. The system produces approximate 10–12 m^3 of gas, 800 to 1000 L biogas slurry and ~2000 to 2500 L of hot water daily, replacing one LPG cylinder every two days.

Utilization of Liquid Biogas Slurry: The acidic outlet slurry (pH 5.3) is evaluated as a liquid fertilizer and for alkaline soil reclamation (pH 9.45). Different slurry concentrations (10, 20, 40, 60, 100%) were tested along with comparative analysis using urea treatments, with 40% and 60% treatments showing the highest growth performance in pea plants. Further studies are ongoing to assess its impact on soil fertility and crop productivity.

Vermicomposting with Biogas Slurry: The dry biogas slurry is used as a bulking agent for vermicomposting in combination with fish processing waste (nitrogen source), eggshell waste (Ca and P source), and rice straw (aeration and microbial activity enhancement). Improper disposal of these organic wastes contributes to environmental pollution, impacting soil, water, and air quality. Initial sampling (at 20 days) of the vermicomposting process (for 60 days) indicates pH 8.6, electrical conductivity 6.2–7.0 dS m^{-1}, and C/N ratio 18–25. Ongoing analysis using CHNS, FT-IR, FESEM-EDX, XPS ETC will characterize the vermicompost's composition. Furthermore, the biogas plant serves a dual purpose by generating energy and supporting organic farming through its slurry. This study will highlight a holistic waste valorisation approach, fostering renewable energy, enhancing soil health, and advancing sustainable agriculture.

Paper ID: 341

Enhancing material circularity through systems thinking: Modelling strategic decisions and policy interventions

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Abstract:

The policy landscape of enhancing material circularity is still evolving and lacks a comprehensive structure. This study investigates how policy interventions can promote material circularity within the Australian construction industry. Addressing this gap, the research employs a participatory system dynamics (SD) modelling approach to capture the complex, multi-stakeholder interdependencies and feedback mechanisms influencing circularity outcomes. The model integrates stakeholder input and simulates policy scenarios across the building lifecycle, focusing on material circularity strategies to reduce material consumption and construction and demolition waste (C&DW). The SD model maps circularity interventions across four lifecycle stages: design, construction, operation, and end-of-life, enabling an assessment of their cumulative impacts. Findings demonstrate that SD-based policymaking leads to more resilient, adaptive, and broadly supported strategies. The study contributes to the advancement of CE policy design by providing an evidence-based decision-support tool for policymakers, capable of aligning environmental objectives with economic and operational priorities in the industry.

Paper ID: 342

Governance of sustainability and sustainable public policies in Mexico.

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Abstract:

In Mexico and in the Latin American region, sustainable and sustainable are not regularly taken as synonyms. This is due to the strong ideological burden that the term sustainable has, which is related to ancestors, communities, and the social within the care of the environment, and sustainable is usually related to the prevention and remediation of pollutants through a series of certifications that are imposed on companies but have no relation to society. Once we have made the difference, we go to which of the environmental public policies that have been developed in Mexico are for sustainability and which are for sustainability and how they are applied, when they are applied, where they are applied and to whom they are applied, what is the governance of these policies and what results are obtained in their applications, the positive and negative externalities. The objective of the work is to show the difference between sustainable and sustainable and its main implications in environmental policy in Mexico. The methodology used was based on the review of the literature, and among the results obtained is the confusion that exists when handling the conceptual difference.

Paper ID: 343

A lifecycle perspective of a new generation sustainable modified asphalt-rubber ingrained with fly ash and pond ash

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Abstract:

Due to rapid global industrialization, several tons of industrial and urban wastes are produced annually. Fly ash and pond ash from thermal power plants as well as end-of-life tire-derived crumb rubber comprise a significant portion of the wastes that get landfilled, further escalating the environmental burden. The increasing accumulation of industrial wastes presents substantial socioeconomic challenges, necessitating innovative recycling solutions. Also, conventional asphalt mixtures often exhibit limitations in durability and performance under varying climatic and traffic conditions. Asphalt-rubber (AR) mixtures ingrained with industrial wastes / byproducts such as fly ash and pond ash offer a promising approach to enhancing pavement sustainability, especially targeting environmental indicators from lifecycle assessment (LCA) perspective. Thus, the major objective of this study was to repurpose industrial waste byproducts such as fly ash and pond ash in road materials, which addressed both environmental sustainability and mechanical performance. Further, a cradle-to-gate LCA approach was employed to evaluate the environmental impact considering eighteen factors such as emissions, resource efficiency, and climate change. Further, rheological analysis revealed the synergistic effects between crumb rubber and the ash components within the binder. Mechanical testing also confirmed that combining crumb rubber with fly ash or pond ash remarkably enhanced elasticity, rutting and moisture resistance, and thermal stability of the mixture, rendering them promising alternatives for pavement applications. Notably, almost 30 tons of waste material, including crumb rubber and ashes can replace virgin materials required to produce 1 km of roadway stretch, thus appreciably reducing the reliance on natural resources and diverting large quantities of wastes from landfills into meaningful infrastructure products / systems. Overall, the ash-modified AR would serve as an eco-friendly durable alternative well-aligned with waste valorization and/or growing demand for resilient and sustainable transportation networks, thus, paving the way for green road construction practices.

Paper ID: 344

Future of steelmaking in India: A comparative analysis of energy demand and raw material requirements across different production scenarios

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Abstract:

The industry sector is the largest carbon dioxide (CO2) emitter globally, responsible for 24% and 10% of the direct and indirect emissions, respectively. The iron and steel sector is the most emission-intensive industry globally, accounting for approximately 11% of total CO2 emissions. In India, this sector is also the most energy-intensive, contributing 39% of the emissions from the industrial sector. India's National Steel Policy projects the per capita steel consumption to rise significantly, reaching 158 kg by 2030 from the current 93.4 kg. With the increase in population coupled with increased per capita steel consumption, the sector's materials and energy requirements will likely disrupt the upcoming decarbonisation targets. This study focuses on comparing the raw materials, and energy requirements of India's iron and steel sector for three technological scenarios: business-as-usual (BAU), resource-optimised (RO) and green steel (GS) for cumulative steel production between 2024 and 2050. The BAU scenario primarily uses the conventional material and energy-intensive Blast Furnace-Basic Oxygen Furnace (BF-BOF) route, while the RO and GS scenarios cater to low material input, improved recycling, and increased share of renewables and scrap. The results indicate a reduction in raw material requirements by 9% and 26%, respectively, for the RO and GS scenario, compared to the BAU scenario. In contrast, the electricity demand increases by 3% for the RO scenario and a significant 239% for the GS scenario. The increased energy demand for the GS scenario is mainly due to the electricity required to produce hydrogen in the electrolyser. This electricity demand needs to be sourced from cleaner renewable sources, to eliminate the negative emissions associated with coal-based electricity. Transitioning to RO and GS production routes is crucial in achieving carbon neutrality and will play a vital role in transitioning towards a more sustainable future.

Paper ID: 345

Water environment carrying capacity of city: Evaluation and analysis for Suzhou city

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Abstract:

Resources have always been of great importance as an essential element for urban development and human survival. The carrying capacity of water environment is a vital for local economic development and human life privided that sustainable development is considered. Therefore, it is very important for a city's health and sustainable development with adequate water environmental carrying capacity. This paper analyse and evaluate the the water environment carrying capacity (WECC) of Suzhou city as a study case, by comining the method of principal component analysis and the entropy weight method. A water environmentalcarrying capacity index system is developed based on 20 indicators from threee subsystem: water and environment, human and society, social economy, and the entropy weight method and the approximate ideal solution ranking method are combined to evaluate the water environmental carrying capacity level of Suzhou city. The future WECC of Suzhou City is predicted by combining an approximate ideal solution ranking method with a grey prediction model. The study shows that the main influencing factors of the WECC index system are chemical oxygen demand (COD) per 10,000 yuan of GDP, the effective utilization coefficient of farmland irrigation water, water consumption, water consumption per 10,000 yuan of industrial value, water consumption per 10,000 yuan of GDP, water consumption per capita inhabitant and farm land irrigation water consumption. The study also shows the the water environmental carrying capacity of Suzhou in the past 22 years is normal, and its WECC in the next five years is forcased to be good. This finding will help for Suzhou City Government to formulate corresponding policies and improve the local water environmental carrying capacity and sustainable development prospects.

Paper ID: 346

Landfilling to road building: synergistic effect of recycled composite waste and crumb rubber in the development of a sustainable asphalt binder

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Abstract:

Crumb rubber (CR) from end-of-life tires has been regarded as an innovative, sustainable, and successful modifier to produce high-performing asphalt pavement materials. However, the practical issues related to the storage stability of CR-modified binder has always been a challenge for the pavement industry. To address this issue, there is a pressing need to develop innovative stabilization strategies that help maintain the beneficial properties of CR-modified binders. Concurrently, the accelerated landfilling of composite waste (CW) derived from wind turbine blades poses a significant environmental challenge ascribed to the absence of appropriate sustainable recycling methods. Thus, the major objective of this study was to combine the compositions of CR and CW to address the phase separation challenges by developing a set of high-performing CR-CW-modified asphalt binder conglomerate along with investigating their environmental sustainability. The scope of the effort included blending CR and CW with base asphalt binder to develop high-performing binders, and evaluate them for rheological performance along with assess the environmental impact indicators, chiefly to quantify sustainability benefits resulting in optimized CR-CW compositions for sustainable road building infrastructure. The mechanical performance test results on CR-CW asphalt binder blends demonstrated synergistic contribution of CR-CW in augmenting the resistance to high-temperature rutting and fatigue cracking, thereby creating a well-balanced asphalt binder with superior rheological properties that also enhanced storage stability. Further, the Pareto optimal fronts developed between the two different parameters identified the range of optimized CR-CW compositions, positively contributing to material sustainability. Overall, this research offered a remarkable solution in responsibly disposing about 12.5 tons of combined CR and CW materials for every 84 tons of asphalt binder per lane km of roadway, thus bolstering pavement circularity and supporting the United Nations Sustainable Development Goals.

Paper ID: 347

Estimating the embodied carbon and costs of concrete modular high-rise residential buildings in Hong Kong

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Abstract:

The concept of Modular Integrated Construction (MiC) has advanced as a disruptive approach in construction project delivery. By their nature, modular buildings are designed, manufactured, and assembled within an integrated value chain that optimizes construction workflows and productivity. Given the current climate change and emission reduction goals, there's an apparent expectation to optimize the carbon performance of modular buildings. However, in a profit-driven construction industry, cost competitiveness is critical for pivoting change and implementation, especially in high-density cities where growth in adoption is imminent. Hence, there is a need to estimate the intrinsic yet tangible carbon and cost performance of modular building designs. This study analyzes the embodied carbon and costs of a typical concrete modular high-rise residential building with various modular flat design layouts ranging from 1-bedroom to 3-bedroom units. Within the cradle-to-site system boundary, the carbon and cost analysis is integrated through LCA-LCC to facilitate a streamlined comparison of impacts. In a preliminary analysis of the cradle-to-site phases, average embodied carbon emissions are estimated as 347.60 to 370.68 kgCO2eq/m2, while average costs ranged between 1,410.58 to 1,483.81 HK$/m2. The findings show that, while embodied carbon emissions and costs are proportional to the gross floor areas, the eco-efficiencies of the flats do not follow this trend since more value is created from higher gross floor areas. An extended analysis of the cradle-to-end-of-construction stage is further undertaken to compare the total impacts and inherent trade-offs. Generally, this paper elevates the existing discourse on the development of low-cost, low-carbon modular buildings and puts forward future research recommendations to further demonstrate the utility and sustainability potential of modular buildings in the built environment.

Paper ID: 348

Advancing circularity in the built environment: sustainable criteria for responsible plastic waste application

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Abstract:

Globally, nearly 400 million tonnes (Mt) of plastic waste are generated annually, yet only 9% is effectively recycled. This unsustainable trend poses significant environmental challenges, threatening both natural ecosystems and human health. Despite the principles of the Circular Economy (CE), the lack of standardised sustainability criteria hinders the widespread adoption of recovered plastics. Circularity criteria for plastic waste management focus on developing systems that minimise waste generation while enhancing reuse, recycling, and remanufacturing at the end of a product's lifecycle. These criteria aim to create a closed-loop system, ensuring that plastic waste is effectively managed and does not become an environmental burden. This study aims to define clear sustainability standards for recovered plastics, where factors such as environmental impact, durability, and safety are critical. Through literature review, this research evaluates existing circularity frameworks and certification schemes to propose a consistent approach that enhances the viability of recovered plastics applications. Establishing robust, standardised criteria will support the transition toward a more sustainable and resource-efficient built environment.

The findings reveal that circularity criteria support the transition to a sustainable plastic economy by addressing waste management limits while highlighting CE adoption drivers. For instance, mitigating limitations such as inefficient recycling infrastructure, poor material design, and regulatory gaps can strengthen enablers like technological innovation, policy interventions, and increased market demand for recycled plastics. Similarly, overcoming driving factors such as consumer reliance on single-use plastics and inadequate waste collection systems can help improve limitations such as high processing costs and material degradation, thereby improving the overall efficiency of plastic circularity initiatives. Finally, this review article highlights the importance of criteria to achieve the circularity of plastic by identifying and addressing key limitations that hinder sustainable plastic management while enhancing driving factors that promote CE principles.

Paper ID: 349

Robust design for a multi-echelon regional construction and demolition waste reverse logistics network with risk pooling effect

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Abstract:

The regional construction and demolition (C&D) waste reverse logistics network serves as a critical mechanism for advancing high-quality circular economy development within the construction sector. Enhancing the robustness of such networks enables improved responsiveness to fluctuating C&D waste disposal demands in uncertain environments. While robustness optimization often incurs elevated costs due to expanded facility capacity and new infrastructure deployment. This study introduces a risk-pooling strategy integrated into network design to simultaneously strengthen robustness and mitigate the price of robustness. A robust optimization-based modeling framework is developed to operationalize this approach. Empirical validation through a case study in Shanghai's Chongming District demonstrates the risk-pooling effect's efficacy in balancing system robustness and economic viability. This research contributes a novel decision methodology for designing robust reverse logistics networks under uncertainty.

Paper ID: 350

Dietary structure and nutrition in Agro-pastoral Transitional Zone of southeastern Tibetan Plateau

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Abstract:

Abstract：Food consumption is crucial for residents' livelihoods. Understanding the dietary patterns of Tibetan Plateau residents is vital for enhancing their nutrition and living standards due to the region's unique agro-pastoral systems and ecological significance. Using Nyingchi as the case, first-hand data on food consumption from 216 farming and herding households were collected through stratified sampling and field surveys in 2022. Utilizing this dataset, a quantitative analysis was executed to examine the dietary structure and nutrition within the Agro-pastoral Transitional Zone of southeastern Tibetan Plateau, including comparisons across regions and demographic groups. The results demonstrate that (1) The per capita food consumption is 494.10 kg/a, mainly plant-based food (4.08× animal-based food) which is primarily grains (mainly flour, rice and highland barley) and vegetables, while the animal-based food focuses on meat and dairy. (2) Dietary structure varies significantly across regions and demographic groups. Higher-income and smaller households tend to consume more food per person, particularly meat and vegetables. (3) Compared to China's Balanced Diet Pagoda, the dietary intake of Nyingchi farmers and herdsmen surpasses the upper limits for grains, oil and meat by 98.41%, 46.07% and 1.01 times, respectively. However, their intake of vegetables, fruits, dairy, eggs and aquatic products is just 64.08%, 37.19%, 38.61%, 48.05% and 3.77% of the lower limits. They consume less vegetables and highland barley but more rice, flour and alcohol than rural residents in the area of Yarlung Zangbo River and its two tributaries. (4) Farmers and herdsmen exceeded Chinese dietary reference intake values for energy, protein and fat by 54.60%, 67.47% and 2.66 times, with grains remaining the primary source of energy and protein. These findings offer insights for improving dietary and nutrition in the Agro-pastoral Transitional Zone.

Paper ID: 351

Effect of retarder derived from fruit peel waste on the rheology of concrete

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Abstract:

Due to the increasing demand for ready mix concrete, research for diverse admixtures offering various benefits is crucial. Organic acids and their derivatives show promise as a viable retarder for ready mix concrete. Gluconic acid (GA) was prepared by submerged fermentation of fruit peel waste as substrate from Aspergillus Niger and used as a retarder in this study. This study was carried out to evaluate the effect of synthesized retarder (GA) on rheological and mechanical properties of concrete. GA showed dispersing effect, reduced the dynamic yield stress and plastic viscosity. Although GA delayed initial hydration reactions of cement, it enhanced the mechanical performance of concrete. Performance evaluation evidenced that concrete containing 0.08% to 0.1% GA has good retarding effect, enhanced workability and a retention time of up to 180 mins. Furthermore, the microstructural analysis reveal that the addition of GA affects the hydration process and the amount of hydration product.

Paper ID: 353

Life cycle environmental impact assessment of tyre manufacturing: A comparison of new and retreaded tyres

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Abstract:

The environmental impact of tyre production is a growing concern due to resource depletion, greenhouse gas emissions, and pollution. India generates approximately 1 million tonnes of discarded tyres annually, which represents about 6% of global tyre waste. Despite strict governmental regulations, a large chunk of the tyres, approximately 60%, are dumped off through illegal dumping. With increasing awareness about environmental protection, sustainable manufacturing practices cater to the issue of discarded tyres by remanufacturing or retreading used tyres, and extending the useful life of old tyres. This reduces the scrap tyre dumping and reduces the natural resources and energy used in new tyre production. This study focuses on carrying out an environmental impact assessment of a new Apollo tyre and a rethreaded tyre manufactured by a franchisee of Apollo Tyres with a cradle-to-gate approach. The results showed the resource consumption significantly reduced in comparison to a new tyre, with 52.4% less rubber, 68.2% less fabric and 67% less chemicals being used in a rethreaded tyre. Additionally, the electricity and water requirements were reduced by 60.8% and 99.99%, demonstrating a substantial amount of energy and resource savings. There was an increase in 81.8% of furnace oil usage, resulting in a 22% increase in the oil and grease levels in wastewater, which shows the need for further improvement in the process and better waste treatment. The environmental impact assessment indicates that rethreaded tyres lower the global warming potential, abiotic resource depletion and acidification by 66.8%, 59.9%, and 68.9%, respectively. The results highlight rethreading as a potential mitigation option to promote a circular economy, conserve raw materials and reduce environmental impact in the tyre industry. There is a need for industry-wide adoption, implementation of proper manufacturing processes, policy interventions and consumer awareness to maximise sustainability benefits.

Paper ID: 354

Enhancing sustainable management of residential buildings in Hong Kong through CIM-based Life Cycle Assessment

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Abstract:

Sustainability, which is aimed at coordinating economic, social, and environmental development, has caught great attention since its contribution to world development in the long term. Building sectors are responsible for a significant share of resource consumption and greatly require sustainable solutions, where the residential building is the essential part. City Information Modeling (CIM) leverages urban sensing technologies and devices and urban computing advancements to provide detailed and precise city information. This enables the development of smart applications for a wide range of urban research purposes. Also, as the data repository, CIM precisely offers an answer for the accurate, specific, and efficient Life Cycle Assessment (LCA) implementation of residential buildings. Therefore, this research proposal aims to explore a novel systemic CIM-based LCA framework framework to aid the sustainable management of residential buildings. In view of the urgent needs and its typical residential building, Hong Kong provides an exemplary testing ground for this research. This research contributes to developing the theoretic CIM-based sustainable development framework for residential building management. The research findings present innovative improvement opportunities for the sustainable management of residential buildings in Hong Kong.

Paper ID: 355

Towards construction digitalization and sustainability: A digital twin-enabled framework

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Abstract:

As one of the largest carbon emitters, construction activities by nature are resource-intensive, where construction-related energy issues are the significant concerns in the world. Therefore, construction projects are responsible for the major parts of total energy resources consumption during its operation. Digital Twin technology plays a pivotal role in the sustainability of construction resources by creating virtual models to simulate, monitor, and optimize the performance and behavior of construction activities in real time. By generating a virtual representative, it enables the monitoring of resource consumption throughout the construction process and predicts energy efficiency and sustainability at various stages. This paper aims to propose a framework based on digital twin technology to evaluate energy management and environmental impact over the entire lifecycle of construction projects. The contributions of this study are twofold: i) by integrating digital twin technology, a research framework is proposed for the sustainable construction development; ii) through the case validation, it demonstrates the significant role and contribution of digital technology in enhancing resource utilization and energy sustainability.

