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OPINION

Climate change mitigation and Sustainable Development Goals: Evidence and research gaps

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Never in the past three decades have the interlinkages between sustainable development and climate change been more pressing. The projected date when the remaining carbon budget will be exhausted if continuing at the current rate of emissions [1] is estimated to be around 2030- which also coincides with the timeline for achieving the Sustainable Development Goals (SDGs). Recent global assessments clearly show the collective global performance on the targets relating to climate change, biodiversity and SDGs is abysmally poor [2, 3]. Urgent efforts are needed to achieve both deep and rapid emissions reductions and to meet the SDGs to set the world on a pathway towards sustainable development.

The appreciation of interconnections between climate change and equity and sustainable development is not recent. In 1992, Working Group III of the Intergovernmental Panel on Climate Change (IPCC) was restructured with a mandate to assess cross-cutting economic and other issues related to climate change including placing socio-economic perspectives in the context of sustainable development. IPCC's Second Assessment Report in 1995 explicitly highlighted the different starting points of countries, trade-offs between economic growth and sustainability, distributional impacts of mitigation and adaptation actions and issues of inter-temporal equity. This understanding has further deepened since then. Successive IPCC reports have highlighted the implications of efforts aimed at achieving targets under Climate Action (SDG 13) on SDGs [2, 4, 5]. There is now more evidence to show synergies of several climate actions with SDGs outweigh the trade-offs [6] Such actions include active transport, passive building design, clean energy, circular economy and urban green and blue infrastructure (Fig 1) [7].

A quick literature search on Scopus for papers focusing on climate change mitigation and SDGs showed 433 papers (Scopus search using search strings for each individual SDGs, for example: (TITLE-ABS-KEY ("SDG 1" OR "SDG1") AND TITLE-ABS-KEY ("Climate") AND TITLE-ABS-KEY ("mitigation" OR "mitigate"))). SDG 7 (Affordable and clean energy), SDG 2 (Zero Hunger) and 15 (Life on Land) were the most studied while SDGs 4 (Quality Education), 5 (Gender Equality), 10 (Reduced inequality) and 16 (Peace, Justice and strong institutions) received less attention.

Despite numerous studies, there's limited evidence of the SDGs being perceived as a valuable tool for making decisions regarding climate action. Firstly, many of the existing studies highlight the potential of mitigation actions supporting SDG achievement through theoretical or modelled methods with few empirical studies demonstrating ex-post evaluation of specific interventions. In particular, there is limited literature on trade-offs and understanding of

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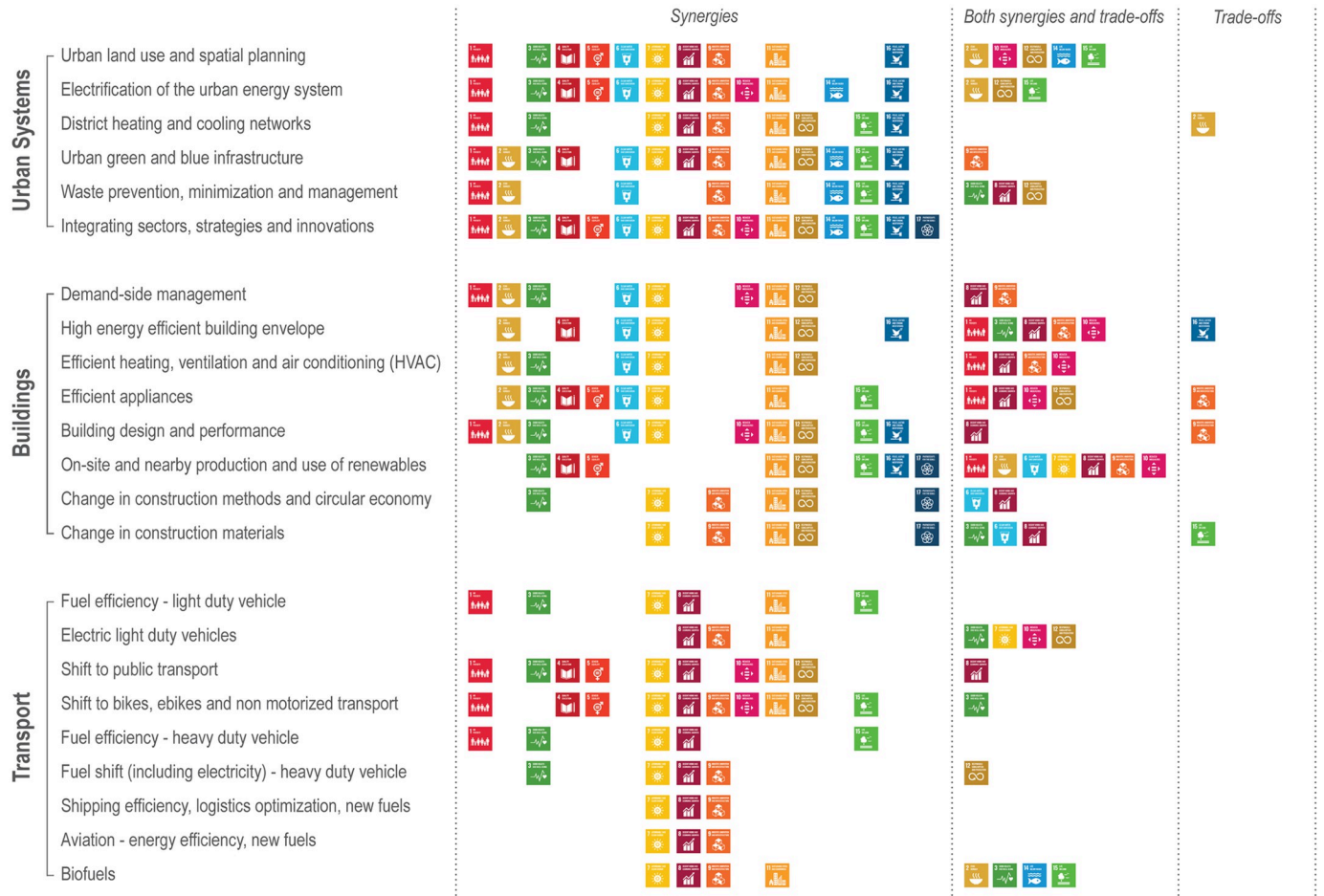
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Sustainable Development Goals (SDGs) List