Paper ID: 360

Particulate matter exposure disparities in construction: A demographic scenario analysis

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Abstract:

Airborne particulate matter (PM) from construction activities poses significant health risks, yet disparities in exposure across gender and age groups remain underexplored. In the Australian construction industry, men dominate younger age groups, while women, though fewer, are mostly older. This uneven distribution may result in unequal PM exposure risks. This study employs scenario analysis, integrating Australian demographic data (two sexes and six group ages) with empirical PM concentration data from construction sites (three occupational categories with five exposure risk level). A total of 180 scenarios were constructed to quantify the daily inhaled doses of PM1, PM2.5, and PM10 across different demographic groups, summing to 15,000 samples obtained. Results show that male workers generally inhale higher PM doses than female workers. However, in certain occupational categories—such as general construction work—female workers experience PM exposure levels similar to male workers engaged in lower exposure tasks. Additionally, PM inhalation surges substantially with age until approximately 25 years old, after which it lessens, likely due to changes in lung capacity and work intensity. Bonferroni correction reduced the number of statistically significant age-based differences, but without it, 44.52% of comparisons were significant, suggesting that strict statistical adjustments may obscure meaningful exposure variations across age groups. These findings underscore the necessity of revising PM exposure standards to incorporate gender and age-specific risk assessments. A more comprehensive approach to air emission risk assessment and management in construction is essential to enhancing workplace health while mitigating long-term air quality impacts, fostering a construction industry that prioritizes both human well-being and environmental resilience.

Paper ID: 361

Integrating success factors for recycling operations in material flow modeling

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Abstract:

Several life cycle management approaches, cumulated as “R strategies”, aim to reduce resource consumption hierarchically. Material recycling is one of the utmost strategies when preferable strategies like remanufacturing or reuse are not feasible, viable, nor desirable. Nevertheless, recycling is indispensable to avoid landfilling once end-of-life products must be converted back to raw materials. Operational efficiency in recycling depends on process capability and is further subordinate to substantial systemic repercussions. For example, a recycler has limited influence on the composition of incoming recycling educts. Therefore, material flows to and within recycling systems must be evaluated in terms of the technological capabilities and limits of the recycling process infrastructure.

This work presents a hierarchical material flow modeling approach for efficient recycling systems based on Petri nets. Through a literature review, we investigate the nature of recycling systems from an industrial and systems engineering perspective in analogy to production systems. We present the main targets and influencing parameters for recycling operations and discuss their relationships and interdependencies. Furthermore, distinctions between single-varietal recycling, such as aluminum or steel, and complex material recycling, such as battery or photovoltaics, are examined.

Based on these examinations, we derive comprehensive success factors for recycling and integrate them as top-down requirements into the hierarchical material flow modelling approach. The approach is evaluated based on the use case of a recycling network for photovoltaics, where we investigate different scenarios. As a result, relevant drivers for recycling operations in process design, process technology, and systems engineering are deduced. The results are concentrated as an overview of capabilities for positive impact recycling operations.

Paper ID: 363

Evaluation of PTE biomineralization of the marine bacterium Lysinibacillus sphaericus PG22

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Abstract:

Today, environmental contamination represents one of the major threats to our generation. Among contaminants, Potentially Toxic Elements (PTE) are of concern due to their bioaccumulation and biomagnification in marine and terrestrial sinks. The removal of these compounds led to methods' advancement, including biobased ones such as biomineralization processes. These processes can form PTE-bearing minerals thanks to the interaction with microorganisms. Microbial Induced Carbonate Precipitation (MICP) is one of the most known processes producing high amounts of calcium carbonate in a very short time. This has encouraged the search for efficient bacteria able to perform MICP. Marine ecosystems host 90% of the global living biomass and represent a priceless archive of biodiversity with unexploited biosynthetic potential, making it a focal point for sustainable innovation in marine biotechnology. In this study we evaluate the MICP potential of Lysinibacillus sphaericus PG22, a marine gram-positive sporulating bacterium isolated from N-Tyrrhenian sediments presenting interesting geochemical characteristics. Genome analysis revealed the presence of urease and metal resistance genes, confirming its validated ability to tolerate1600 ppm of $Pb(NO_3)_2$. We demonstrated PG22's ureolytic activity, leading to the biomineralization of 61.7 g/L calcium carbonate in the presence of urea. TGA, XRD, and ESEM-EDX analyses proved calcite polymorph formation already within 16 h of incubation. Additionally, in presence of Pb^{2+}, PG22 promoted the formation of cerussite ($PbCO_3$) and hydrocerussite [$Pb_3(CO_3)_2(OH)_2$], effectively removing 100% of the Pb in solution, bioaccumulating 2% and biomineralizing 98%. Future experiments will evaluate PG22 fitness in the treatment of more complex anthropogenic waste matrices enriched of PTE and precious elements. The evidence of spores' involvement in the process could guarantee efficiency over time and in extreme conditions. These findings highlight L. sphaericus PG22's potential for MICP-based bioremediation strategies, offering a sustainable solution to restore marine and other contaminated environments, including most sensitive marine and transitional zones.

Paper ID: 367

High production of nitrous oxide (N2O) via acidic denitrification approach

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Abstract:

Nitrous oxide (N2O) is the third most abundant greenhouse gas (GHG) in the atmosphere, with a global warming potential 265-298 times greater than carbon dioxide (CO_2) over a 100-year period. In addition to its climate impact, N_2O significantly contributes to ozone layer depletion. Reducing N_2O emissions is crucial for mitigating the overall GHG emissions and achieving net-zero carbon targets. In wastewater treatment systems, direct N2O emissions can account for up to 80% of the operational carbon footprint. As a result, numerous strategies have been developed to mitigate N2O emissions, either by reducing its production or enhancing its consumption. Recently, however, attention has shifted towards an alternative approach—recovering N2O from wastewater as an energy resource. N2O can be used as a co-oxidant in combustion, offering greater energy output than oxygen. Therefore, N2O recovery not only reduces GHG emissions but also enhances resource recovery, presenting a promising opportunity for sustainable wastewater management.

This study demonstrates significant N2O production via microbial denitrification under acidic conditions. Using a bioreactor maintained at pH 5, continuously fed with nitrite and acetate, an acidic microbial culture was cultivated, with Rhodanobacter emerging as the dominant denitrifying genus. The culture achieved a nitrite-to-N2O conversion efficiency exceeding 60%, with a production rate of 6.0 ± 0.2 mg N2O-N/h/g volatile suspended solids. Stable acidic denitrification was sustained in semi-continuous operation, with liquid N2O concentrations accumulating up to 150 mg N/L. This discovery introduces a novel pathway for N2O production and recovery, offering new possibilities for wastewater nitrogen management.

Paper ID: 368

Synergizing circular economy and industrial green TFP for sustainable industrial development

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Abstract:

Global resource depletion necessitates sustainable environmental management for ecosystem conservation as the basis for sustainable industrial development based on strong sustainability. The gaps identified by this research were the absence of an economic strategy for effective environmental management and an innovative industrial model for strong industrial sustainability. This research elucidates the significance of Industrial Green Total Factor Productivity (IGTFP) in managing an industry's environmental impact by incorporating natural capital accounting into productivity evaluations. IGTFP complements circular economy (CE) in industrial systems based on its endogenous Industry 4.0 Technologies that generate sustainable productivity, ecological preservation, and optimal profit maximization. Based on the synergies between IGTFP and CE, this study proposes an integrated Circular IGTFP (CIGTFP) model to promote eco-efficiency, cleaner production, and responsible resource consumption and facilitate collaboration between businesses and researchers to accelerate the transition to strong sustainability. This model synchronizes productivity with environmental, social, and governance principles, enhancing ecological resilience and yielding socioeconomic advantages such as job creation and resource stewardship. The pragmatic applications of the CIGTFP model incentivize entrepreneurs to adopt restorative activities to reduce the associated costs of environmental input by internalizing optimal pollution tax. This research contributes to theoretical discourse by clarifying the triadic synergy among technology, industry, and CE and incorporating strong sustainability into industrial sustainability evaluation. The government should enact robust environmental regulations based on the IGTFP framework and stimulate innovation in CE through incentives, infrastructure development, and public-private partnerships to support the application of the CIGTFP model to accelerate strong sustainability in the industry.

Paper ID: 369

A sustainable design approach for net-zero energy housing in rural pakistan: a case study

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Abstract:

This study investigates a sustainable design approach for net-zero energy housing in rural Pakistan, primarily focusing on the village of Garhi Yasin, Shikarpur. The research emphasizes the integration of locally sourced materials, particularly bamboo, and renewable energy resources to create affordable housing solutions that meet rising energy demands while addressing environmental concerns. Traditional building techniques are combined with modern sustainable practices to enhance the resilience and comfort of homes. The design promotes effective natural ventilation and daylighting, employing materials such as mud bricks and bamboo to optimize thermal insulation in the region's hot climate. This innovative housing model incorporates solar energy systems and features kitchen gardens to promote food sustainability, thereby bolstering community well-being. The study highlights the significance of using bamboo, which has a higher carbon storage capacity than conventional timber and provides ecological and economic benefits to rural communities. The findings demonstrate that through energy-efficient designs, the proposed housing achieves net-zero energy consumption, minimizes reliance on artificial heating and cooling, and enhances indoor air quality. By prioritizing cultural privacy and utilizing local labour and materials, the project supports the local economy and fosters community engagement. Ultimately, the research presents a scalable and replicable framework for sustainable housing in similar rural contexts, proposing holistic solutions that improve living conditions and encourage ecological sustainability.

Paper ID: 370

Comparative assessment of groundwater and reverse osmosis (ro) qater quality using water quality index (wqi) in karachi, pakistan

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Abstract:

Access to safe drinking water is essential for public health, necessitating the thorough assessment of water quality from Reverse Osmosis (RO) plants. This study presents a comprehensive evaluation of the physicochemical parameters, including the potential of hydrogen (pH), Total Dissolved Solids (TDS), Turbidity, Electrical Conductivity (EC), Total Suspended Solids (TSS), Chloride, and Hardness of bore and RO water samples. A total of 172 water samples, including 119 from RO plants and 53 from bore wells, were collected across different areas of Karachi, Pakistan. The water quality of these samples was assessed using the Water Quality Index (WQI) method by evaluating its efficiency in providing safe drinking water compliant with World Health Organization (WHO) guidelines. The results revealed that 68% of bore water samples were deemed unsuitable for drinking, whereas 91% of the RO water samples fell into the excellent and good categories of the WQI classification. This study also includes surveys in which a significant portion of RO plant owners were unable to provide proof of registration and licensing from relevant agencies, suggesting a potential lack of awareness and compliance with regulations. Additionally, a correlation matrix was used to study relationships between water quality parameters in RO-treated water, which revealed that no strong correlation was found among them. Furthermore, it was found that there is no direct correlation between the cost and quality of RO water, dispelling the notion that a higher price indicates improved water quality.

Paper ID: 371

Evaluation of Manufactured Sand as River Sand Substitute in Concrete in the Philippines

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Abstract:

The escalating population, rising living standards, and accelerated urbanization in the Philippines have led to a substantial increase in sand consumption. Consequently, the exploration of river sand alternatives in concrete production has become imperative. This study aimed to evaluate manufactured sand as a viable substitute for river sand, ensuring no compromise in concrete properties. Scanning electron microscopy (SEM) was employed to characterize the sand particles, while ASTM standards were utilized to determine its properties. The study assessed the effect of manufactured sand on concrete properties, including workability, compressive strength, split tensile strength, and resistance to acid attack. The roughness and angularity of the manufactured sand particles resulted in increased slurry consumption, leading to a decrease in concrete workability. However, results revealed no significant differences in compressive strength, split tensile strength, or resistance to acid attack among concrete mixes containing varying proportions of manufactured sand. These findings demonstrate that the inclusion of manufactured sand does not significantly impact these critical concrete properties. Therefore, this study concludes that manufactured sand presents a viable alternative to river sand in concrete production.

Paper ID: 372

Municipal solid waste dynamics in karachi's district east: insights from gts imtiaz and adjacent areas

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Abstract:

The management of municipal solid waste presents a critical challenge for rapidly urbanizing megacities such as Karachi, Pakistan. This study conducts an in-depth assessment of waste generation and characteristics within District East, with a particular focus on GTS Imtiaz, a prominent garbage transfer station in the territory. Through scrupulous sampling and analysis, the research investigates essential waste properties, including moisture content, chemical composition, and density, while also reviewing comprehensive daily waste collection records from January 2023 to quantify the magnitude of waste generation. To broaden the scope, the study extends its analysis to three additional strategic locations: Purani Sabzimandi, Nipa, and Bahadurabad, enabling a comparative evaluation of waste composition across these areas. The findings reveal significant insights into the volume and composition of waste produced, uncovering both commonalities and unique characteristics among the studied sites. By synthesizing these results, the research aims to inform practical interventions for enhancing waste management strategies in District East. Moreover, the study provides a foundational framework to support the development of comprehensive, data-driven policies to address Karachi's escalating waste crisis, fostering sustainable urban growth and environmental stewardship.

Paper ID: 373

A Comparative Study of Compressive Strength and Workability of Concrete made with River Gravel and Crushed Rock

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Abstract:

Concrete is typically composed of cement, water, fine aggregates, and coarse aggregates. It is known that coarse aggregates, such as river gravel or crushed rock, significantly influence the compressive strength and workability of concrete due to its physical and mechanical properties. However, studies about the characteristics of locally available coarse aggregates and their effects on concrete in Luzon region are limited. Thus, this study evaluates the effects of river gravel from Sablayan River in Romblon, river gravel from Balili River in La Union, and crushed rock from Laguna on the compressive strength and workability of concrete. Concrete mix designs were prepared using the ACI 211 method for proportioning, and tests were conducted in accordance with ASTM standards. Regression models predicting compressive strength based on curing age were developed and statistically validated for adequacy. The results show that concrete made with Sablayan River gravel exhibited the highest workability, attributed to its smooth surface and round shape. On the other hand, concrete using crushed rock achieved the highest compressive strength due to better interlocking from its angularity and rough texture. River gravel from Balili River provided intermediate performance for both workability and compressive strength. All mixes met satisfactory standards, confirming the suitability of these aggregates for concrete proportioning. Analysis of variance (ANOVA) established a significant linear relationship between curing age and compressive strength, with models demonstrating high predictive accuracy through strong coefficients of determination and well-distributed residuals.

Paper ID: 374

Exploring the correlation between environmental factors and water quality in Taihu lake: Implications for future control strategies

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Abstract:

Amid accelerating urbanization, human activities have substantially elevated nutrient levels (e.g., phosphorus and nitrogen) in aquatic systems, leading to recurrent cyanobacterial blooms. As a critical freshwater resource for surrounding cities, maintaining water quality in Taihu Lake is vital for regional water security. This study investigates the correlation between environmental factors and water quality dynamics in Taihu Lake from 2007 to 2020, aiming to inform future control strategies. Utilizing Pearson correlation analysis, key relationships between chlorophyll-a (Chl-a) concentration and environmental variables, including total phosphorus (TP), total nitrogen (TN), permanganate (MnO4-), and air temperature, are identified. Nonlinear regression models are developed using a machine learning-based modelling approach to predict water quality variations under different environmental scenarios. The optimal relationship is obtained for predicting Chl-a concentration with a high accuracy.
Results reveal significant positive correlations between Chl-a levels and TP, TN, MnO4-, and air temperature. TP and MnO4- are considered potential primary drivers of algal proliferation, while rising temperatures under global warming exacerbate eutrophication risks. Seasonal variations in Chl-a concentration are observed, with higher levels during warmer months, highlighting the role of temperature in algal growth. Predictive modelling indicates that a 2oC increase in global temperature could lead to a substantial rise in Chl-a concentrations, particularly in May. To mitigate climate-induced water quality degradation, targeted reductions in nutrient emissions (particularly TP and TN) and enhanced monitoring of temperature-sensitive zones are proposed. Such measures are critical for safeguarding ecosystem resilience and ensuring sustainable water resource management in the Taihu Basin.

Paper ID: 375

Carbon footprint assessment of bio-based products in the context of carbon neutrality

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Abstract:

Biomass is a renewable resource in the time scale of human life. Bio-based products made from biomass is considered to be "carbon neutral", and its replacement of fossil products is an important mean to tackle climate change. However, the whole life cycle process of bio-based products involves many carbon sources and carbon sinks, which challenges the assumption of "carbon neutrality" of bio-based products. Based on the analysis of the characteristics of three types of biomass raw materials and bio-based products, this paper analyzes the carbon source and carbon sink processes of bio-based products in the life cycle, provides accounting methods for different carbon source and sink processes, and constructs carbon footprint accounting framework of bio-based products. Taking printing paper from wheat straw as an example, this paper analyzed the carbon source and sink in its whole life cycle and calculated its carbon footprint. Compared with only considering the production process (2633.38 kg CO2e), the carbon footprint of 1t of printing paper from wheat straw was 1221.50 kg CO2e. Carbon sinks formed by by-products such as agricultural fertilizer, waste paper landfill and paper product storage are important ways to reduce carbon footprint. Waste paper treatment methods have a significant impact on the carbon footprint of paper products. However, only changing waste paper treatment methods cannot achieve "carbon neutrality" of paper products, and the optimization of energy system and chemical inputs is still needed. In addition to the carbon footprint, the impact of bio-based products on water resources, land use change and biodiversity also needs to be comprehensively considered to realize the important role of bio-based products in addressing the triple planetary crisis of climate change, biodiversity loss, and pollution.

Paper ID: 376

Dopamine and tannic acid surface engineering of recycled carbon fibers: Revolutionizing interfacial bonding in high-performance alkali-activated composites

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Abstract:

The utilization of pyrolyzed carbon fibers (rCFs) derived from carbon fiber-reinforced polymer waste in alkali-activated materials (AAMs) offers a promising route for developing high-performance, sustainable construction materials. However, the weak interfacial bonding between rCFs and the AAM matrix has hindered the full exploitation of the fibers' tensile strength. This study introduces, for the first time, a novel surface modification strategy using polydopamine (PDA) and tannic acid (TA)/ethanolamine (EA) to enhance the interaction between rCFs and AAMs. Untreated and modified rCFs were incorporated into waste-based AAMs at dosages of 1 and 3 wt%. Results indicate that while PDA treatment slightly reduced the tensile properties of rCFs, TA/EA modification significantly improved fiber tensile behavior. Both treatments enhanced fiber wettability but negatively impacted thermal stability. Single-fiber pullout tests revealed remarkable improvements in interfacial bond strength, with TA/EA and PDA treatments increasing it by 25% and 66%, respectively. These enhancements are attributed to the introduction of amino and hydroxyl groups on fiber surfaces, which promote chemical bonding and affinity with the AAM matrix, as well as increased surface roughness that enhances mechanical interlocking. Notably, the incorporation of 3 wt% TA/EA-treated rCFs resulted in a 30% increase in compressive strength compared to the plain matrix, driven by improved interfacial bonding and reduced porosity. This study not only provides a scalable and eco-friendly approach to recycling carbon fiber-reinforced polymer waste but also establishes a roadmap for optimizing fiber-matrix interactions in sustainable construction materials, paving the way for high-performance, low-carbon building solutions.

Paper ID: 377

Optimization of mechanical properties and workability of fiber-rubber synergistically reinforced geopolymers

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Abstract:

Geopolymer is a sustainable building material known for its lower carbon footprint and mechanical properties comparable to traditional Portland cement, making it a focal point of research in sustainable construction. However, its relatively low flexural strength and limited flowability restrict its application in high-toughness structures. This study explores the combined effect of varying short fibre contents (0.5%, 1%, 1.5%) and rubber aggregates on the compressive strength, flexural strength, and flowability of fly ash-based geopolymer composites. The experimental design involves the preparation of geopolymer samples with different fibre contents and a fixed proportion of rubber aggregates. The mechanical properties and workability of the samples were evaluated according to ASTM standard testing methods. The results indicate that as the fibre content increases from 0.5% to 1.5%, the flexural strength significantly improves, with the increase closely related to the bridging effect of the fibres and the flexibility-enhancing of the rubber aggregates. The compressive strength slightly increases at lower fibre contents (0.5%), attributed to the damping effect of the rubber, but decreases somewhat at higher fibre contents (1.5%), possibly due to an increase in porosity. The flowability decreases as the fibre content increases, but the inclusion of rubber aggregates somewhat mitigates this trend, improving the workability of the mixture. The study reveals the synergistic effects between fibres and rubber aggregates; for instance, the fibres enhance toughness, while the rubber aggregates optimise particle gradation and stress dispersion, improving the overall performance balance. These findings provide new insights for the design of geopolymer composites, particularly for sustainable construction applications requiring high crack resistance and workability.

Paper ID: 378

An integrated design approach for improving energy efficiency and thermal comfort in social housing: a case study in temperate climate australia

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Abstract:

Social housing plays a critical role in providing affordable and sustainable living environments for low-income populations. However, many social housing units suffer from poor thermal comfort and high energy consumption due to suboptimal design which leads to occupant discomfort and energy poverty, making it essential to improve energy efficiency and thermal comfort for better well-being. Though previous studies have explored technical strategies on energy efficiency and thermal comfort improvements independently, integrated approaches that simultaneously consider improving energy efficiency, thermal comfort while keep it affordability is still limited. Hence, this research developed a multi-objective optimization framework that enables to achieve global optimal solutions for social housing design including using advanced computational methods for building performance simulation and multi-objective optimization using a genetic algorithm coupled with a Pareto front approach with specific design variables with social housing conditions. The proposed methodology allows for the systematic exploration of design alternatives to accommodate occupants' thermal comfort with an accepted level of building energy efficiency cost-effectively. The genetic algorithm facilitates the identification of optimal design parameters by iterating through multiple solutions, while the Pareto front analysis ensures trade-offs between objectives are effectively captured and analysed. Through a case study of social housing retrofitting, this research quantifies the outcomes include: (1) an optimized set of design solutions specific for social housing that improve energy efficiency while maintaining occupants' thermal comfort with an affordable initial cost based on local market conditions; and (2) a decision-support framework to assist designers, policymakers, and housing authorities in making informed choices to deliver a sustainable building design solution. By integrating energy, thermal comfort, and initial cost into a single optimization framework, this research contributes to enhances resource efficiency in the built environment, promoting sustainable use of materials and energy in social housing developments.

Paper ID: 379

Exploring systemic challenges in wastewater reuse for agriculture: A modified Delphi and cross-impact analysis approach

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Abstract:

Water scarcity presents a critical challenge to sustainable agriculture, particularly in water-stressed regions of Brazil. Although Brazil possesses abundant freshwater resources, uneven distribution and rising agricultural demands have intensified the need for wastewater reuse. Most studies address isolated barriers such as regulatory or financial constraints, yet the interaction of governance, infrastructure, financial, and social factors remains underexplored. This study identifies and analyzes key barriers to sustainable wastewater reuse in Brazilian agriculture, examining their combined effects. Using a mixed-methods approach, Delphi and Cross-Impact Analysis (CIA) were employed to gather expert consensus and investigate interdependencies among barriers. Findings indicate that governance issues, including insufficient public policies and legal uncertainties, exacerbate infrastructure and financial challenges, positioning governance reform as a potential leverage point. Infrastructure constraints, insufficient financial incentives, and public distrust further complicate wastewater reuse adoption, emphasizing the role of integrated policy frameworks and social acceptance. These insights suggest that cohesive regulatory frameworks, targeted economic incentives, and awareness campaigns could support wastewater reuse adoption in Brazil and inform sustainable water management policies globally. Future research should focus on longitudinal studies and cross-regional comparisons to refine these strategies, enhancing water security and promoting sustainable agricultural practices in water-stressed regions.

Paper ID: 380

"Propose a commodity supply chain model adapted to carbon tax policy"

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Abstract:

The increasing urgency of climate change mitigation has driven the adoption of carbon tax policies worldwide, fundamentally reshaping supply chain dynamics, especially within the energy-intensive steel industry. This study proposes a commodity supply chain model specifically adapted to carbon tax policy, with a focused case study on the steel industry in Vietnam. By integrating quantitative methods—including Ordinary Least Squares (OLS), Fixed Effects, and Random Effects Model (REM)—with a comparative analysis of supply chain practices in four EU countries and Vietnam, the research examines how variables such as carbon tax, exchange rate, iron price, fuel cost, Brent oil price, CO_2 emissions, and EU trade policies affect steel pricing and overall supply chain efficiency.

The findings reveal that while carbon tax policies increase production costs and impose regulatory challenges, they also incentivize the adoption of greener strategies such as carbon-efficient supplier selection, investment in clean technologies, and the optimization of logistics networks. The proposed model incorporates carbon pricing mechanisms, emission monitoring frameworks, and stakeholder coordination strategies to enhance supply chain resilience and sustainability. This research contributes to the literature by addressing gaps in empirical validation, multi-tier supply chain coordination, and the long-term impact of carbon taxation on industry competitiveness, offering actionable insights for policymakers, supply chain managers, and business leaders as they navigate the transition toward a low-carbon economy.

Paper ID: 381

Biomimicry and circular economy thinking - lessons from nature

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Abstract:

The concept of biomimicry, which involves drawing inspiration from nature's designs and processes, is increasingly gaining attention in pursuing circular economy (CE) strategies. Nature operates in a closed-loop system where waste is minimised and resources are continuously recycled efficiently. These principles align closely with the CE's goal of reducing environmental impact and driving sustainability. Hence, this study utilised a bibliometric literature review to analyse the evolution, key themes, and research trends at the intersection of biomimicry and CE thinking. Using the keywords "Biomimicry, Bio-inspired design, Nature-inspired innovation, Circular economy, Sustainable design, Industrial ecology, Eco-design, Regenerative economy, and Nature-based solutions", data was retrieved from the Scopus database, focusing on publications from the last two decades. The analysis examines publication trends, co-authorship networks, keyword co-occurrence, and citation patterns to map the intellectual structure of this research domain. The study's findings reveal that biomimicry-based circular strategies are being explored across various sectors, including sustainable architecture, regenerative materials, and industrial ecology. Emerging research clusters indicate a growing focus on biodegradable materials, closed-loop manufacturing, and nature-inspired industrial symbiosis. However, technological feasibility, scalability, and policy integration remain key barriers to mainstream adoption. The study also identifies leading researchers, institutions, and key publications shaping the discourse. Finally, by synthesising insights from biomimicry-driven innovations, this study highlights the untapped potential of learning from natural ecosystems to advance CE implementation. The findings provide a roadmap for future research directions, emphasising the need for transdisciplinary collaboration, policy support, and industry engagement. Ultimately, this study contributes to bridging the gap between biological intelligence and sustainable economic models, offering valuable lessons from nature for a regenerative future.

Paper ID: 382

Governance frameworks for circular economy implementation in construction projects: a bibliometric approach

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Abstract:

The construction sector's transition towards a circular economy (CE) necessitates effective governance frameworks to facilitate sustainable resource management, waste reduction, and closed-loop material flows. However, fragmented policies, regulatory inconsistencies, and institutional barriers hinder CE implementation in construction projects, particularly in developing economies. Hence, this study conducts a bibliometric literature review to systematically analyse the trends and key themes in research on governance frameworks for CE adoption in construction. Relevant scholarly publications were retrieved using the keywords "Governance frameworks, Circular economy, Construction projects, Sustainable construction, Built environment" from the Scopus database, and bibliometric techniques such as co-authorship analysis, keyword co-occurrence mapping, and citation network analysis were applied to identify authors, institutions, and research clusters. The study's findings reveal the critical governance components driving CE implementation in construction. In addition, the analysis highlights a growing emphasis on digital governance tools and data-driven decision-making as emerging enablers of circular practices. The study also identifies research gaps. Furthermore, while developed nations demonstrate advanced CE governance strategies, developing countries face barriers such as weak institutional frameworks, financial constraints, and inadequate enforcement mechanisms. Thus, this study contributes to the existing body of knowledge by mapping the intellectual structure of CE governance research and providing insights into future research directions. It also underscores the need for harmonised policies, stronger regulatory oversight, and enhanced industry-government partnerships to accelerate CE adoption in construction projects. The findings serve as a reference for policymakers, industry practitioners, and researchers aiming to develop robust governance models for circular construction.

Paper ID: 383

Rational design of quantum dot-modified MOF/COF composites for efficient photocatalytic hydrogen generation and pollutants degradation

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Abstract:

Abstract:

Nowadays, environmental pollution and the increasing consumption of traditional fossil fuels represent critical challenges, precipitating a grave energy crisis. This has prompted the search for sustainable solutions to counteract these problems. Photocatalysis in the presence of photoactive materials has emerged as a highly effective and environmentally friendly technology for the decomposition of toxic contaminants from both air and water, production of hydrogen and conversion of CO2 into useful fuels. Nevertheless, the development of highly efficient, stable and solar-driven photocatalytic materials that can utilize sunlight as a renewable energy source remains a highly desirable challenge.

Therefore, in this study, novel ternary photocatalysts based on covalent organic frameworks, metal-organic frameworks and quantum dots have been designed and prepared according to a well thought-out strategy and proper selection of components tailored to the specific task. This approach allows to obtain effective materials for photogeneration of hydrogen as a clean energy source and degradation of pollutants under visible light. Furthermore, the excitation mechanism of the ternary hybrid photocatalysts has been explored and proposed, showing the great potential of the this group of materials.

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Paper ID: 385

Optimising material utilisation in modular construction: strategies for minimising waste through advanced material selection

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Abstract:

Building projects can now be completed more quickly and affordably with the help of modular construction. Nevertheless, there are still issues with maximising material use while maintaining sustainability and reducing waste. This study suggests implementing sophisticated material selection techniques to overcome these obstacles and open fresh possibilities for modular construction innovation. Selecting materials with high efficiency, recyclability, and low waste throughout the manufacturing and assembly stages is part of advanced material selection techniques. These tactics seek to improve resource efficiency, lessen environmental effects, and support the long-term viability of modular construction processes by prioritising sustainable solutions, including recycled steel, engineered timber, and low-carbon concrete. This study conducted seven virtual interview sessions with industry professionals, including regulatory body officials, senior managers from construction businesses, project managers, and modular construction specialists, in order to obtain thorough insights. The material collected from these interviews was thoroughly examined using a thematic analysis technique. The study results offer a better understanding of the methods for reducing waste in modular buildings by using the available materials. Furthermore, the findings are anticipated to influence design principles, regulatory frameworks, and industry standards to encourage the broad use of sustainable material practices in modular construction.

Paper ID: 386

Integrating Renewable energy systems into modular manufacturing facilities: implementation strategies

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Abstract:

Modular construction has allowed building projects to be finished more rapidly and economically. Cost, effectiveness, and implementation issues arise when incorporating renewable energy into modular manufacturing plants. To address these problems and create new opportunities for enhancing the energy efficiency of modular construction, this study recommends employing state-of-the-art implementation strategies. These tactics entail improving energy storage devices, wind turbines, and solar panels to reduce dependency on non-renewable energy sources throughout production. These strategies prioritise renewable energy sources to minimise energy expenses, lessen operational carbon footprints, and promote the long-term viability of modular construction methods. A quantitative research technique was used in this study, and organised surveys were given to a range of industry professionals, such as energy consultants, facility managers, and specialists in modular construction, to gather data. The data was statistically examined to find essential patterns, obstacles, and the efficacy of different approaches to integrating renewable energy. The study's findings shed light on how modular manufacturing's renewable energy systems can improve energy efficiency. Furthermore, the results are anticipated to influence industry standards, legal regulations, and design guidelines to encourage the broad use of renewable energy techniques in modular buildings.

Paper ID: 387

Advancing circular economy practices in non-mineral, non-municipal construction waste

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Abstract:

While sustainability discussions often focus on household recycling and plastic waste reduction, non-mineral, non-municipal construction and demolition (C&D) waste remains an overlooked but pressing challenge. In 2019, the UK generated over 62.3 million tonnes of C&D waste, with 4 million tonnes of non-mineral residual waste primarily ending up in landfill or incineration due to inefficient sorting, inadequate infrastructure, regulatory constraints, and human behavior in decision-making. Despite its potential for recovery, this waste stream lacks the necessary policies and economic incentives to be effectively integrated into a circular economy.

This research, conducted by a collaborative team from the University of Surrey and Loughborough University in the UK, investigates the barriers preventing effective sorting and recycling of non-mineral C&D wastes. Through stakeholder interviews and existing data analysis, the study examines policy constraints, industry practices, technological limitations, and behavioural factors influencing waste management decisions. Key participants include policy bodies (DEFRA, Environment Agency), construction firms, waste handlers, and landfill operators, providing a comprehensive perspective on the challenges and opportunities within the sector.

Findings highlight that lack of source separation, and economic disincentives significantly hinder material recovery. The broad classifications under the European Waste Catalogue (EWC) make tracking and recycling specific waste streams more complex.

By generating qualitative and quantitative insights, this research aims to support policy reforms and enhance recycling infrastructure. The outcomes will contribute to policy report and academic publication, providing practical recommendations to reduce landfill dependency, and improve material recovery in the construction industry. This work moves beyond theoretical discussions, offering actionable strategies to drive systemic change in non-mineral C&D waste management.

Paper ID: 388

Evaluating the structural performance of additively manufactured earthen blocks using sugarcane by-products

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Abstract:

Over the past years, Additive Manufacturing (AM), the technology describing material deposition to build objects by joining successive layers, has been promoted as a sustainable production method. Its potential for an environmentally friendly production, design flexibility, and wide range of material variety are gradually gaining prominence.

Clay has been used in construction for ages due to its availability and low thermal conductivity. The applications of employing clay materials in AM could contribute to reducing construction time, providing solutions with lower environmental impact, and enabling the recyclability of materials.

On the other hand, in 2018, the agricultural sector was responsible for 13.5% of Australia's GHG emissions, out of which Queensland alone produced 28% of these emissions. Australia crushes more than 30 Million tonnes of sugarcane every year. Over 90% of sugar produced in Australia is grown in Queensland. Sugarcane Bagasse (SCB), the heterogeneous fibrous by-product after sugarcane crushing and juice extraction. Sugarcane Bagasse Ash (SBA) is generated during SCB combustion to power the sugar mills. Mill mud is another residual material after juice clarification in rotary vacuum filters and is comprised mainly of water, fibre, solids, and natural impurities in the sugarcane.

This study examines the viability of using sugar by-products in clay blocks additive manufacturing. An electromechanical RAM extruder with a 4 mm nozzle that is attached to a 6-axis collaborative robotic arm (UR10) with a load capability of up to 10 kg is employed to additevly manufacture the earthen blocks.

During the additive manufacturing, fibre alignment has been maintained along the printing direction by employing a smaller nozzle diameter than the fibre’s length. This study looked at the printability and structural performance of additively manufactured clay blocks with and without the utilization of SCB, SBA and mill mud by performing compression tests using a 50kN Universal Testing Machine.

Paper ID: 389

Analysing global copper trading resilience and domestic capacity for stable supply networks

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Abstract:

Copper's stable supply is crucial for global industry; however, reliance on international trade increases vulnerabilities to disruptions such as geopolitical tensions and pandemics. Consequently, assessing global trading resilience and countries' inherent capacity to sustain supply during isolation is increasingly critical. Few studies track resilience trends or domestic strengths, and currently, no widely accepted framework exists for analyzing the resilience of the global metal trading network. This research addresses these gaps through a dual approach: measuring global resilience and its evolution from 2000 to 2022, comparing the inherent capacities of major trading nations in 2020, and offering strategies to enhance the reliability of copper supply.

Utilizing complex network theory to map trading relationships, this multi-stage framework—comprising preparedness, robustness, and recovery—evaluates system performance. Preparedness employs the Gini index to assess countries' integrated structural and supply roles, analyzing whether uneven influence exists, where the failure of a dominant country could lead to systemic collapse. Robustness measures countries' avalanche sizes and the system's largest strongly connected component during sequential disruptions, gauging cascading impacts and network durability under such failures. Recovery analyzes the capacity of countries to identify short-term supplier alternatives. To assess inherent capacity, we evaluate self-sufficiency and the recovery potential of alternative materials as emergency buffers. Together, these metrics provide a comprehensive profile across both global and domestic scales.

This study empowers policymakers to identify vulnerable countries and tailor resilience strategies effectively. It traces the impacts of events such as COVID-19 on trading stability, models the cascading effects resulting from the withdrawal of a major exporter, and provides a method to assess sustainable supply performance for optimizing supply chains. This comprehensive approach informs robust policy design, addressing immediate global challenges arising from increasingly frequent trade disruptions while strengthening resilience against future uncertainties.

Paper ID: 390

Shifting resilience analysis from stations to exits: investigating resource sustainability in metro upgrades

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Abstract:

Metro systems are critical components of urban infrastructure, and enhancing their resilience is essential for sustainable cities. Previous studies on resilience have primarily focused on station-level analysis, often overlooking exits. While modifications at the station level aim to improve accessibility, redundancy, and recovery, they typically require substantial resources. In contrast, adjustments to exits present a more sustainable alternative, demanding fewer resources and minimizing ecological harm. Given that exits are key points for passenger flow, their design and distribution may also significantly influence overall system resilience. Therefore, this study hypothesizes that a more detailed examination of exit-level factors is essential for uncovering unique insights into the resilience of metro systems.

To validate this hypothesis, we employ a multi-stage resilience analysis framework to evaluate and compare system performance at both exit and station levels during the phases of preparedness, robustness, and recovery. This framework is applied to the Mass Transit Railway (MTR) system in Hong Kong, a vital public transportation network serving millions daily. We utilize integrated data from OpenStreetMap and Google Maps to construct a heterogeneous network that incorporates both stations and exits. Accessibility coverage is calculated using the Gaussian-based two-step floating catchment area (G2SFCA) model, incorporating census datasets from the Hong Kong government. We apply complex network theory and conduct statistical tests to assess whether exit-level analysis provides different insights than station-level analysis.

This study's findings enhance urban transport design by aligning resilience with resource sustainability. Grounded in the Resilience-by-Design (RbD) perspective, we investigate whether exit-level analysis yields distinct conclusions, identifying targeted opportunities to enhance resilience through more resource-efficient redundancy. By clarifying the most effective level for creating redundancy—whether at the station or exit—this approach strengthens infrastructure resilience while minimizing resource consumption and reducing the environmental impacts associated with infrastructure expansion.

Paper ID: 391

The journey towards net zero emissions in buildings: The role of community participation in South Africa

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Abstract:

The adverse effects resulting from carbon emissions are increasingly being felt all over the world. Some of these are captured within the ambits of climate change, drought, air pollution, and human respiratory diseases. From a built environment perspective, there is a need to heed the call for actualising net zero emissions (NZE) from buildings. This study focuses on the drivers of community participation towards achieving NZE in built-up facilities. Resulting of the review of extant literature, the drivers were identified. Adopting a quantitative technique, data was retrieved from relevant stakeholders and subjected to analysis using appropriate data analysis tests. Findings from the study unravelled the significant drivers for communities' participation towards the attainment of NZE in South Africa. The study findings would help relevant stakeholders formulate policies that aim to actualise actions against climate change from a community participation perspective, which serves as one of the core mandates of the sustainable development goals.

Paper ID: 392

Assessing the Variability and Performance of Drinking Water Treatment Sludge as a Supplementary Cementitious Material

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Abstract:

Drinking water treatment sludge (DWTS) is a by-product of drinking water purification, generated as contaminants are removed from raw water. Its potential as a supplementary cementitious material (SCM) in cementitious composites and as an aluminosilicate precursor (AP) for alkali-activated materials (AAMs) has been well demonstrated in our previous research. Concrete incorporating DWTS has exhibited satisfactory mechanical properties and enhanced sulfate resistance, highlighting its potential as a value-added material. However, scaling up to industrial production presents challenges due to the inherent variability of DWTS as a raw material. Key properties such as chemical composition, particle size, and impurities can fluctuate between batches and sources, necessitating robust quality control measures to ensure consistency. While AS 3582.4 outlines requirements for waste-derived manufactured pozzolans—including chemical composition, fineness, moisture content, and loss on ignition—additional factors, such as crystalline and amorphous phase variations, solubility, and thermogravimetric properties, may also influence DWTS performance. This study aims to assess the variability of DWTS and its impact on SCM performance, supporting quality control for large-scale applications. A strategic sampling campaign was conducted at a local water treatment plant, yielding eight representative samples. These samples will undergo comprehensive characterization (chemical composition, mineralogy, particle size distribution, and impurity analysis) and performance-based testing (pozzolanic reactivity, strength activity index, and sulfate resistance). The results will be correlated to identify key factors affecting DWTS consistency and performance, paving the way for its wider adoption in sustainable construction.

Paper ID: 393

Quantitative assessment of carbon reduction mechanisms in low-carbon agricultural technologies: optimizing complementary, substitution, spillover, and rebound effects

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Abstract:

This research quantitatively evaluates four carbon reduction mechanisms of low-carbon agricultural technologies in crop and livestock sectors with life-cycle thinking. While previous studies have primarily focused on analyzing individual technology effects, this study addresses the complex interactions between complementary effects, substitution effects, technological spillover effects, and energy rebound effects that have been insufficiently examined in agricultural carbon reduction research.

The study investigates technologies in crop production (including fertilizer and pesticide reduction, agricultural machinery energy conservation, heating energy reduction, carbon capture/storage/utilization, and rice methane reduction) and livestock management (species-specific feeding management, manure management, and environmental management). Through a comprehensive methodological approach combining literature review, theoretical framework development, primary and secondary data collection, quantitative modeling, and scenario analysis, this research aims to determine optimal technology combinations and develop policy recommendations.

For complementary effects, we quantify how technologies like biochar maximize carbon storage while improving soil quality and reducing fertilizer requirements. For substitution effects, we measure how alternatives to high-carbon inputs (such as domestic forage replacing imported feed) affect energy consumption and emissions. Technological spillover effects are analyzed by quantifying productivity improvements and their impact on emissions per unit of production. Energy rebound effects are examined through scenario and sensitivity analyses to identify potential increases in energy consumption following efficiency improvements.

The findings will provide scientific evidence for policymakers and agricultural stakeholders, develop optimal technology integration strategies considering interaction effects, and establish management approaches for potential energy consumption increases resulting from efficiency improvements in agricultural systems.

Paper ID: 394

A criteria system of Environmental, Social, and Governance (ESG) in transportation based on Sustainable Development Goals (SDGs) : How does it contribute to urban metro ?