Fig 1. Synergies and trade-offs between sectoral and system mitigation options and the SDGs adopted from [5].

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distributional effects for specific groups [8]. Secondly, a study on mapping SDG interactions of mitigation actions would not necessarily reveal the full picture. For example, urban public transport could show potential synergies with multiple SDGs however, it wouldn't necessarily provide evidence on whether benefits could accrue to the most vulnerable groups. Similarly, a new urban transit system could have potential synergies with SDGs 3, 6, 9 and 11, however, this would fail to capture the near-term trade-offs e.g. relocation or costs or emissions.

It becomes more challenging when a particular action can result in mixed impacts, presenting both synergies and trade-offs across indicators within the same SDG. For example, while renewable energy can create green employment opportunities (synergy SDG 8 Target 8.5), it remains uncertain whether these jobs will ensure a safe and secure working environment for all workers throughout the supply chain (trade-off SDG 8, target 8.8). Mitigation options often

work across sectors and systems and such interactions are not yet fully dealt with in existing studies.

Additionally, there are gaps in studies and available data for various crucial indicators worldwide, [6] which complicates the comprehensive assessment of comparing these key indicators across different countries, projects or entities. For instance, the Sustainable Development Report 2023 (Includes time-series data for 122 SDG indicators (out of 169 indicators) for 193 UN member states.) which measures progress across indicators for UN member states compiles data for 3 indicators to construct the index for SDG 13—all of which are related to emissions. Adaptation-related indicators are missing. Finally, studies do not cover temporal and spatial dimensions or the status of these interactions for alternate warming scenarios.

What does this mean for the scientific community?

Addressing the gaps identified presents an opportunity to enhance our understanding of progress towards SDGs and reduce missed opportunities [9, 10]. Action that takes into account co-impacts can increase efficiency, reduce costs and support early and ambitious climate action, particularly in developing countries where there are simultaneous development priorities [11].

A business-as-usual approach to understanding mitigation SDG interactions has made progress but this is not enough. Data, indicators and methodologies, resources, the huge scope of SDGs, limitations of capturing non-measurable development dimensions and capacity constraints remain major challenges for in-depth research in this area [12, 13]. New research therefore must focus on the SDGs and targets that have received limited attention and find ways to generate and report data ensuring access and transparency. Where specific data is not available, alternative approaches are needed for e.g. establishing reliable assumptions for utilizing proxy data through expert engagement. Developing indices specific to each goal and setting up reporting guidelines is essential for comparing progress. Failure to report the complete set of indicators limits comparability across goals and targets, and risks missing key priority areas.

Future research needs to focus on comprehensive assessments. For example, demonstrating how, where and to what speed and scale the implementation of a particular intervention resulted in synergies or trade-offs and whether these impacts are sustained. Similarly, going beyond acknowledging trade-offs towards a deeper understanding of what the trade-offs are, for which groups and whether and how these were resolved particularly in relation to questions around power and politics. In-depth studies require both time and resources. Funding needs to be directed to interdisciplinary research as well as building capacity of researchers to undertake such assessments. Quantitative studies involving new tools or modeling exercises, if complemented by qualitative approaches, can deliver more useful insights on synergies and trade-offs, particularly in situations where data is limited. Research institutions and universities can contribute by creating standardized templates and guidelines, as well as consistently reporting data using these templates.

Climate change mitigation research relies significantly on Integrated Assessment Models (IAMs) to provide a comprehensive perspective on the interactions between socio-economic systems and earth systems. Existing models do not fully capture all development dimensions [14] or climate change adaptation though efforts are underway. Future research can focus on developing SD/G-compatible scenario storylines that prioritize development. More work is needed on variables and assumptions to better incorporate equity and justice issues [15] Modeling teams need to work closely with experts on various aspects of adaptation and sustainable development, including poverty, urbanisation, human well-being and biodiversity.

In conclusion, research frameworks and practices to assess mitigation SDG interactions are inadequate in their present form. Given the urgency, researchers and funders need to move away from business-as-usual approaches towards more in-depth assessments that significantly advance knowledge.

Author Contributions

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Methodology: Minal Pathak, Shreya Some.

Resources: Shreya Some.

Visualization: Shaurya Patel.

Writing – original draft: Minal Pathak, Shreya Some.

Writing – review & editing: Minal Pathak, Shaurya Patel, Shreya Some.

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