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Abstract:

The Sustainable Development Goals (SDGs) aim to address global challenges by achieving a balance among economic growth, social inclusion, and environmental sustainability. The Urban metro systems not only provide mobility to support the daily life of residents, but also plays a pivotal role in fostering economic development, improving environmental sustainability and ensuring social equity within cities and nations. To assist enterprises in aligning with these objectives, Environmental, Social and Governance (ESG) criteria have been introduced as an effective framework for evaluating performance. However, there is a gap in ESG metrics construction and prioritization tailored for the urban metro system. This research aims to develop an integrated ESG evaluation framework tailored to the urban metro sector and employ a hybrid methodology that combines the fuzzy Best-Worst Method (BWM) with the Entropy approach to assess the relative significance of diverse indicators. The comprehensive ESG criteria framework is initially developed through the systematic review of relevant literature and unique attributes of the urban metro sector. After considering evaluations from experts in the transportation field and passengers, the importance weights are obtained by combining the objective and subjective weights calculated through the integrated fuzzy BWM-entropy method. The findings of this study serve as a valuable benchmark for urban metro companies to achieve long-term goals aligned with the SDGs by adjusting their policies to improve ESG performance

Paper ID: 395

Has the Belt and Road Initiative reshaped the ecological sustainability of Eurasia: A perspective of three-dimensional ecological footprint

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Abstract:

Based on data of ecological footprint and ecological carrying capacity for Eurasia from 2000 to 2022, this paper employs a three-dimensional ecological footprint model to conduct a multi-scale analysis of sustainability on Eurasia. Furthermore, a difference-in-differences model is used to further analyze the impact mechanism of the BRI on the ecological footprint of Eurasia, and the differential impact of the BRI on the ecological footprint of different countries is demonstrated in multiple dimensions by combining quantile regression and heterogeneity analysis. The study findings indicate that: (1) From 2000 to 2022, the unsustainable development situation on Eurasia has been deteriorating, with the ecological footprint depth increasing from 1.966 ha/cap to 2.513 ha/cap and the per capita ecological footprint size slightly decreasing from 1.092 ha/cap to 1.023 ha/cap. (2) Based on the ecological footprint depth and per capita ecological footprint size, 83 countries are classified into 9 types of sustainable development. During the study period, Asia exhibited low size-medium depth and low size-low depth types, indicating weak sustainability, while Europe was predominantly characterized by the low size-medium depth type, with a more optimistic sustainable situation. In terms of country size, the sustainability of 6 countries weakened and 6 countries improved. (3) The BRI has a significant positive impact on the ecological footprint of Eurasian countries, indirectly affecting them through mechanisms such as industrial structure, technological innovation, and foreign direct investment. Quantile regression shows the BRI has a more pronounced promotional effect on countries with lower ecological footprint. Additionally, heterogeneity analysis reveals the BRI has a greater impact on countries with lower ecological footprint depth, lower per capita ecological footprint size, and weaker sustainability. The research findings can provide important guidance for implementing the "2030 Agenda for Sustainable Development" and formulating relevant policies, thereby enhancing the long-term sustainability of the BRI.

Paper ID: 396

Sustainable resource allocation for transportation mega projects in developing countries: Barriers and Challenges

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Abstract:

Developing countries face unique challenges in allocating resources for transportation mega projects while ensuring long-term sustainability. These projects require substantial financial, material, and human resources, yet constraints such as limited funding, inefficient supply chains, and regulatory gaps often hinder sustainable development. This study investigates the barriers and challenges to sustainable resource allocation in transportation mega projects within developing economies, aiming to identify strategies for improving efficiency, resilience, and environmental responsibility.

The research adopts a qualitative approach, integrating expert interviews and case study analysis. Interviews with policymakers, project managers, and sustainability experts provide insights into systemic obstacles and emerging best practices. Additionally, case studies of major transportation projects in developing countries offer empirical evidence on resource management strategies, sustainability integration, and project performance.

Preliminary findings highlight critical barriers, including inadequate institutional capacity, lack of sustainable procurement frameworks, and reliance on conventional rather than circular economy principles. The study also reveals that weak stakeholder coordination and political uncertainties further exacerbate resource inefficiencies. However, innovative financing models, technology-driven resource optimization, and policy interventions are emerging as viable solutions to enhance sustainability in resource allocation.

This research contributes to the growing discourse on sustainable infrastructure development by offering practical recommendations for policymakers, project stakeholders, and investors. It underscores the urgency of adopting a holistic resource management approach that balances economic, environmental, and social considerations, fostering more resilient and efficient transportation mega projects in developing countries.

Paper ID: 397

Decision support system for optimizing greenhouse heating strategies in south korea

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Abstract:

In facility horticulture, a significant amount of energy is devoted to heating, placing a substantial burden on farm management. In Korea, heating costs account for 30-40% of total production expenses. In particular, greenhouse heating predominantly relies on fossil fuels such as diesel, kerosene, and LPG, which not only elevates energy consumption but also increases greenhouse gas emissions, adversely impacting the environment. Therefore, it is necessary to establish optimal heating strategies by simulating heating loads based on different greenhouse types and heating system characteristics to accurately determine the required energy consumption. In this study, we developed a model to predict the heating load of greenhouses using hourly forecast data for solar radiation and temperature for the next day provided by the Korea Meteorological Administration. Implemented in Python, the model is based on the first law of thermodynamics and integrates meteorological data with heat loss calculations that take into account the structural features of the greenhouse (size and covering materials, etc.), enabling detailed quantification of energy consumption and costs for different heating technologies and various temperature settings. This approach can provide decision support for farmers to minimize heating costs while also contributing to comprehensive environmental impact assessments.

Paper ID: 398

Cropland expansion and forest decline: A remote sensing assessment of landscape modifications in amazon brazil

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Abstract:

The Amazon rainforest plays a critical role in the world's ecosystems, and its destruction has severe implications for the global environment. In 2021, deforestation in the Brazilian Amazon reached its highest level in 15 years, leading to a decline in biodiversity, threatening the survival of indigenous communities, and exacerbating the climate crisis. Consequently, there is an urgent need for research and policy initiatives to explore ways to conserve and sustainably manage the Amazon rainforest. This study is to analyze land cover changes based on Sentinel-2 and Landsat 8 satellite imagery from 2017 to 2024 using Google Earth Engine, especially focusing on the northern and central-western regions in Brazil. The analysis revealed that the areas of cropland and pastureland continued to increase, while forest cover showed a tendency to decrease. In particular, large-scale agricultural development and land clearing for pasture were identified as the main drivers of these changes, with significant implications for carbon storage and biodiversity. This study confirms the ongoing land use changes in Brazil. The data obtained could provide a crucial basis for future land use policy formulation and environmental monitoring.

Paper ID: 399

Sustainable and circular management of separate waste collection: evidence from panel quantile regression

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Abstract:

Nowadays waste management is recognized as a critical requirement to promote the transition from a linear to a circular economy model. According to the World Bank, annual waste generation is estimated to grow by 70% by 2050, while raw material consumption is projected to double by 2060. The shift towards Circular Economy relies heavily on sustainable waste management: reducing waste material, promoting recycling and reuse, as well as embracing innovative green technologies, could move towards a greener and more sustainable future. In this context, European regulations established a set of separate waste collection (SWC) targets to be reached in different time periods (35%, 45% and 65%), complemented with a set of landfilling targets. The Italian government also meet the targets set in the European Green Deal framework to encourage recycling and to impose a reduction of landfilled waste.

To this purpose, this work applies a novel method of moments quantile regression (MMQR) approach to investigate the heterogenous effects of environmental laws along with other important control variables (such as economic growth, population density, unemployment and tourism rate) on waste management practices in Italy by using regional data for the period 2002-2024.

The panel quantile regression findings reveal that the first threshold reduces separate waste collection. Environmental regulation thresholds can initially lead to a decline in separate waste collection due to several transitional challenges. On the contrary, the second and third thresholds have a positive impact on separate waste collection across all quantiles. We obtain similar results by focusing on landfill waste targets (the first threshold significantly increases the landfill waste, whilst the second and the third thresholds reduce it). Finally, this study suggests some important implications on waste policies, indicating that stronger environmental regulatory frameworks promote sustainable waste management by encouraging individuals and businesses to adopt efficient recycling practices.

Paper ID: 400

Blockchain impact on supply chain resilience and sustainability: Influence of the blockchain ecosystem

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Abstract:

Technology adoption for enhancing supply chain resilience (SCRes) and sustainability has attracted the attention of both supply chain management practitioners and academics. Sustainability and resilience are key performance outcomes driving the use of blockchain technologies in supply chain operations. Blockchain use, on the one hand, can enhance economic sustainability by improving operational efficiency. The technology also helps develop green activities and track production stages and their location in the supply chain, ensure quality control and guarantee consumer safety and social responsibility. Despite available research suggesting that blockchains offer supply chains positive SCRes and sustainability outcomes, the current literature offers little knowledge about the role of legal, cultural, and social (LCS) factors of the blockchain ecosystem influencing the impact of blockchain on these outcomes. This knowledge gap in the adoption and use of blockchain often engenders implementation challenges and leaves potentially new positive outcomes difficult to determine. Our research will explore the LCS factors in the blockchain ecosystem and how they influence the impact of blockchain technologies on SCRes and sustainability. Drawing on the Public Value Theory lens, we attempt to explain how the blockchain ecosystem legitimises and operationalises blockchain use through the LCS factors to generate 'common' value for the ecosystem. Our proposed research adopts a mixed methods approach to address the research questions and hypothesis. In-depth interviews and the Fuzzy-set qualitative comparative analysis (fsQCA) are used. We contribute by advancing a configurational perspective about the role LCS plays in the blockchain ecosystem and how that influences the impact of blockchain on SCRes and supply chain sustainability. We also explore the complementary role of LCS factors and SCRes dimensions on blockchain-based supply chain sustainability. Finally, this study will provide insight into how threats and disruptions to the regional Australian food processing and distribution supply chain are anticipated through blockchain technologies.

Paper ID: 401

Development of a Framework to Support Whole Life Cycle Net-Zero Carbon Buildings through Integration of Building Information Modelling and Digital Twins

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Abstract:

To achieve a net zero carbon building, it is essential to effectively use resources, so both embodied and operational carbon emissions can be reduced while increasing the use of renewable energy to offset any remaining emissions. Emerging digital technologies, such as real-time data, Digital Twins, the Internet of Things, big data, sensor networks, and Artificial Intelligence, have been adopted at various stages of the building lifecycle, to help to improve the effectiveness of resource utilisation, resulting in a revolution in the building industry. However, there is no systematic research to understand how these emerging digital technologies are employed in the decision-making process to achieve net-zero building outcomes. This paper presents key findings from in-depth case studies of two net-zero carbon buildings to address this knowledge gap. Two office buildings with net-zero outcomes were identified to analyse key decision pathways in effective use of resources across the design, construction and operational stages, incorporating real-time data and emerging digital technologies used throughout the building lifecycle. Evidence was gathered through interviews and site inspections, followed by thematic analysis to generate key findings. A decision tree method was developed to represent these findings, with the potential to evolve into an evidence-based information management framework that integrates dynamic real-time data and digital twin models in the future. This paper paves the way for future research into novel, evidence-based digital approaches for accelerating the achievement of net-zero carbon buildings.

Paper ID: 402

Rethinking plastic packaging substitution: Life cycle assessment studies of polyethylene and alternatives across the US and Europe to guide decision-making

Tacker, Manfred[1], Avery, Elizabeth[2], Hafner-Kuhn, Tasja[1], Lawrence, Emma[2], Gstöhl, Andrin[1], Rauch, Marius[1], Nduagu, Experience[3], Sotomayor, Luis[3], Richa, Kirti[3], Roux, Timothee[4], Auras, Rafael[5]

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Abstract:

Packaging plays an essential role in society by ensuring product containment, protection, and preservation. The growing consumption of packaging, often linked with economic growth, has sparked interest in the potential environmental impacts of packaging and materials substitution. This cradle to end-of-life (excluding use phase, such as breakage rates and shelf life) life cycle assessment (LCA) study compares the potential environmental impacts of polyethylene-based (PE) packaging and alternatives (paper, metals and glass) in the US and Europe. Nineteen comparisons were made in the US and twenty-two in Europe, covering five PE packaging applications. The potential environmental impacts were assessed using ten and six impact categories in the US and Europe, respectively.

Our comparative analysis reveals methodological and regional variations with directionally similar environmental performance of PE packaging relative to the alternatives. In the US, out of the 19 comparative cases on each indicator, PE-based packaging showed lower potential environmental impacts in 14 (74%) for fossil resource use, 15 (79%) for Global Warming Potential (GWP) with and without biogenic CO2 uptake, mineral resource use, acidification (freshwater and terrestrial) and land transformation, 16 (84%) for water scarcity, 18 (95%) for land occupation, and 19 (100%) for freshwater eutrophication. In Europe, PE-based packaging showed lower potential environmental impacts in 10 of 22 (45%) comparisons for fossil resource use, 14 of 22 (64%) for water use, 15 of 22 (68%) comparisons for GWP, 18 of 22 (82%) for acidification, and 21 of 22 (95%) for land use and freshwater eutrophication.

For different end-use applications in Europe and the US, the analysis suggests that replacing PE packaging with alternatives could increase potential environmental impacts across multiple indicators. Decision-makers should consider life cycle impacts because some packaging policies that promote material substitution may increase environmental burdens.

Paper ID: 403

Unintended consequences of material substitution: Life cycle assessments of polyethylene packaging and alternatives in the US

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Abstract:

Packaging helps ensure product containment, protection, and preservation. Growing packaging consumption and waste issues have sparked interest in the potential environmental impacts of packaging and material substitution. This life cycle assessment (LCA) study compares polyethylene (PE)-based packaging and alternatives (paper, metals, and glass) in the US, covering cradle to end-of-life, excluding use phase impacts (e.g., breakage and product loss). Nineteen comparisons of PE formats with alternatives from five PE packaging applications (collation shrink films, pallet wraps, heavy-duty sacks, rigid non-food bottles, and flexible food pouches) were assessed using ten impact categories. The study also compares the potential impact of packaging systems to the packaged product and single use to reusable formats.

Of the 19 comparative cases on each indicator, PE-based packaging showed lower potential impacts in 14 (74%) for fossil resource use, 15 (79%) for global warming potential (GWP) (with and without biogenic CO2 uptake), mineral resource use, acidification (freshwater and terrestrial) and land transformation, 16 (84%) for water scarcity, 18 (95%) for land occupation, and 19 (100%) for freshwater eutrophication. The packaging system generally has a lower environmental footprint than the packaged product except for heavy materials like glass and metal packages or less processed products. Some reusable formats have higher potential impacts than single-use alternatives and could not reach breakeven points with single use PE packaging due to additional transportation and washing if needed. End-of-life dispositions for PE packaging were studied including recycling methods that can produce recycled feedstocks. Results showed similar or lower potential impacts across most indicators studied including a potential fossil resource use benefit, an indicator for finite resource conservation.

These results indicate that broad-based plastic substitution proposals and regulations can lead to unintended consequences of increasing potential environmental impacts, highlighting the need for nuanced, application-specific decision-making that considers life cycle impacts of packaging materials.

Paper ID: 404

Facile and highly sensitive colorimetric nanoparticle sensor for perfluorooctanoic acid (PFOA) in water

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Abstract:

Perfluorooctanoic acid (PFOA) is a prominent per- and polyfluoroalkyl substance, a group of persistent environmental contaminants widely detected in water sources due to their extensive use. Long-term exposure to PFOA is associated with adverse health effects, including endocrine disruption, liver toxicity, and carcinogenic potential, making its detection in drinking water a critical public health concern. However, traditional analytical techniques such as liquid chromatography-mass spectrometry while providing high sensitivity, are expensive, labor-intensive, and impractical for in-situ environmental monitoring. Our study presents a practical and highly sensitive colorimetric sensor for PFOA in water based on aggregation properties of colloidal nanoparticles. The sensor is based on chitosan-stabilized silver nanoparticles (Chi-AgNPs) which present bright yellow colored solution with a maximum UV-Vis absorbance peak at 420 nm. With the addition of NaCl, the sensor solution immediately turns red at 0 ppb PFOA and gradually shifts to orange with higher PFOA concentrations, which presents the originally bright-yellow color at the highest PFOA concentration at 100 ppb. The maximum absorbance peaks of Chi-AgNPs tend to split into two peaks (around 390 nm and 500 nm). Furthermore, the quantitative analysis confirmed a strong linear correlation (R2=0.9902) between PFOA concentration and absorption ratio (A500/A390), with the sensor achieving the limit of detection (LOD) at 0.83 ppb, which outperforms other reported colorimetric PFOA sensors.

The sensor's performance was further evaluated in different water matrices demonstrating consistent color and absorbance response across varying water matrices. Notably, the sensor maintained its functionality in real-world samples with lowest absorbance response difference at 11.76% when used in tap water. Overall, the results establish the Chi-AgNP-based anti-aggregation sensor as a promising low-cost, portable, and effective method for detecting PFOA contamination in water, providing a valuable tool for environmental health professionals in assessing and potentially mitigating emerging PFAS contamination issues in waters.

Paper ID: 405

Life cycle data challenge replacing plastics with alternatives: Potential environmental impacts of polyethylene packaging and alternatives in European markets

Tacker, Manfred[1], Gstöhl, Andrin[1], Hafner-Kuhn, Tasja[1], Rauch, Marius[1], Nduagu, Experience[2], Sotomayor, Luis[2], Richa, Kirti[2], Roux, Timothee[3], Auras, Rafael[4]

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Abstract:

Plastics are lightweight, versatile, and valuable materials used across a range of applications and industries, from transporting goods and packaging products to protecting and preserving food. The topic of waste and potential environmental impacts from packaging continues to be a discussion topic globally and a focus of EU legislation. This comprehensive life cycle assessment study compares polyethylene (PE), which is the main polymer type used in packaging, with alternatives (e.g., paper, glass, metal) in Europe to better understand the potential environmental impacts. Twenty-two comparisons of non-plastic alternatives to PE packages were assessed considering packaging formats from five PE packaging applications (collation shrinks, pallet wraps, heavy duty sacks, rigid non-food, and flexible food applications). Additional two comparisons of single use PE with reusable plastic formats were made. Six impact categories were used to assess the potential environmental impacts from cradle to end-of-life, excluding use phase impacts (e.g., breakage and shelf life).

PE-based packaging showed lower potential environmental impacts in 10 of 22 (45%) comparisons for fossil resource use, 14 of 22 (64%) for water use, 15 of 22 (68%) comparisons for GWP, 18 of 22 (82%) comparisons for acidification and 21 of 22 (95%) for land use and freshwater eutrophication. Results also showed higher potential impacts for reusable collation/transport packaging in most impact categories than for single use PE packaging.

These results indicate that replacing PE-packaging with alternatives such paper, metal and glass in these applications may inadvertently increase environmental impacts, a likely unintended consequence from broad-based plastic substitution proposals and regulations. The study could support decision-making as it highlights the need for nuanced, application-specific decision-making approach that considers potential life cycle impacts of packaging materials.

Paper ID: 406

Challenges and insights in recycling perovskite photovoltaics at low TRL: an LCA perspective

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Abstract:

Perovskite photovoltaics (PVs) have emerged as a highly promising next-generation solar technology due to their high efficiency, tunable bandgap, and low-cost processability. However, while these technologies are advancing through low Technology Readiness Levels (TRLs), their long-term sustainability and environmental impact remain widely unaddressed, particularly in the area of end-of-life (EoL) management and recycling. Key challenges in recycling perovskite photovoltaics (PVs) include their complex composition, requiring specialized recovery methods. Effective material separation may hindered by the multilayered architecture, while high operational costs and the low value of recovered materials may limit economic viability. The lack of standard recycling plants also prevents mass implementation. In addition, the energy demands of solvent-based extraction, thermal processing, and mechanical separation must be assessed to provide a net environmental benefit over primary material extraction. Scalable and efficient recycling pathways must be created for the integration of perovskite PVs into a circular economy.

Using an LCA methodology, this study assesses the environmental implications of various novel recycling approaches and their alignment with circular economy principles. The design-for-recycling needs to be incorporated at an early design stage in perovskite PV to enhance recyclability and minimize environmental impacts. By establishing the most significant barriers and realistic pathways to sustainable recycling, this work illuminates the future environmental and scalability potential of perovskite PV technologies. This research performs a comprehensive attributional LCA of recycling of perovskite PV. The primary data were gathered from project partners and for the secondary data, ecoinvent v3.9.1 were used. The study is complied with ISO 14040/44, PEFCR, and IEA guidelines, and to ensure methodological rigor, the study also harmonized with other innovative PV projects across Europe.

Paper ID: 407

Assessing the Impact of User Behavioural Characteristics on the Market Potential for V2G Participation in Ancillary Services

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Abstract:

The intermittency and volatility problems caused by the rapid deployment of distributed renewable energy sources (RES) have induced higher requirements on the transient and steady-state active power support capabilities of the power system. Vehicle-to-Grid (V2G) technologies provide a channel to integrate idle electric vehicle (EV) batteries into mobile energy storage resources, but its potential to provide active power support to the low-voltage distribution network can be limited by subjective and objective factors, such as the number and characteristics of participating EVs as well as the behavioral logic of EV owners. Given that existing studies involving V2G energy storage mainly focus on macro perspective which might require the description of EV user to calibrate the output characteristics of V2G, this paper develops an agent-based model (ABM) framework incorporating Monte Carlo Simulation (MCS) to capture the stochastic and heterogeneous nature of EV owner behaviours as well as the dynamic interactions between EVs and the grid. This allows for a detailed analysis of the flexible evolution of V2G active power support over time under different agent behaviour pattern. By incorporating transient active power support into the scope of V2G, the profit channels are expanded and the user's willingness to participate is improved. The results show that, V2G can inject more transient active compensation into the low-voltage distribution network compared with output management, but its stability is lower than output management. The irregular usage patterns of commercial vehicles and their longer daily mileage limit the ability of commercial vehicles to participate in the active support of the power distribution network. Frequency regulation services and output management encounter policy conflicts due to their essential differences. The dual-track policy design which able combining stable long-term subsidies with flexible electricity price incentives is required to ensure V2G participation willingness.

Paper ID: 408

How allocation method selection shapes carbon benefits for recyclers

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Abstract:

Recycling is crucial to address environmental issues caused by increasing wastes. The allocation of environmental burdens and benefits of recycling is a hot topic in life cycle assessment. Usually, the benefits of the recycling can be allocated to two stakeholders: the recycler of the waste and the user of the recycled product. Since different materials have distinct recycling processes, recyclability rates and market demand pressures, appropriate allocation methods should be chosen to incentivize both stakeholders to engage in recycling activities. However, a standardized methodology for determining the allocation approach is absent in current research. In this work, we investigated the carbon emission reduction of construction waste recycling. Five allocation methods including cut-off approach, end-of-life recycling approach, 50:50 method, circular footprint formula, and economic allocation were analyzed. Based on the case studies, we summarized the strengths and limitations of different allocation methods. Finally, a policy-oriented framework for selecting allocation methods was proposed. Our work serves as a basis for allocation method selection and also as a reference for quantifying the carbon benefit of recycled wastes.

Paper ID: 409

What are the indicators to assess the behaviour of stakeholders in adopting circular economy in construction and demolition waste?

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Abstract:

Construction and Demolition Waste, which constitutes over 30% of global waste and is the world's largest waste source, can be significantly reduced by adopting Circular Economy principles. However, stakeholder behaviour presents a significant barrier to CE adoption in Construction and Demolition Waste Management, and it has not been explored in depth. To address this gap, it is essential first to identify the constructs and indicators that influence stakeholder behaviour in the context of CE adoption. Hence, this study aims to identify and validate a set of indicators to measure constructs critical to assessing the behaviour of stakeholders. The indicators and constructs were identified through a systematic literature review and validated through expert interviews. Seven constructs were identified using the Theory of Planned Behaviour (TPB) and Norm Activation Model (NAM), and 19 related indicators were identified. By focusing on validated indicators, this research equips policymakers, industry practitioners, and researchers to assess the behaviour of stakeholders and study the behaviour in depth.

Paper ID: 410

Thermal separation and characterization of cathode materials from high-nickel NCM processing waste

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Abstract:

The rapid expansion of the lithium-ion battery manufacturing industry has given rise to a substantial amount of electrode production waste. Among them, the recycling of high-nickel ternary cathode waste is particularly pressing. This type of waste consists of high-value $LiNixCoyMnzO_2$ (NCM) active substances combined with an aluminum foil current collector. It poses both environmental risks and holds resource potential. In this study, a low-temperature thermal separation technology was developed to achieve efficient recovery without resorting to chemical leaching or high-temperature smelting. By precisely controlling the heating conditions at 250°C in an air atmosphere, the polyvinylidene fluoride (PVDF) binder was decomposed, enabling the clean separation of the cathode material from the aluminum foil. XRD and SEM analyses revealed that the recovered NCM particles retained their original layered structure. ICP-OES analysis indicated that the content of aluminum impurities was less than 0.1wt %. The first coulombic efficiency of the reconstituted half-cell reached 86.2% at a 0.1C rate, which was on par with that of commercial materials, thus confirming the structural and electrochemical integrity of the material. This solvent-free method achieved a material separation rate of 98.7%, establishing an ecologically efficient pathway for adding value to battery manufacturing waste. In comparison with traditional high-temperature processes, it significantly saves energy. Moreover, by avoiding the use of organic solvents, it eliminates the risk of secondary pollution, offering a new strategy for the green recycling of batteries and demonstrating great industrial potential.

Paper ID: 411

Model and effectiveness of green bond issuance by power groups: empirical evidence based on carbon neutral bonds in China

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Abstract:

With the world's largest carbon emissions, developing green finance is an important force to help China achieve the goal of carbon peak and carbon neutrality. Green asset securitization is an important part of green finance, which can alleviate the problems of difficult and expensive financing in the greening process and transformation of various industries in China. However, the development of green asset securitization in China is in the primary stage, and a series of problems and obstacles still need to be solved. This paper adopts the case study method and selects the first issue of carbon-neutral debt issued by China Three Gorges New Energy (Group) Corporation in 2021 as the research object, which is the first publicly issued carbon-neutral product among banks after the Notice on Clarifying the Relevant Mechanisms of Carbon-Neutral Debt in 2021. It marks a new beginning for securitizing China's carbon-neutral asset products. This paper first analyzes the financing model, market, and social impact of this carbon-neutral debt and then analyzes its problems. The results indicate that the issuance of this product can quickly solve the problem of capital shortage in the green industry and satisfy the demand of investors for green financial products in the market. However, it also has problems such as low credit rating of underlying assets, insufficient information disclosure system, and imperfect credit enhancement measures. Therefore, it is recommended to further improve the credit rating of the underlying assets and strengthen the management of capital recovery, promote product innovation, increase the participation of social capital, improve the credit enhancement measures, and strengthen the post-issuance management of the carbon and Chinese bonds.

Paper ID: 412

Decomposition and allocation of carbon emission allowance in megacities: A case study of Shenzhen, China

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Abstract:

Megacities face escalating challenges in managing total carbon emissions, driven by high population density, constrained energy resources, and tightening environmental limits. To address these challenges, systematic research into carbon emission quotas and their allocation methodologies is imperative. This study provides a comprehensive review of carbon emission control systems and best practices from developed countries and leading cities. Using Shenzhen, China, as a case study, the research adopts a multi-model analytical framework, combining historical allocation methods, two-stage approaches, and the ZSG-DEA model to decompose the city's carbon emission control targets across its administrative regions. A comparative analysis reveals that each method offers distinct advantages: the historical allocation method ensures continuity, the two-stage method integrates economic and demographic factors, and the ZSG-DEA model prioritizes efficiency. Together, these approaches establish a robust, multidimensional framework for the scientific and equitable allocation of carbon emissions, providing critical decision-making support for Shenzhen's carbon budget management. This study advances the precision of regional carbon budget management and offers tailored strategies for regions with varying efficiency levels to enhance sustainable development. In practice, carbon allocation must balance fairness and efficiency while addressing regional disparities, implicit carbon transfers, and consumption-based emissions. Establishing differentiated low-carbon development goals, aligned with the responsibilities of diverse stakeholders, is essential. The findings from Shenzhen present a scalable and replicable model, offering actionable insights for other megacities striving to implement effective carbon emission control strategies.

Paper ID: 413

Lithium in sonora, mexico: a social life-cycle assessment

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Abstract:

Considering the increasingly frequent economic and socio-environmental disruptions caused by natural phenomena resulting from climate change, global leaders from numerous institutions have urged the world toward decarbonization through an energy transition. To achieve this carbon-free transition, critical minerals play a key role, as they serve as the raw materials for the development of clean technologies. In the state of Sonora, Mexico, a lithium extraction project was recently initiated. Lithium is classified as a highly critical mineral. Mining operations were initially planned under foreign investment; however, modifications to the Mining Law halted progress. Currently, lithium exploitation activities remain on standby, and mining concessions have been transferred to the Mexican government. This situation presents an opportunity to analyze the social impact that lithium extraction may have on communities near the lithium mine.

The objective of this research is to present a social life cycle analysis to identify the potential impacts of lithium extraction on nearby populations in northwestern Sonora. This study includes an analysis of various actors and institutions, both local and international, involved in the lithium supply chain and examines the interconnections between their roles. The findings are framed within a Social Life Cycle Assessment (S-LCA). The results indicate that, as observed in other natural resource extraction areas, lithium mining would have both positive and negative social externalities. It is crucial to propose and implement public policies based on social life cycle analysis to mitigate the potential negative social effects of mining in this region. This approach aims to prevent what has been termed the “resource curse” in other locations and to ensure a truly equitable energy transition.

Paper ID: 416

Understanding industry performance through market-driven entry barriers: Lessons from China's ICEV to EV industries

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Abstract:

Electric vehicles (EVs) have emerged as a critical strategy for decarbonizing transportation as environmental concerns grow. China exemplifies the transition from internal combustion engine vehicles (ICEVs) to EVs. While previous studies highlight government subsidies in this shift, the role of market factors remains underexplored. This study examines how market-driven entry barriers influence China’s automotive industry and the transition from ICEVs to EVs.

Using a mixed-methods approach, this study combines quantitative analysis with semi-structured expert interviews. Unlike prior research, which focuses on specific periods—such as EV development around 2010 or rapid market expansion in 2015—this study covers a broader time span, capturing the full transition of China’s automotive sector. The dataset includes financial data from traditional and emerging automakers (1990–2023) and vehicle product data (2002–2024). The analysis compares entry barriers in the ICEV and EV sectors, focusing on capital requirements, product differentiation, technological barriers, and supporting systems.

Findings indicate that entering China’s EV market requires an initial investment of about $1.1 billion. Compared to ICEV firms, new EV companies have better access to financing due to diverse and less restrictive funding sources. New entrants must allocate about 3% of revenue to advertising for at least ten years to overcome product differentiation disadvantages. Unlike ICEVs, EVs do not face technological barriers related to combustion engines and transmissions. Instead, key barriers are in power batteries, electronic controls, and motors, where Chinese firms dominate. Rapid innovation, driven by a strong engineering workforce and intense competition, is establishing new technological barriers. This study provides insights for China and other countries in identifying market-driven strategies to support EV development.

Paper ID: 417

Implications of changing dietary structure for optimizing phosphorus metabolism pattern

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Abstract:

Phosphorus is ubiquitous in biogeochemical processes and is a key nutrient element in supporting sustainable food systems. During the course of economic and social development and urbanization, changes in dietary structure significantly influence phosphorus metabolism patterns, especially in urban areas with intensive human activity. Clarifying the patterns and characteristics of phosphorus metabolism can provide opportunities both to alleviate the pressure on phosphorus resource supply and to reduce phosphorus losses. Based on the material flow analysis method, this study constructed a set of dietary-driven phosphorus metabolism models, combining the coupling of anthropogenic and natural activities, to quantify phosphorus flow in the Greater Bay Area of China, which contains 11 cities. Integrating the results of phosphorus flow analysis, the phosphorus metabolism characteristics in urban agglomerations were revealed via phosphorus resource footprint and phosphorus pollution footprint, and the driving factors of these characteristics were explored. Furthermore, the spatial correlations of phosphorus metabolism characteristics in the region were evaluated. By analyzing the process of dietary-driven phosphorus metabolism in urban agglomerations, this study emphasizes the coordinated development of phosphorus resources within urban ecosystems. It further provides scientific and effective methods for the sustainable management of phosphorus resources in urban agglomerations.

Paper ID: 418

Sustainable food systems: upcycling & supply chain optimization

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Abstract:

Sustainable agricultural and food systems are essential for addressing the global issues of food security, environmental degradation and economic inequalities. The loss of up to 25% of agricultural yields as a result of global issues including growing populations, climate change and water scarcity has raised the demand for sustainable agriculture and food systems. Modern, environmentally friendly farming practices that increase agricultural productivity and address the critical issues of long-term food security are examined in this review. The world's population is predicted to increase to 9.7 billion people in 2050 and 11.2 billion in 2100, resulting in an exponential increase in demand for food that stipulates a fundamental shift in the production and distribution of food. The Food and Agriculture Organization reports that about one-third of the 1.3 billion tons of edible food produced annually are lost or thrown away throughout the entire supply chain. The manufacturing, processing, transportation, shipping, storage, retail, food service and consumption sectors of the food supply chain are all affected by food waste. Supply chain optimization and upcycling are two key strategies for promoting sustainability in the food sector. Utilizing the edible parts of food that are discarded to make food for human consumption is one approach to mitigating waste in the food supply chain, regardless, the food would not be discarded. Through better decision-making, cost reduction and resource allocation, artificial intelligence dramatically increases supply chain efficiency. This article highlights significant developments in artificial intelligence technologies, including robotics, machine learning and natural language processing, and how they are used in a variety of supply chain operations, such as demand forecasting, inventory control and logistics optimization. By increasing transparency and traceability, the use of artificial intelligence in food supply chains can help address the particular problems of food safety, quality and waste.

Paper ID: 419

AI and biotechnology in sustainable food production systems

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Abstract:

Producing enough food and fiber to meet current needs while protecting and enhancing natural resources for future generations is the goal of sustainable agriculture. Climate change, resource scarcity and the need for sustainable practices are some of agriculture's extraordinary challenges. To address these problems, this article examines how biotechnology and artificial intelligence can be combined. Biotechnology, such as genetically modified organisms, CRISPR-Cas9 and synthetic biology, offers ways to improve agricultural resilience, enhance crop yields and improve resource efficiency. Biotechnology adds bioactive components to prevent disease, enzymes that increase metabolism to treat obesity and nutrigenomics-based foods adapted to lifestyle and genetic requirements. AI improves these technologies by tracking crop health, predicting agricultural outcomes, and improving crop management through robotics, machine learning, and predictive analytics. This review demonstrates how AI improves data analysis for genetic modifications and optimizes crop management strategies, highlighting the synergies between biotechnology and AI. CRISPR optimization and the development of disease-resistant crops have benefited from applying AI technologies. Compared to conventional methods, AI-driven phonemics and genomics advancements increase the effectiveness of choosing and breeding plants with desirable traits. The development of crop varieties that are more resilient to diseases and climate change will be accelerated by this trend. Artificial intelligence is being used in many food industries for modeling, prediction, control tools, sensory evaluation, quality control, and solving complex food processing problems. Similar to this, artificial intelligence is used in agriculture to enhance every aspect of farming, including fruit harvesting, herbicide application, crop yield optimization, and weed identification. AI technology is revolutionizing food enterprises through increasing productivity, boosting food safety, and stimulating innovation. To increase food safety, there is much interest in applying various AI applications, including computer vision, natural language processing, and machine learning models, which are significant areas of AI pertinent to food safety.

Paper ID: 421

Regional specialization and spatiotemporal evolution of China’s photovoltaic manufacturing industry chain

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Abstract:

The rapid expansion of China’s photovoltaic (PV) manufacturing industry has been driven by increasing global demand and advancements in clean energy technology. Understanding the regional specialization and spatial evolution of the PV industry is crucial for optimizing industrial planning and policy-making. While previous studies have examined the carbon footprint of PV production, limited research has analyzed the spatial distribution and specialization of different manufacturing stages within the industry chain.

This study investigates the spatiotemporal evolution of China’s PV manufacturing sector by analyzing 2,849 investment project filings across 14 provinces from 2017 to 2024. The analysis covers core industry segments—silicon materials, silicon wafers, solar cells, and modules—along with auxiliary components such as PV glass, mounting brackets, inverters, and silver paste.

Findings reveal distinct regional specialization patterns. Jiangsu remains the central hub, but PV module production has expanded significantly across multiple provinces, while silicon material and solar cell production remain concentrated in select locations. Auxiliary component manufacturing also exhibits specialization: PV mounting brackets are widely dispersed, whereas PV inverters are primarily produced in Guangdong. Additionally, technological transformation projects account for 14% of all filings, indicating that established investment hubs continue to attract further capital. Technological advancements have driven down per-unit investment costs, leading to larger-scale production projects.

As government policies, technological advancements, and global trade dynamics evolve, China's PV manufacturing industry is expected to exhibit further regional differentiation and spatial restructuring. To ensure sustainable growth, aligning industrial planning with regional strengths and global market conditions is essential.

Paper ID: 422

Low-carbon energy transition for residential centralized heating in China: measurement, policy impacts, and mitigation potential

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Abstract:

The energy transition of residential centralized heating (RCH) in China has achieved remarkable progress, driven by improvements in heating efficiency, optimization of energy structures, and enhanced building energy performance on the demand side. The implementation of clean heating policies has further accelerated this process. In this study, we developed a Low-carbon Energy Transition Index (L-ETI) to evaluate the progress of RCH energy transition in 129 cities from 2013 to 2022, focusing on two dimensions: energy system performance and transition readiness. Additionally, we applied a bivariate analytical framework to illustrate the historical transition pathways of city RCH. Our findings reveal significant disparities in the energy transition progress among cities. Although the L-ETI scores for RCH have generally increased over time, the transition faces substantial challenges due to insufficient driving forces. Using a Regression Discontinuity in Time (RDiT) approach, we confirmed the positive impact of clean heating policies on promoting RCH energy transition. Further analysis with the difference-in-differences (DID) model indicates that this positive effect is more pronounced in the "2+26" key cities. Moreover, we estimate that if the heating facility mix and building energy efficiency levels (adjusted for climatic factors) in all cities were elevated to the top 10% national benchmark, total carbon emissions from RCH could be reduced by 50.5 $MtCO_2$ (14.0%). This study provides an in-depth analysis of RCH energy transition, offering valuable insights for similar analyses in other sectors and serving as a reference for city policymakers.

Paper ID: 423

Green packaging innovations: reducing plastic waste in the food industry

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Abstract:

The food industry generates over 146 million tons of plastic packaging annually, yet only 14% is recycled, with the rest polluting landfills and oceans. Addressing this issue requires innovative packaging solutions that minimize environmental impact while maintaining food safety, quality, and shelf life. This review explores green packaging innovations, including biodegradable materials, reusable systems, and improved recyclability strategies.

Biodegradable alternatives such as polylactic acid (PLA) decompose within 6–12 months under industrial composting conditions, while seaweed-based polymers are fully biodegradable and even edible. Notpla's seaweed-derived films have demonstrated an 80% reduction in single-use plastic waste in pilot applications. Loop's reusable packaging system has cut packaging waste by 40–60% for participating brands, offering a circular economy approach. Water-soluble materials like polyvinyl alcohol (PVA) dissolve entirely, eliminating plastic waste in single-use applications. Additionally, mono-material packaging has improved recyclability rates by 30–50% over multi-layered plastics. Despite these advancements, widespread adoption faces challenges such as limited composting and recycling infrastructure, high production costs, and consumer acceptance barriers. Addressing these issues requires interdisciplinary research, industry collaboration, and supportive policies to scale up sustainable packaging solutions. By integrating biodegradable materials, reusable packaging, and enhanced recyclability, the food industry can significantly reduce its environmental footprint, contribute to a circular economy, and align with global sustainability goals. This study highlights the need for continued innovation and systemic changes to transition towards a more sustainable packaging landscape.

Paper ID: 424

The cost of green: environmental regulations, corporate finance strategies and sustainable growth

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Abstract:

To shift towards eco-friendly growth trajectories, enterprises are refining their production decisions, which may affect their capital requirements and the associated financing costs with green finance. Using a 10-year firm-level panel dataset (2014-2023), we apply an integrated approach of pair propensity score matching (PSM) and difference-in-difference (DID) estimation to examine the impact of China Pilot Policy of Green Finance Reform and Innovation (GFRI) on the capital strategies of A-listed enterprises in China. Our findings indicate that GFRI effectively encouraged a reconfiguration of their debt structures and decreased financing cost. Furthermore, the pilot policy has a certain squeeze on R\&D expenditure of enterprises. And enterprises promote the transformation and disposal of intangible assets, which can improve the financing capacity of enterprises. Thus, the increased debt structure is partly attributed to such allocations. While firms can significantly benefit from financial policies, the long-term success hinges on the development of market mechanisms for sustained support.

Paper ID: 425

Developing the Extended Theory of Planned Behaviour to investigate consumer circular economy behaviour in WEEE management

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Abstract:

In circular economy concepts, extending the lifetime of an electronic product through repair will result in environmental gains and decrease the ecological burden of consumer electronics. Consumer consumption behavior plays a crucial role in promoting a circular economy by supporting repair, reuse, and recycling practices that reduce waste and extend the life of products. Since there is little empirical data from a consumer perspective on engaging circular repair behaviour for EEE in Hong Kong, this study aims to investigate the factors that underpin consumers' behavioural intention to circular repair practice. The extended theory of planned behaviour (TPB) was developed to explore the antecedents of consumers' behavioural intention for repairing EEE. The eight research hypotheses were examined using the Structural Equation Modelling technique from 609 respondents in Hong Kong. To acquire a stronger explanatory power, we extended the original TPB model such as attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC) with three extra factors such as awareness of consequences (AC), environmental concern (EC) and policy concern (PRS). The study found that extending the TPB model resulted in higher explanatory power (54%) for behavioural intention. According to the hypothesized results, EC (β= 0.473***,) showed the strongest influence on repair behaviour followed by PBC (β= 0.224***), AC (β= 0.195***), SN (β= 0.175***) and finally ATT (β=0.164***). However, PRS (β= 0.068ns) was not statistically significant. The results of the analysis indicated that AC, EC, ATT, PBC, and SN are the major factors affecting the behavioral intention to repair behaviour. The study offers novel insights for researchers and policymakers to create a more consumer-centric CE framework to expand understanding about repair behaviour of EEE.

Paper ID: 426

Urban morphology and traffic congestion: Identifying spatial drivers for enhancing sustainable road transport and emission reduction

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Abstract:

Traffic congestion is a persistent and escalating challenge in urban environments, significantly contributing to transport-related emissions and escalating energy consumption. Mitigating congestion is crucial for reducing traffic-induced pollution and addressing the environmental impact of increasing mobility demands in urban agglomerations. However, conventional studies often fail to account for the interdependent influences of neighboring cities and their spatial interactions that shape congestion patterns. To bridge this gap, this study develops a Local Characteristics Regression (LCR) model integrating a newly developed geocomplexity index, which quantifies spatial interactions and complexities within urban regions. By incorporating urban morphology, along with socioeconomic and natural indicators, this study provides a refined understanding of congestion dynamics. Empirical investigations, conducted across 100 Chinese cities, including 42 cities from three major urban agglomerations, reveal that geocomplexity significantly enhances the explanatory power of congestion models by capturing non-linear and emergent spatial patterns. The findings highlight that congestion hotspots are strongly linked to spatial dependencies among land-use configurations and urban morphology, exhibiting substantial spatial heterogeneity. This study underscores the critical role of urban morphology and other characteristics in shaping congestion patterns, offering key insights for designing targeted congestion mitigation strategies to curb emissions and improve transport efficiency in rapidly expanding urban regions.

Paper ID: 427

Dual-Coupling of Carbon Effects: Linking Emission-Absorption Patterns to Land Use Intensity and Economic Contribution in Urban Agglomerations

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Abstract:

Land use serves as a critical nexus integrating carbon emission-absorption dynamics with regional economic performance. Optimizing this dual-coupling relationship, between carbon effects and land use Intensity, is essential for achieving sustainable development in urban agglomerations. This study proposes a novel framework to quantify and evaluate the coupled effects of land use carbon intensity and economic contributions. Taking the Pearl River Delta as a case study, this research analyzes spatiotemporal patterns of carbon emissions and absorption from 2010 to 2020, and assess the coupling between Carbon Ecological Support Capacity (ESC) and carbon economic contribution coefficient (ECC). Results reveal a spatial mismatch. ESC exhibited a "high periphery, low center" pattern, while ECC showed the opposite trend. The coupling coordination degree declined over time, indicating a persistent mild imbalance between carbon mitigation and economic growth. Key findings highlight that land use Intensity was the dominant factor suppressing emissions, whereas economic development level drove emission growth. Meanwhile, carbon sink capacity (NEP) improvements partially offset emissions, underscoring the potential for ecosystem-based optimization. By integrating carbon emission-absorption dynamics with land use Intensity and economic performance, this study provides an actionable pathway for low-carbon economic optimization in urban agglomerations, emphasizing the need for tailored policies to reconcile ecological and economic goals.

Paper ID: 431

A data-driven framework for building decarbonization policy recommendation based on large language model-powered agent

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Abstract:

Building decarbonization is a crucial pathway to promoting sustainable urban development. Climate policies have effectively advanced the process of building decarbonization by enhancing the ability of the building to address global climate challenges. Due to multiple factors such as geographical location and institutional environment, the carbon reduction effect of policy implementation presents regional heterogeneity. Although existing studies have explored the mechanism and synergistic effect of policies in depth, the mining and utilization of policy data is still insufficient. This study proposes a policy recommendation framework based on Large Language Model (LLM)-powered agent to address the problem. The framework comprises three modules: database construction, building carbon assessment, and intelligent policy recommendation. It leverages fine-tuning Bidirectional Encoder Representations from Transformers (BERT) model to extract policy features of 3293 building policies in the International Energy Agency (IEA) database, and combines the regional characteristics, building carbon assessment results, and reasoning ability of LLM for realizing dynamic and adaptive policy recommendation. The case study in a representative city confirms that the method provides a data-driven decision-making basis for regional differentiated building energy saving and emission reduction policy formulation, contributing to the realize climate goals and sustainable development.

Paper ID: 432

The "vortex effect" in heterogeneous e-commerce networks: an examination of resource dissipation in the evolution of e-commerce spaces and its governance strategies

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Abstract:

In the era of the "digital turn," the e-commerce industry has triggered profound economic transformations. Constructing a new landscape for the e-commerce industrial system requires overcoming the bottleneck of disorderly resource dissipation within heterogeneous e-commerce networks and achieving resource regeneration and value enhancement. What are the root causes of resource dissipation in the evolution of e-commerce spaces? How can it be governed? To answer these questions, this study conducts a longitudinal case analysis using five formerly impoverished counties in China as research samples, systematically exploring the structural characteristics of their internal e-commerce spaces and the mechanisms driving resource dissipation in their evolutionary processes. The findings reveal that: (1) The heterogeneous e-commerce networks in formerly impoverished counties exhibit a three-tiered structure, progressing from the inside out: the resource-enriched layer dominated by core actors, the resource-enclosed layer led by intermediary actors, and the resource-dissipating layer controlled by disadvantaged actors. (2) A distinct "vortex effect" exists within these networks, evolving through the process logic of "vortex formation → vortex intensification → vortex solidification." (3) The "vortex effect" catalyzes internal stratification and the dissipation of key resources within the network. The underlying mechanisms manifest in different phases as "disciplining," "harvesting," and "degradation." (4) The dissipation of resources during the evolution of e-commerce spaces is both a consequence of imbalanced social exchange and disordered interaction among different tiers of actors, as well as a result of the breakdown in the network's resource circulation mechanisms and mismatches in power and responsibility. By unveiling the formation logic and intrinsic mechanisms of resource dissipation in county-level e-commerce space evolution, this study contributes to relevant theoretical research and provides insights for promoting regional economic circulation and sustainable development.

Paper ID: 433

Integrating the use of Generative AI for Enhanced Resilience and Sustainable Business Value Creation in Malaysian Manufacturing

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Abstract:

This study explores the transformative role of Generative Artificial Intelligence (GenAI) in advancing sustainable business value across Malaysian manufacturing sectors, emphasising supply chain integration, and enhanced resilience. Amid the complex global supply chain dynamics, this research investigates how firms can concurrently achieve economic profitability and uphold environmental and social responsibilities. Employing a quantitative method approach, the study draws on survey data from 217 manufacturers to provide empirical insights into GenAI's impact. The findings indicate that the impact of use of GenAI to achieve sustainable business value creation would be done through supply chain integration and supply chain resilience. This research identifies key mechanisms through which GenAI drives sustainable business value, including resource optimisation that lessens environmental impacts, enhanced collaboration that strengthens social sustainability, and improved risk management that supports economic viability. While recent studies highlight GenAI's potential to transform supply chain management by fostering new market opportunities and redefining business processes through enhanced data analysis and decision-making, there remains a notable gap in understanding its full potential for promoting sustainable value creation and resilience within the Malaysian context with the use of Generative AI. By addressing this gap, the study highlights the critical need for firms to balance the triple bottom line of sustainability—economical, environmental, and social—while meeting evolving stakeholder expectations, thus enriching the existing literature on sustainable business practices within emerging markets. This research contributes to both theoretical understanding of AI-driven sustainable value creation and provides practical insights for Malaysian manufacturers seeking to implement GenAI solutions. The findings suggest that strategic integration of GenAI technologies across organisational and supply chain operations represents a significant opportunity for Malaysian manufacturing industries to remain competitive and resilient while simultaneously advancing sustainability objectives.

Paper ID: 434

How does climate change impact the low-carbon transition of power sector in negative power supply areas? Evidence from the Greater Bay Area

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Abstract:

Climate change is significantly reshaping power supply and demand structures, posing profound challenges to the low-carbon transition of the power sector. Particularly in negative power supply areas, due to insufficient local generation capacity to meet the rapidly growing electricity demand, coupled with the increasing share of renewable generation, it faces a greater risk of supply-demand imbalance under the influence of climate change. This imbalance in turn leads to significant changes in the carbon emission pattern of the power sector. With unique energy structures and emission profiles, negative power supply areas must tackle additional challenges: ensuring power supply-demand balance while achieving low-carbon transition goals. This study takes the Greater Bay Area as an example, modeling various emission reduction pathways under different climate conditions while maintaining power supply-demand equilibrium. To achieve this, a multi-level framework is constructed to analyze the spatiotemporal patterns of supply-demand imbalances in emerging power systems, and a response model is developed, integrating stochastic weather simulations to investigate the dynamic interactions between supply and demand under varying climatic conditions. It examines the dynamic changes in power supply-demand structures and carbon emissions, assessing the risk of carbon rebound under specific conditions. The study provides optimization strategies for low-carbon power system transitions under the influence of climate change. These suggestions aim to achieve emission reductions and stable electricity supply simultaneously, supporting the region’s energy security transition and contributing to sustainable economic and social development.

Paper ID: 435

Decarbonization potential of the transportation system in the Bay Area urban agglomeration from power-transportation synergy perspective

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Abstract:

As a pivotal sector closely related to socioeconomic dynamics and also a principal contributor to carbon emissions, the deep decarbonization of the transportation system is significant to achieve carbon neutrality. Bay Area urban agglomerations, characterized by high-intensity transportation demand and three-dimensional transportation networks, face unique challenges in the low-carbon transformation of transportation. Electrification is globally recognized as a critical strategy to decarbonize the transportation system, and it is also a key path for the International Bay Areas to move towards net zero emissions. However, the decarbonization benefits of transportation electrification are limited by the cleanliness level of the power system. Current researches focus more on the direct decarbonization benefits brought by transportation electrification, while neglecting the transfer of carbon emissions caused by unclean power generation. Synergistical promotion of low-carbon transformation in the power -transportation system is essential to fully unleash the decarbonization potential of transportation electrification. This study established a comprehensive accounting model for transportation carbon emissions in the Bay Area urban agglomerations from the perspective of power-transportation synergy to construct carbon emissions inventories encompassing maritime, terrestrial, and aerial transportation subsystems, and further revealed the correlation between the cleanliness level of the power system and the decarbonization benefits of the transportation system. Through taking the Guangdong-Hong Kong-Macao Greater Bay Area as a case study area, this study accounted the carbon emissions generated by direct energy consumption and electricity consumption of four transportation modes in the Bay Area: road, railway, aviation and waterway transportation. Furthermore, based on the comprehensive accounting, the decarbonization benefits brought by transportation electrification under different power generation structures have been quantified, and the effective pathways to deeply decarbonize the transportation system have been analyzed. The research results provide a cross system theoretical framework and quantitative tool for achieving low-carbon transportation systems in the Bay Area urban agglomerations.

Paper ID: 436

Study on the Impact and Mechanism of Resource Taxes on Carbon Emissions from a Spatial Measurement Perspective

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Abstract:

Taxation is an important tool for environmental governance and plays a critical role in achieving the goals of "carbon peaking and carbon neutrality." Originally, the resource tax was designed to adjust for profit differences among enterprises caused by disparities in resource endowments. This study uses data from 29 provinces in China from 2007 to 2021 to investigate whether the resource tax has a suppressive effect on carbon emissions. Based on the STIRPAT model and a series of model tests, we adopt the Spatial Durbin Model (SDM) to further assess the spatial spillover effects of carbon emission reductions driven by the resource tax.

The results show that the resource tax significantly reduces carbon emissions both locally and in neighboring regions. The carbon reduction effects of the resource tax exhibit regional heterogeneity, and industrial structure plays a key role in the mechanism through which the resource tax influences carbon emissions. Therefore, this study offers a new perspective and empirical basis for the development of cross-regional coordination mechanisms in carbon emission governance, providing new pathways and policy options for achieving the "carbon peaking and carbon neutrality" goals.

Paper ID: 437

Validating LEAF for emerging waste-derived construction materials inclusions towards a robust UK circular economy

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Abstract:

LEAF (leaching environmental assessment framework) is a collection of laboratory leaching tests, data management tools and leaching assessment approaches developed to identify detailed characteristic leaching behaviours of a wide range of solid materials, including by-products. It was developed by a consortium of research centres, universities, environmental regulatory agencies and consulting firms in Europe and the USA. There is a critical need to update the regulatory frameworks and compliance monitoring systems for the evolving frontiers of new low-carbon binders and additive concrete mixtures in the United Kingdom (UK). Circular economy and sustainability-driven inclusions of (cement replacement materials) various waste forms such as agricultural residues, power plant ashes, slags, construction, and demolition waste/aggregates, mine tailings, heavy metal contaminated soils, and emerging contaminants contaminated soils in concrete mixtures necessitate the adoption of a robust environmental risk assessment framework that embraces updated standards with rapid screening and compliance monitoring systems. This validation for the UK construction industry, would provide the basis for the upgrading of industries standards, strengthen existing regulatory frameworks, and foster the resilience and sustainability of regional and national infrastructure development. It will also result in an expanded database/expert system for the environmental risk assessment of contaminated soil, sediment, sludge, waste and construction materials, based on scenario-based assessments, wholistic impact analysis and visualization of the effects of constituents of potential concern (COPCs) on the environment. This paper presents a status update on the global application of LEAF and the database/expert system, appraising the level of implementation in the United Kingdom.

Paper ID: 438

Transformations and developments of medical waste disposal technologies and management models in China

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Abstract:

China has faced epidemic threats unflinchingly in the sphere of public health security, evolving from the SARS outbreak to the COVID - 19 pandemic. Throughout this period, China has implemented a series of far - reaching strategies. By committing to international environmental conventions, the country has driven remarkable transformations in medical waste disposal technologies and management frameworks. After the SARS crisis, China actively upgraded incineration technologies and introduced high - temperature incinerators with enhanced emission control systems. Meanwhile, China began exploring non - incineration technologies such as autoclaving and chemical disinfection. During the COVID - 19 pandemic, China adopted digital platforms to track medical waste in real - time, ensuring full - process supervision. China rapidly deployed mobile treatment units, significantly improving emergency response capabilities. These measures have not only curbed the pollution risks of medical waste during outbreaks but also laid the foundation for industry sustainability. China’s experience provides other countries with valuable insights. By sharing these practices, we can jointly promote the harmonious development of global public health and environmental protection.

Paper ID: 439

Precisely selective and environmentally friendly thiol-functionalized mesoporous silica for Hg(Ⅱ) removal from wastewater

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Abstract:

Given the environmental and health risks of Hg(Ⅱ) and the shortage of widely applicable adsorbents, this study focuses on "green synthesis" and "precise selection", successfully functionalizing mesoporous silica (MS) with thiol to create thiol-modified mesoporous silica (TMS) with sulfur-active sites. Results showed that TMS demonstrated a promising adsorption capacity (81.14 mg·g-1), effective dynamic repair (reusable for at least 5 cycles), and rapid desorption (eluting over 98% of Hg(Ⅱ) within 20 min) at an optimal pH of 6. Meanwhile, it exhibited excellent selectivity for Hg(Ⅱ) removal, with minimal adsorption of coexisting As(III), Cd(II), Cr(III), Cu(II), Ni(II), Pb(II), and Zn(II), while achieving a Hg(Ⅱ) removal rate exceeding 99.78%. The mechanism and kinetic studies showed that Hg(II) forms stable dπ-pπ back-donation interactions with thiol groups and undergoes a rapid intraparticle diffusion process, with internal diffusion times of 10 min and 30 min for Hg(II) concentrations of 35 mg·L-1 and 15 mg·L-1, respectively. The adsorption performance of commercial adsorbents, including activated carbon granules (ACG), activated carbon powder (ACP), and zeolite powder (ZP), was compared with that of TMS. The removal efficiencies were as follows: TMS (99.94%) > ACP (46.99%) > ZP (0.56%) > ACG (0.38%) in simulated water, and TMS (82.44%) > ACP (38.68%) > ZP (0.82%) > ACG (0.43%) in chemical wastewater. All results demonstrated that TMS is highly selective, recyclable, widely applicable, and a promising alternative to current commercial adsorbents for the removal of Hg(Ⅱ) from wastewater.

Paper ID: 440

Development of 3D printed sustainable bio composite materials from biomass and e-waste for energy saving applications

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Abstract:

Most of the countries imposed rules and regulations for the replacement of petroleum based products with bio composite materials. The object of the present work is development of bio composites utilizing polylactic acid (PLA) as matrix and elephant grass and e-waste as reinforcement for energy saving applications. In this study, elephant grass/e-waste ranging from 0% to 10% are incorporated into a polylactic acid (PLA) to develop novel bio 3D printing filaments via a melt extrusion process. Thermal conductivity and acoustic test samples were prepared via fused deposition modeling (FDM) method. The thermal and acoustic insulation of samples were examined using guarded thermal conductivity meter and an impedance tube method. Thermal conductivity of pure PLA was 0.164 W/mk. With the addition of elephant grass to PLA thermal conductivity of composite decreased to 0.144 W/mk. Sound absorption coefficient (SAC) for PLA and composite was 0.68 and 0.74 respectively. As fiber content increased, thermal and acoustic insulation of 3D print composites increased. Further, with the addition of e-waste to PLA, thermal conductivity marginally increased. Hence, the present developed composites are used in the applications such as building and automotive industries for the reduction of power consumption. This investigation enhanced the value of biomass and e-waste, which is currently underutilized.

Paper ID: 441

Contagion mechanism of land market cooling on local government debt risk

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Abstract:

Land, as a fundamental production factor and a scarce resource, plays a pivotal role in China's urbanization process. Under China's land finance system, the issuance and repayment of local government debt are heavily reliant on the sustainable development of the land market. A downturn in the land market can significantly reduce local governments land-based fiscal revenues, thereby exacerbating debt risks. This study, adopting a land resource perspective, constructs a mediation effect model within a local government financing framework to empirically investigate the transmission mechanisms through which land market cooling influences local government debt risks. The findings show that a downturn in the land market leads to an increase in local government debt risks. The cooling of the land market propagates and amplifies debt risks through multiple contagion channels, including debt repayment constraints, government credit deterioration, and disruptions in endogenous financing mechanisms. These findings provide robust empirical evidence and policy implications for preventing local government debt risks, mitigating local governments' excessive dependence on land-based revenues, and promoting the sustainable utilization of land resources.

Paper ID: 442

Development of sustainable hybrid composite material from agro and e-waste for thermal management in electronic packing

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Abstract:

Nowadays, the demand for composite materials with good thermally conductivity and electrical insulation capability is increasing, for the development of electronic devices used in high-power integrated 5 G systems. In this work, hybrid composites were developed by incorporating hexagonal boron nitride (hBN), agro and e-waste waste as reinforcements in to epoxy matrix via hot press method. Thermal conductivity of samples is examined using guarded thermal conductivity meter as per ASTM standard. Thermal conductivity of epoxy is 0.178 W/mk. With the addition of agro/e-waste and hBN thermal conductivity of composite increased to 0.749 W/mk. As hBN content increased, thermal conductivity of composites increased. Further, with the addition of agro/e-waste and hBN to matrix, electrical insulation and fire retardant properties of composites increased. Hence, the present work, not only provides sustainable solution to resolve e-waste pollution but also value-added electronic materials for thermal management applications.

Paper ID: 443

Assessing sustainability reports by universities in reporting on Sustainable Development Goals

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Abstract:

Sustainable Development Goals (SDGs) provide an integrated framework for organizations such as universities to demonstrate their long-term impacts on society and the environment. However, contributions to SDG implementation are not directly disclosed in any reports by universities. This study aims to assess sustainability reports by universities in Victoria, Australia in reporting on SDGs for unveiling the impacts of these universities on society and the environment. Empirical analysis is conducted to mine sustainability reports by these universities. Natural Language Processing (NLP) captures reported information about SDGs for assessment. Results indicate that most of the universities in Victoria, Australia have contributed to all the SDGs, while SDG 1, 4, 9, 13, and 17 have captured the majority of their contributions. The findings of the study support translating sustainability actions into impacts for communication to engage internal and external stakeholders and modify next-term strategies for contributing to SDG implementation. Eventually, the method of assessing sustainability reports in reporting on SDGs that are introduced by the study can be introduced to different contexts and scales for them to suggest action priorities, construct a transparent and consistent reporting landscape, modify strategies, and refine assessment systems.

Paper ID: 444

Unlocking the potential of refuse-derived fuel in cement co-processing: Factors affecting its low uptake

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Abstract:

In recent years, refuse-derived fuel (RDF) has emerged as a compelling alternative fuel, offering a promising strategy for mitigating fossil fuel dependency and reducing carbon emissions. A perusal of the literature reveals that research on RDF usage in cement co-processing as a strategy for decarbonising the cement manufacturing industry remains in its nascent stages, with existing research providing insufficient attention to its market uptake. Therefore, this study conducted a systematic literature review (SLR) to discern trends in research on the use of RDF in cement co-processing and identify factors that limit uptake. To accomplish the aim, the objectives of this paper are twofold: (i) to explore the factors that affect the low uptake of RDF in cement co-processing and (ii) to identify future research directions of RDF. A total of 62 articles published between 2000 and 2025 January were subjected to descriptive and content analysis. Descriptive analysis has shown growing research interest over the past decade. Content analysis was guided by the Attitude-Behaviour-Context (ABC) Theory, focusing on the pro-environmental behaviour (PEB) perspective, recognising RDF uptake as a form of PEB. As the ABC Theory suggests, a combination of attitudinal and contextual factors influences the low uptake of PEB. Key attitudinal factors include resistance to new fuel types, lack of knowledge, and negative decision-making attitudes. Contextual factors, such as high moisture and chlorine content in municipal waste, affordability of traditional fuels, and inadequate regulations, were also explored as factors limiting RDF co-processing.

This study contributes to both theory and practice. Theoretically, it extends the application of the ABC Theory and PEB perspective to alternative fuel adoption. Practically, it provides a foundation for promoting RDF uptake in cement co-processing. Additionally, it identifies avenues for further research, including validating the actual impact of limiting factors and exploring mitigation strategies to enhance RDF adoption.

Paper ID: 447

Utilization of landfill-recovered aggregates in geopolymer concrete: A step towards circular economy

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Abstract:

Landfill mining offers a sustainable way to manage the legacy waste present in the old landfills. Coarse aggregates consisting of stones and construction and demolition waste constitute a significant portion accounting for around 20% of the total legacy waste, making its valorization a vital parameter for the success of a landfill mining project. The current study attempts to replace natural aggregates (NA) with landfill-recovered aggregates (LRA) in geopolymer concrete. Geopolymer concrete was prepared using ground-granulated blast furnace slag (GGBS) as binder (B), alkali solution (A) (mixture of sodium silicate (SS) and sodium hydroxide (SH)), river sand, and coarse aggregates (NA and LRA). The design of experiments (DoE) was adopted to optimize the mixture components for obtaining the optimum Geopolymer concrete mixture with maximum compressive strength (CS) and a model equation for the prediction of CS at 28 days. I-optimal mixture design was used and the variables were A:B (0.4−0.6), SS:SH (1.5−2.5), and molarity of SH (6, 8, and 10M). The optimum mixture obtained through DoE was tested by replacing NA with LRA by 25, 50, and 100%. The results showed that a maximum CS of 46.9 MPa was obtained when the SS:SH and A:B ratios were 2.5 and 0.6, respectively, with a NaOH molarity of 10. The model equation predicted the maximum CS of 47.7 MPa whereas the actual compressive strength of 48.4 MPa was obtained. Replacing NA with LRA at 25%, 50%, and 100% in the optimal mix reduced CS by 27%, 38%, and 66%, respectively. At 50% replacement, although the CS was reduced by 38%, the concrete had a CS of 30.1 MPa which can be used for structural applications. The study shows that geopolymer concrete made with GGBS and LRA could serve as a sustainable alternative to cement concrete, promoting a circular economy in construction.

Paper ID: 448

Catalytic conversion of inert gas molecules based on MOF composites

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Abstract:

Small gas molecules such as CO_2 and N_2 have considerable chemical inertness due to their stable bond structure, meanwhile, they are also important chemical resources. CO_2 can be used to produce chemical raw materials such as methanol and ethylene, and can also be converted into high-value products such as pharmaceutical intermediates, insecticides, and food additives. Fertilizer generated from N_2 supports the survival of the world's population. Therefore, the exploration of their utilization has emerged as a frontier topic in modern chemistry, holding great potential for both fundamental research and industrial applications. Metal-organic frameworks (MOFs) is a porous material which has shown certain application prospects in gas enrichment, separation, and catalytic conversion. Introducing active sites into MOFs to form composites enhances the catalytic activity, providing an ideal platform for hosting and activating gas molecules.

Here, we have made progress in MOF composites catalysis for small gas molecules conversion. 1) Introducing MOF (ZIF-8) coating on the surface of nano Cu_2O for electrochemical catalytic conversion of CO_2 to obtain syngas with adjustable H_2:CO, which has high FE (> 90%). 2) Constructing a new "2+2" photocatalysis system Ni@CdS⊂Zn/Co-ZIF with a bimetallic MOF and a hybrid photoactive center, leading a high photocatalytic syngas production rate. 3) Coating Cu nanowires with a layer of MOF, and by adjusting the ratio of Zn/Co in the MOF, different proportions of syngas can be generated. The single atom alloy catalyst generated by the pyrolysis of the MOF layer can achieve the hydrogenation of CO_2 to methanol at lower temperature. 4) Integrating ultrathin Fe_3O_4 nanoparticles into the MOF lattice (MIL-101(Fe)) to form a composite catalytic material from the perspective of improving desorption efficiency. The synergistic effect of the triple iron sites allows it to activate N_2 to produce NH_3 under extremely mild conditions of 100 °C and 10 atm.

Paper ID: 449

Government strategy for charging infrastructure construction: A tripartite evolutionary game framework

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Abstract:

The construction of smart cities has put forward high requirements for the development of the new-energy automobile industry, leading to charging piles becoming an important urban infrastructure. The key to addressing the dilemma of charging pile construction lies in the cooperation of multi-sector. This research establishes an evolutionary game model among the government, charging operation enterprises, and site property owners. The adoption strategies interactions among the three parties are unrevealed in promoting the construction of charging piles in the short term. Then, the evolution game model is simulated to compare the impact of strategy adoption according to the data of China. Research results indicate that only when the government adopts the incentive strategy with low or moderate subsidy intensity can cooperation among the three parties be promoted. The high subsidy intensity may lead to the burden of fiscal expenditure affecting the sustainability of the policy, thereby producing a negative impact on the cooperation of multi-sector. The intensity of government subsidies received by charging operation enterprises and the profit distribution received by site property owners should be within a moderate range, which will drive participants to choose collaborative strategies and promote the achievement of cooperation. Based on the findings, insightful policy implications are provided for the construction of charging infrastructure in smart cities.

Paper ID: 451

Generation of a green construction material from recycle of paper mill sludge & data analysis via statistics

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Abstract:

The paper-mills in Taiwan produce 4,400 thousand tons of pulp annually, resulted in plenty of paper mill sludge production. Therefore, this study aimed to discover the features of paper mill sludge and produce a new construction mixture. Paper mill sludge acquired thermal insulation due to constitution of paper fibers. Water absorption test revealed that the optimal vaule was 19% with 4 wt% paper mill sludge addition. Thermal insulation test showed a maximum value of 10 oC differences on the upper surfaces of the concrete and cement with or without paper mill sludge addition.Thermal conductivity coefficient was evaluated as 0.83 and 0.98 (W/m*K) for cement and concrete. The compressive strength ranged from 83.6–51.7 MPa, and the flexural strength varied from 2.76–1.65 MPa, while paper mill sludge addition varied from 0–5 wt%. Therefore, 4 wt% paper mill sludge addition was considered the optimal concentration for brick manufacturing. According to results of ANOVA test and Turkey HSD post hoc test, compressive strength and flexural strength were effected vividly by various ratio of sludge addition, which matched results of compressive strength and flexural strength test. Consequently, this study developed a valuable construction mixture of paper mill sludge and cement.

Paper ID: 452

Sustainability through misplaced resource valorisation: Biochar-based adsorbent for pharmaceutical pollutant remediation

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Abstract:

Resource conservation and recycling are crucial for environmental sustainability and long-term economic stability. Many organic wastes generated in developing countries present a challenge to waste management. Addressing the critical link between resource sustainability and environmental pollution, this study explores the valorisation of non-industrial garden waste (GW) and industrial cashew nut shells (CNS) into biochar adsorbents for removing the pharmaceutical contaminant ciprofloxacin (CIP).

Garden waste and cashew nut shell biomass were converted to biochar through pyrolysis under varying thermal conditions to optimise their physicochemical properties and performance to remove CIP assessed. Comparative batch adsorption studies revealed the superior performance of garden waste-derived biochar, produced at 700°C with a 2-hour residence time (GW700/2hr), sequestering CIP from aqueous solutions (85.35% removal efficiency). Comprehensive characterisation of this potent biochar, utilising techniques such as DFT-BET, FTIR, and FE-SEM, elucidated its promising surface area (59.107 m^2/g), and porous morphology – key attributes for effective pollutant adsorption. Further, the model fitting studies revealed that the biochar-CIP interaction follows pseudo-second order kinetics and the Freundlich isotherm, suggesting multilayer chemisorption.

Pharmaceuticals are emerging pollutants that threaten the population's health through the spread of antimicrobial resistance. Low-cost waste-derived biochar offers a promising solution for the remediation of such pollutants. This study illustrates a resource-sustainable approach to converting untapped, readily available waste biomass into efficient functional materials for environmental remediation. The efficiency of garden waste biochar in removing a pharmaceutical pollutant underlines its potential to be used as a water/wastewater cleaner, thereby promoting the circular economy. Further research on this waste resource will enable the development of a successful remediation technology. Such waste-to-resource solutions for environmental challenges are imperative to foster a sustainable future.

Paper ID: 453

Transforming UAE date palm biowaste into sustainable resources: activated carbon and ferrite nanocomposite for water treatment applications

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Abstract:

Access to safe and clean water continues to be a significant global issue, especially in dry areas like the Gulf, where the shortage of freshwater is intensified by climate change and the rise in population. The United Arab Emirates (UAE) depends largely on energy-demanding desalination methods, which has led to a transition towards sustainable options such as treated wastewater. This research investigates a novel, resource-efficient approach that tackles both waste valorization and the challenges of water treatment. Date palm leaves, which are a plentiful and underused agricultural waste in the UAE, are transformed into high-surface-area activated carbon (AC) through a controlled pyrolysis process. The AC is then functionalized with zinc–copper ferrite ($ZnCuFe_2O_4$) nanoparticles to create a nanocomposite that offers improved adsorption, magnetic recovery, and regeneration capabilities. This multifunctional material shows great promise for eliminating emerging pharmaceutical pollutants from wastewater, thereby aiding in the circular utilization of resources. The prepared adsorbent materials, AC and its composite with $ZnCuFe_2O_4$ (i.e., AC/$ZnCuFe_2O_4$) is characterized with advanced characterization techniques, like FTIR, XRD, SEM-EDX, BET, and XPS which showed successful formation. The prepared materials, AC and AC/$ZnCuFe_2O_4$ showed high efficiency, i.e., 84.5% and 97% in the treatment of pharmaceutical contaminant, atenolol (AT) at 180 minutes, respectively. The removal of AT by AC and AC/$ZnCuFe_2O_4$ best fitted Freundlich adsorption model and pseudo-second-order kinetic model. The composite material showed high reusability and stability and greater adsorption efficiency even in the presence of counter ions. The proposed mechanism showed that adsorption of AT by AC and AC/$ZnCuFe_2O_4$ occurred through electrostatic, H-bonding, π- π, and n- π interactions. The high removal efficiency, high reusability and greater stability suggest greater potential of AC/$ZnCuFe_2O_4$ in the removal of target water pollutants.

Paper ID: 454

Decarbonizing hard-to-abate refineries via co-deployment of green hydrogen and CCUS

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Abstract:

The refining industry is a cornerstone of energy production and chemical manufacturing. Refineries' GHG emissions are difficult to quantify with multiple impacting factors, and thus their practical decarbonization pathways remain to explore. Here, for the first time, we accurately quantify GHG emissions in China's refining sector considering the crude oil properties, processing routes, product demand mix of 3,727 equipment units at a plant level. Then, we customize the refinery-level carbon mitigation technical options, through cost minimization incorporating refineries' emission features and resource constraints. GHG emissions of China's refineries have ramped up from 84 MtCO2eq in 1998 to 294 MtCO2eq in 2023. Emission intensities span 270–659 kgCO_2eq per ton of crude, which are significantly influenced by the relative density index and sulfur content of crude oil. Deep coking refineries contribute 64% of total emissions. During 2025-2050, carbon mitigation cost via green hydrogen deployment will decline from 1,240 CNY/tCO_2eq to –1,552 CNY/tCO_2eq, with breakeven by 2032. Shandong, Jiangsu and Liaoning offer the largest reduction potentials (~150–170 MtCO_2eq each). CCUS, at first, is best applied to the processes of hydrogen production and fluid catalytic cracking after 2030, then to heating after 2040. >400 cost-effective source–sink linkages will generate 27.2 million CNY annually, with an average distance of 805 km and mitigation of 0.35 MtCO_2eq/year. For early economic gains, green hydrogen should be prioritized at 37% of refineries and the rest deploying CCS. To achieve effectiveness from co-deployment, switching CCS-first mitigation options to hydrogen-first can boost cumulative GHG reductions by 5% and improve total economic benefits by 40%. This study shows the necessity of systematic assessment on the deployment sequence of mitigation technologies to bring additional benefits.

Paper ID: 456

Cycling Infrastructure as a Resource-Saving Strategy for Urban Resilience in the Global South

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Abstract:

In the face of increasing urban vulnerability to climate-related events, cycling infrastructure emerges as a critical component of urban resilience and environmental sustainability. This study explores how bicycle networks contribute to the optimization of land use, reduction of greenhouse gas emissions, and improved resource efficiency in medium-sized cities of the Global South. By integrating the concepts of cycleability and sustainable planning, the research investigates infrastructure as a low-impact mobility solution capable of reshaping the urban form while enhancing air quality, thermal comfort, and accessibility. Drawing on field data and case evidence from Brazilian urban contexts, the paper highlights how cycling systems can reduce the demand for fossil fuels and hard infrastructure, promoting environmental regeneration and long-term resilience. The results support a shift towards active transportation not only as a mobility choice but as a planning paradigm to ensure the sustainability of natural and built resources in cities under climate stress.

Paper ID: 457

A multidimensional urban planning approach: interlinking key areas of focus to promote sustainable resource management

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Abstract:

Urban sustainability requires a systemic and integrative perspective capable of addressing the interconnected challenges cities face. This research proposes a multidimensional planning approach based on the articulation of eleven strategic areas of focus—environmental, social, economic, health, infrastructure, operational efficiency and accessibility, technology, security, behavioral, legal and regulatory frameworks, and cultural and educational factors. By examining the intersections among these domains, the study highlights how a holistic urban diagnosis can guide resource-efficient strategies and long-term planning decisions. Drawing on empirical analysis from Global South cities, the framework demonstrates how inter-sectoral alignment fosters greater sustainability outcomes than fragmented interventions. The proposed approach serves as a policy-support tool that enhances urban resilience, maximizes resource circulation, and supports equity-driven development pathways. Ultimately, the study reinforces the need for multidimensional assessments to prioritize actions and investments that respond to the complexity of contemporary urban systems.

Paper ID: 458

Nature-based urban planning and active mobility: legal, cultural, and behavioral pathways beyond car-centric cities

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Abstract:

Car-centric urbanization has produced significant environmental, health, and social burdens, particularly in rapidly urbanizing regions of the Global South. This study investigates the potential of nature-based urban planning and active mobility systems—such as walking and cycling—as transformative strategies to mitigate these impacts. The analysis is grounded in four strategic dimensions: public health, legal-institutional frameworks, cultural dynamics, and behavioral patterns. By examining case studies and policy frameworks, the research reveals how green infrastructure and active transport not only reduce air pollution and sedentary-related illnesses, but also demand new legal instruments, foster cultural shifts, and promote inclusive mobility behavior. The study emphasizes the importance of participatory governance, educational campaigns, and regulatory innovation to support these transitions. The results suggest that shifting toward nature-based and human-centered urbanism can unlock co-benefits for sustainable resource management, health equity, and socio-environmental justice in cities facing climate and mobility crises.

Paper ID: 459

Securing China's chromium supply through circular economy

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Abstract:

Chromium (Cr) has been regarded as a critical mineral due to its irreplaceability in many sectors. The sustainability of the Cr supply chain has raised broad concerns since many countries rely on importing Cr to meet their demands, leading to concerns on how to ensure its sustainable supply. This study aims to address such concerns by tracing the Cr flows and stocks along its life cycle in China for the period of 2020-2023 through a dynamic material flow analysis. Scenario analysis is then conducted to project future Cr supply and demand until 2050. Results indicate that the total Cr flows and stocks increased slightly from 2020 to 2023 due to the stable growth of stainless-steel industry. The demand for Cr is projected to peak in 2024 as both per capita in-use stock and population approach their maximum levels. Moreover, secondary Cr resources embedded in those End-of-Life (EoL) flows are expected to rise rapidly from 2024 to 2034, surpassing the demand for Cr between 2028 and 2030. Under a combined policy scenario, China's Cr import reliance may reduce to 8% by 2050 if the domestic EoL recycling rate reaches the global leading level (95%) and the primary Cr resource efficiency is improved across various stages of the entire Cr industrial chain. Finally, several policy recommendations are proposed to improve the overall Cr resource efficiency.

Paper ID: 460

Integrating life cycle assessment into refinery planning for low-carbon product development

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Abstract:

As global carbon emission regulations tighten and carbon border adjustment mechanisms (CBAM) come into force, the petroleum industry faces mounting pressure to reduce product carbon footprints (PCFs) and develop more sustainable products. Traditionally, PCF reduction has depended on low-carbon technology adoption and carbon capture and storage (CCS) deployment—approaches that often entail high capital investment. However, for blended products like gasoline, further reductions can be achieved through cost-effective strategies such as optimizing blending component selection and allocation.

In practice, petroleum companies commonly rely on planning systems like PIMS (Process Industry Modeling System) and RPMS (Refinery and Petrochemical Modeling System) to optimize operations and blending. Yet, these systems face two major limitations: they cannot trace PCFs systematically throughout the production chain and do not support PCF-based optimization in operational planning.

To address these challenges, this study proposes an integrated modeling framework that couples Life Cycle Assessment (LCA) with production planning. Utilizing advanced recursive algorithms and dual-linear programming techniques, the framework establishes a method for PCF calculation under various allocation rules. By treating PCF as a transferable physical attribute, it enables cradle-to-gate tracking and facilitates product-specific PCF minimization.

The framework is validated through a case study of a 10-million-ton-per-year refinery on China's east coast. Results show that polypropylene exhibits the highest PCF, followed by gasoline, while aviation kerosene has the lowest. By adjusting blending strategies—e.g., increasing low-PCF inputs like light naphtha and raffinate, and reducing high-PCF components such as etherified gasoline, alkylate, and MTBE—the PCF of gasoline can be reduced by 27.2%, equivalent to 0.23 tCO_2 per ton.

This study demonstrates a feasible approach to PCF mitigation through targeted planning, although broader reductions still depend on further low-carbon investments.

Paper ID: 461

Evaluation of enhanced Chitosan beads as an Effective Chelating Agent for the Removal of Ni^{2+} and Cd^{2+} Ions from Aqueous Solutions

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Abstract:

The material properties of chitosan were characterized through Fourier Transform Infrared Spectroscopy, Scanning Electron Microscopy, Thermogravimetric Analysis, X-ray Diffraction, and Brunauer-Emmett-Teller analyses. In the batch mode, various factors that influenced metal ion adsorption, including pH, contact time, initial ion concentration, temperature, stirring speed, and competing ions, were systematically evaluated. A comparative analysis of equilibrium and kinetic models revealed that the Langmuir model accurately described the adsorption process, while the Freundlich model did not fit the data as effectively. The pseudo-second-order model best described the kinetics of the adsorption process. Multiple adsorption and desorption cycles were conducted to evaluate the reusability of the chitosan material, demonstrating its potential for practical applications in removing heavy metal ions from contaminated water sources.

Paper ID: 462

Upcycling of End-of-Life Solar Panel Waste into Self-cleaning and Anti-Fouling Applications

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Abstract:

Two decades after the rapid expansion of photovoltaics, a considerable number of solar panels have already reached their end-of-life (EoL), posing a global challenge for safe disposal and sustainable waste management. Herein, we have adopted a ‘waste-to-wealth’ strategy to upcycle the EoL solar panels and designed self-cleaning and anti-fouling coatings from recovered material converted into oxide-based particles (e.g., alumina). These oxides and their functionalized forms were characterized by structural, morphological, and thermal properties using X-ray diffraction, Fourier-transform infrared spectroscopy, scanning electron microscopy, and thermogravimetric analysis. Finally, the modified particles were incorporated into a polymeric matrix to form coating compositions and applied to glass substrates. The resultant coatings exhibited excellent water-driven self-cleaning action and robust anti-fouling properties against various aqueous solutions. Furthermore, the coatings demonstrated strong adhesion and functionality across a wide range of substrates such as wood, stone, plastic, metal surfaces, cotton fabric, and paper. Therefore, the current study highlights a sustainable and scalable approach for repurposing electronic waste, viz., EoL solar panels, transforming into high-value materials for advanced applications, thereby contributing to circular economy principles and effective e-waste mitigation.

Paper ID: 463

Ultrasound-assisted extraction of brominated flame retardants from WEEE Plastics: Efficiency and environmental impact

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Abstract:

Waste Electrical and Electronic Equipment (WEEE) plastics often contain brominated flame retardants (BFRs) to meet flammability safety standards. Due to environmental and health concerns, certain BFRs are now restricted under the European Regulation on Persistent Organic Pollutants (POP Regulation 2019/1021). Thus, efficient methods for extracting BFRs are essential for regulatory compliance and sustainable recycling of this waste stream.

This study evaluates ultrasound-assisted extraction (UAE) as an effective and environmentally friendly approach for removing BFRs from WEEE plastics. A factorial experimental design demonstrated that diethyl ether is the most effective solvent for extracting brominated compounds from brominated acrylonitrile butadiene styrene (ABS) derived from WEEE. The results indicate that using a solvent volume that is at least ten times the sample mass is adequate, as increasing the solvent amount does not significantly enhance extraction efficiency. X-ray fluorescence (XRF) analysis revealed that diethyl ether removed up to 87.0% of bromine, while ethanol achieved a maximum of 61.9%. Gas chromatography-mass spectrometry (GC-MS) confirmed that diethyl ether extracted 99% of polybrominated diphenyl ethers (PBDEs), ensuring compliance with POP regulations. Thermogravimetric analysis (TGA) further validated these findings. Additionally, the UAE-treated plastics remained non-agglomerated, making them suitable for mechanical recycling.

Life Cycle Assessment (LCA) analysis suggests that while UAE reduces abiotic resource consumption, acidification, eutrophication, and ozone depletion, incineration is the more viable environmental solution overall. Incineration performs better regarding marine and terrestrial ecotoxicity, oxidation, and ozone depletion. In contrast, recycling methods combined with UAE have a lower impact on human toxicity, freshwater ecotoxicity, and greenhouse gas emissions. To make recycling a more environmentally competitive alternative, further process optimizations are needed to reduce primary resource consumption and enhance efficiency.

These findings highlight UAE with diethyl ether as an efficient and regulation-compliant method for BFR removal, presenting opportunities for optimization and scalability in future recycling strategies.

Paper ID: 464

Rhodamine-B (RHB) adsorption by modified chitosan beads in a synthetic wastewater. A comparative study of RSM, ANN and ANFIS techniques for predictive modeling

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Abstract:

A technique was developed to assess RHB adsorption from wastewater. In this regard, the properties of the applied material was examined using FTIR, XRD, SEM, and TGA. Several factors were considered during the adsorption studies, such as pH, concentration, contact time, and adsorbent dose. These factors were employed as input data for the study, while the output data focused on the removal efficiency of RHB. RHB adsorption was subjected to response surface methodology/central composite design (RSM-CCD), artificial neural network (ANN), and adaptive neuron-fuzzy inference system (ANFIS) models for prediction and optimization. Furthermore, the significance of these models was assessed using statistical metrics like root means square errors (RMSE), Pearson's Chi-square ($\chi 2$), mean squared error (MSE), average relative errors (ARE), coefficient of determination (R2), Marquart's percentage standard deviation (MPSD), and the sum of squares of errors (SSE). In order to create the ANN and ANFIS models, 70% of the data utilized in the data simulation was used for training, and 15% was used for validation and testing, respectively. Based on the RSM-CCD findings, the optimization results for the process variables were achieved at, pH of 7, contact time of 55 minutes, 6.0 grams of adsorbent, and RHB concentration of 125 mg/L. However, an ideally trained neural network is described using training, testing, and validation phases, and the R2 values at these phases were found to be 0.99987, 1, and 1 respectively. Based on the statistical findings, it was clear that the ANFIS technique outperforms the RSM and ANN model approach.

Paper ID: 465

Photo-electrochemical osmotic system enables simultaneous metal recovery and electricity generation from wastewater

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Abstract:

Global depletion of natural resources provides an impetus for developing low-cost, environmentally benign technologies for the recovery of valuable resources from wastewater. In this study, we present an autonomous photo-electrochemical osmotic system (PECOS) that can recover a wide range of metals from simulated metal-laden wastewater with sunlight illumination while generating electricity. The PECOS comprises a draw solution chamber with a nickel nanoparticle-functionalized titanium nanowire (Ni-TiNA) photoanode, a feed solution chamber containing synthetic wastewater with an immersed carbon fiber cathode, and a forward osmosis (FO) membrane mounted between the chambers as a separator. Using a Na2-EDTA anolyte as a draw solution at neutral pH, we demonstrate that a sunlit PECOS achieves copper recovery at a rate of 51 g h–1 per m–2 of membrane area from simulated copper-laden wastewater while simultaneously producing a maximum power density of 228 mW m–2. Moreover, because of the osmotic pressure difference generated by the photo-electrochemical reactions, the PECOS reduces the wastewater volume by extracting fresh water through the FO membrane at a water flux of 0.84 L m–2 h–1. We further demonstrate the feasibility of the PECOS in recovering diverse metals from a simulated metal-laden industrial wastewater under sunlight irradiation. Our proof-of-concept PECOS prototype provides a sustainable technological solution that leverages sunlight in an electrochemical osmotic system to recover multiple resources from wastewater.

Paper ID: 466

Next-generation data infrastructure for life cycle assessment

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Abstract:

The increasing complexity and scale of Life Cycle Assessment (LCA) studies expose critical limitations in current XML-based data standards. While formats like ILCD offer comprehensive schemas, their rigid hierarchical structures and verbosity significantly impede efficient data processing, integration, and scalability—especially for large-scale, multi-source environmental datasets. In this study, we propose a JSON Schema-based architecture that addresses these challenges through three key innovations: (1) a lightweight, semantically interoperable data structure validated by formal JSON Schema rules, (2) direct compatibility with document-oriented databases through native JSON storage, and inherent support for representing LCA process networks as graph structures, and (3) demonstrated lossless compatibility with ILCD through bidirectional mapping protocols that preserve semantic content and metadata relationships. Empirical validation with real-world LCA datasets demonstrates substantial improvements in data processing speed, structural integrity, and ease of interoperability. The open-source toolkit built on this architecture provides a practical migration path for existing LCA systems, while its standardized, modular design facilitates distributed data integration and rapid scenario analysis. By modernizing the foundational data infrastructure, this approach supports more transparent, scalable, and timely environmental assessments—empowering data-driven decision-making for resource sustainability and climate action.

Paper ID: 467

Analysis of the Effects of Biochar on the Carbon Sequestration Capacity of Cement Composites

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Abstract:

In recent years, various studies have shown that biochar (BC) can enhance the carbon sequestration capacity of cement composites, offering a promising strategy for reducing carbon emissions in the construction industry. This review investigates the BC influence on the carbon sequestration capacity of cement composites from a microstructural perspective. First, the effects of biomass type, pyrolysis conditions, and activation methods on the physicochemical properties of BC are discussed. Then, the effects of various types of BC on the hydration and carbonation reactions of cement matrices were summarized using Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD). The results indicate that the microstructure of BC promotes the formation of calcium-silicate-hydrate (C-S-H) and calcium carbonate ($CaCO_3$). In addition, the mechanisms of carbon sequestration in biochar-cement composites (BCC) are analyzed. Both physical and chemical methods can significantly modify the microstructure of BC, thereby enhancing the carbon dioxide (CO_2) adsorption capacity of BC. With increasing CO_2 concentration, both the hydration and carbonation processes in cement composites are further enhanced. BCC sequestrates CO_2 through both physical adsorption and chemical carbonation. Finally, the carbon sequestration benefits of BCC are quantitatively summarized. This review systematically analyses the influence of the physicochemical properties of BC on low-carbon cementitious composites, demonstrating that BC with different properties exhibits significant variations in carbon sequestration capacity of cement composites. Therefore, optimizing the physicochemical properties of BC represents an effective strategy for reducing the carbon emissions of cement composites in the future.

Paper ID: 468

Rural household dietary characteristics in agricultural, pastoral, and agropastoral transition zones of the Qinghai Plateau, China

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Abstract:

While urbanization and modernization have boosted logistics and resource exchange between the Qinghai-Tibet Plateau and inland China, they have impacted residents' daily food consumption habits. Qinghai Province, in the plateau’s agropastoral ecotone, shows striking transitional dietary differences among populations. Identifying and understanding variations in food consumption structures and characteristics is fundamental to promoting healthy diets and nutritional balance among residents. Based on primary data from household food consumption surveys conducted in agricultural zones and pastoral zones of Qinghai in 2019, and agropastoral transition zones in 2024, this study compares and analyzes dietary characteristic differences across these zones. Key findings include: 1) Annual per capita total food consumption was highest in pastoral zones (544.8 kg), followed by agropastoral transition zones (498.7 kg) and agricultural zones (439.9 kg). 2) Agropastoral transition zones showed distinct transitional traits, with plant-based (79.9%) and animal-based (20.1%) food consumption proportions falling between those of agricultural and pastoral zones. 3) The dietary structure in agropastoral transition zones was most balanced: the variance in the proportion of per capita consumption of various food categories relative to the total across the three regions was smallest, while the mean value was largest. 4) Agropastoral transition zones had the lowest food self-sufficiency rate (6.1%), compared to agricultural zones (39.9%) and pastoral zones (9.8%). The foods with the highest self-sufficiency rates in each zone were cornmeal (96.7%) in agricultural zones, beef (66.2%) in pastoral zones, and edible oil (24.5%) in agropastoral transition zones. 5) Residents exhibited unhealthy dietary-nutritional structures, particularly excessive fat intake. Fat consumption in agropastoral transition zones reached 142.74 g per capita, far exceeding the recommended values in Chinese Food Guide Pagoda. These comparative insights provide a scientific basis for improving food consumption patterns and enhancing dietary nutrition in the Qinghai-Tibet Plateau region.

Paper ID: 469

Assessing the quality of recycled Low-Density Polyethylene (LDPE) pellets: Influence of source segregation on material properties and applications

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Abstract:

In India, flexible packaging plastic waste (FPPW) comprising low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC) contributes significantly to plastic waste. Among these, LDPE is least recycled due to lightweight and its contamination. While LDPE recycling challenges are known, limited studies focus on its characteristics and how these impact recycling. This study evaluates how source segregation of plastic waste influences thermal, mechanical, and morphological properties of recycled LDPE pellets produced through mechanical recycling. Approximately 10 kg of FPPW was sampled using coning and quartering from two Material Recovery Facilities (MRFs) and one Plastic Recycling Facility (R) in the Mumbai Metropolitan Region, Maharashtra, India. Three waste streams included mixed household and industrial plastic waste (R1), source-separated dry household waste (MRF1), and plastic waste from mixed municipal solid waste (MRF2). Waste was manually sorted into food/non-food type, polymer type, and color using Resin Identification Codes or application-based. During sorting, non-food LDPE was found to be highest fraction and was selected for further processing. Pre-processing included shredding, washing, and oven-drying. Pre-processed plastics were ground into 2.5 mm flakes. Plastic recovery was determined by comparing initial and final weights of plastic after pre-processing. Flakes were extruded, pelletized, and injection molded. Recycled pellet quality was assessed using thermal analysis (DSC, TGA), oxidative degradation (carbonyl index via FTIR-ATR), surface morphology (SEM), and mechanical properties (tensile and flexural tests). Source-segregated LDPE (R1 and MRF1) showed higher plastic recovery (R1: 99%, MRF1: 91%), and resulting pellets exhibited greater elongation at break (R1: 100 mm, MRF1: 72 mm), lower carbonyl index (R1: absent, MRF1: 0.08), higher thermal stability (R1: 414 °C, MRF1: 419 °C), and reduced surface degradation in SEM images compared to pellets made from MRF2 LDPE waste. Results showed that source-segregation enhanced plastic recovery and pellet quality, improving suitability for packaging and agricultural film use.

Paper ID: 470

The emission reduction potential of "replacing plastic with bamboo" for takeout tableware in China

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Abstract:

In recent years, the frequent use of plastic in takeout tableware has generated a significant amount of carbon emissions, making it an important scenario for replacing plastic with bamboo. However, the potential for emission reduction throughout the lifecycle of using bamboo instead of plastic is still unknown. Additionally, the carbon sequestration capability of bamboo resources has not been fully considered during lifecycle analysis. It is still unclear whether China's bamboo resources are sufficient to replace plastic with bamboo for takeout tableware. Therefore, this study, based on factory survey data and considering the carbon sequestration function of bamboo, evaluates and compares the lifecycle carbon emissions of takeout tableware made from bamboo, plastic, and PLA. A material flow analysis was also conducted to explore the stock and flow of bamboo resources in China. The results of the study indicate that: (1) the average carbon footprint of bamboo tableware is about 1/14 that of plastic tableware, and increasing the proportion of bamboo material is the most effective measure for carbon emission reduction; (2) the transportation phase is the largest contributor to lifecycle carbon emissions of bamboo tableware, so the bamboo-to-plastic policy should fully consider transportation distances; (3) further development of idle bamboo resources is necessary to meet the demand for bamboo takeout tableware domestically and internationally. Based on these conclusions, the study proposes policy recommendations, such as encouraging technological upgrades in the pre-processing and molding stages to expand the emission reduction potential of bamboo tableware; selecting regions rich in bamboo resources for policy pilots to reduce transportation costs and carbon emissions; increasing the transfer of bamboo forests and reducing the abandonment of bamboo forests, to help promote the bamboo-to-plastic transition and achieve China's dual carbon goals.

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Policy acceptance drives Chinese consumers' support for the Plastic Straws Ban

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Abstract:

The escalating issue of plastic pollution has become a widely recognized global consensus. In 2020, China implemented a new plastic ban (The Ban). This ban mandated the replacement of single-use plastic straws in the catering industry with eco-friendly alternatives to promote sustainable consumption. However, existing research has not sufficiently explored the factors influencing consumer support for The Ban, nor has it provided comparative analyses of the relative importance of these factors. Moreover, the complex, non-linear processes involved in consumer decision-making remain underexamined. Therefore, this study uses a decision tree model to analyze the intentions and influencing factors of 1,984 consumers in Zhejiang Province regarding their support for The Ban and their willingness to report violations. The results indicate that (1) User Experience (UE), Consumer Subjectivity (CS), Policy Awareness (PAW), Policy Acceptance (PAC), Consumption Intention (CI), and individual demographic factors such as Age, Education level (Education), and City of residence (City) all influence consumer acceptance of The Ban. (2) Policy Acceptance has emerged as the most significant factor influencing whether consumers accept The Ban. Unexpectedly, despite public complaints about the poor experience associated with eco-friendly straws, User Experience was not as important as previously anticipated. (3) Individuals aged between 18 and 40 were more likely to support The Ban. Contrary to existing studies, consumers from the six cities in Zhejiang Province with higher per capita GDP, as well as those with higher education levels, were more inclined to refrain from reporting violations of The Ban. The results have important practical implications and suggest that it would be important to consider the important factors for designing sustainable consumption policies for eco-friendly straws.

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How does industrial transformation affect carbon emissions?

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Abstract:

Industrial transformation is one of major contributors of carbon emissions. Previous studies have examined this challenge at multiple dimensions and scales. However, there is a lack of systematic studies on the influences of land use during industrial transformation on carbon dioxide emission under socioeconomic system. Therefore, this paper aims to fill in this gap. We constructed socioeconomic panel data from 2000 to 2020 for 30 prefecture-level cities in the urban agglomeration of the middle reaches of the Yangtze River in China. Consequently, the impacts of industrial transformation on carbon emissions were analyzed from two dimensions, i.e. industrial structure optimization and industrial spatial layout. This study reveals that: (1) Industrial rationalization in the dimension of industrial structure optimization reduces carbon emissions, while industrial upgrading increases carbon emissions. Specialized industrial agglomeration in the industrial spatial layout dimension reduces carbon emissions, while industrial diversified agglomeration increases carbon emissions. (2) The emission reduction effect of industrial transformation is heterogeneous in both space and time. (3) At different levels of economic development, industrial transformation has different threshold effects on carbon emissions. This study provides a theoretical framework to analyze the impacts of industrial transformation on carbon emissions that allows the examination of inherent logical relationship between carbon emissions and industrial transformation. This framework also enables the exploration of the dynamic process of the carbon reduction effect of industrial transformation at different stages of economic development. These findings provide useful references for industrial transformation towards a low carbon future.

Paper ID: 473

Unveiling the virtual water use of China's rural residents through regional trade network

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Abstract:

Water security has emerged as a pivotal concern for sustainable development in China and globally. While the significance of China's rural residents for water consumption is well-recognized, the impact of their final demand on water use cross-regional and cross-sectoral networks (known as virtual water) remains largely overlooked. This study analyzes virtual water use associated with rural residents in 313 China's regions in the year 2012, 2015, 2017, and 2020, using an environmentally extended multiregional input-output model. The analysis reveals significant spatial and temporal variations in water use; the eastern and developed regions consume more water, while the western and less developed regions consume less. Notably, we find that most of the virtual water driven by rural residents flows to neighboring and more developed regions, primarily driven by demand from the agriculture and food industries. Additionally, hotspot regions and sectors are identified, and policy recommendations are provided to promote sustainable water resource management at the level of sectors and regions.

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Utilization of waste glass as partial replacement for fine aggregates in concrete pavement blocks

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Abstract:

This study explores the use of post-consumer soda-lime glass as a partial replacement for fine aggregates in concrete pavement blocks. Driven by environmental concerns over excessive sand extraction and low glass recycling rates, the research investigates a sustainable alternative for concrete production. Waste glass cullet—clear, green, brown, and mixed-color—replaced 20% by weight of natural fine aggregates in concrete mixes designed for light-traffic applications. Specimens were tested for absorption, compressive strength, and abrasion index following ASTM C902 standards. All glass-modified mixes satisfied the minimum performance requirements: absorption remained below 14%, compressive strength exceeded 20.7 MPa, and abrasion index stayed under 0.11. Moreover, all mixes incorporating waste glass exhibited slightly lower water absorption than the control mix without glass. Clear and green glass variations showed slightly better strength and abrasion resistance than the control specimens. The results suggest that glass color related to chemical composition influences performance outcomes of pavement blocks as confirmed by one-way ANOVA. This research concludes that soda-lime waste glass is a feasible alternative for partial fine aggregate replacement in concrete pavement blocks, thus, offers a means to reduce reliance on natural sand, promotes sustainable material use within the pavement block industry, and inform future research and policy development on glass recycling and green infrastructure.

Paper ID: 481

Research on information gain of keyhole satellite imagery

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Abstract:

Keyhole reconnaissance satellite series launched in the 1960s are the only satellite image source for tracking long-term historical land use changes. Unfortunately, the edge noise patches, image overlap, and grayscale more limit the extraction of the detailed land use information. In this study, we developed a new framework for Keyhole image reconstruction, including: removal of edge noise patches by using a pixel feature detection technique, seamless multi-image stitching based on scale-invariant feature transform with a multiband blending algorithm, and image super-resolution and colorization using a generative adversarial network. We applied this framework to the city of Zhengzhou, China in the 1960s, 1970s, and 1980s, and built the land use maps in the three periods with overall accuracies ranging from 85.2 to 90.4%. A similarly accuracy land use mapping based on the Jilin-1 satellite image also showed the reliability of the data reconstruction framework proposed in this study. Additionally, through the cross-spectral feature mapping capability of CU-Net, the NIR band was successfully extended and generated. The correlation coefficient between the generated image and the real NIR data reached 0.62, and the spatial consistency between the NDVI index calculated based on the generated NIR and the reference data reached $R^2=0.85$, verifying the physical rationality and application value of spectral reconstruction. The reconstruction stage significantly improved the multi-dimensional information expression capability of KH images, laying a solid data foundation for historically monitoring of surface dynamics.

Paper ID: 490

Experimental and numerical study of the hygrothermal behavior of earthen wall.

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Abstract:

The building sector is among the most energy intensive. It is also among the most polluting in terms of CO_2 and greenhouse gas emissions [1]. Considering this, there has been a great deal of thought put into developing energy-efficient, economical, and sustainable buildings. A relevant alternative already exists. It involves incorporating natural materials such as raw earth, plant fibres, and so on. Research in this field has shown that the use of these materials in the building envelope provides an effective response to this problem [2] and improves occupant comfort. In fact, these studies have shown that these materials can naturally control the temperature inside a building. These materials also offer significant energy and environmental benefits in terms of their composition, manufacturing, processing, and recyclability. However, we need to make better use of these natural materials. It is essential to deepen our knowledge in this field. This is the background to our contribution which concerns the study of hygrothermal transfer phenomena developing within a hygroscopic wall. We have developed a numerical model that simulates the interaction between heat and moisture transfer, considering the actual physical conditions of indoor and outdoor environments. We applied the model to a wall made of raw earth, a material renowned for its hygrothermal properties. The results obtained from the numerical model were compared with those of experimental tests carried out as part of previous work [2]. This comparison revealed good agreement, both qualitatively and quantitatively, confirming the relevance and reliability of the proposed model.