Supplementary Information

Promoting Sustainable Development Worldwide in the Metacoupled Anthropocene

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Supplementary Table 1. Six interrelated steps for implementing the metacoupling framework and examples of potential tools and inputs.

Steps	Brief description	Tools	Inputs
1	*Setting the SDG research goals*	✓ Metacoupling framework: Identify knowledge gaps ✓ Stakeholder Analysis Matrices: Identify key actors at local, regional, and global levels who affect or are affected by the SDGs. ✓ Problem Framing Tools (e.g., DPSIR): To structure the Drivers, Pressures, States, Impacts, and Responses related to the SDGs across scales. ✓ Multi-criteria Decision Analysis (MCDA): To prioritize which SDG interactions and metacouplings are most critical to study.	✓ Sustainable Development Reports (https://www.unsdsn.org/) ✓ Voluntary National Reviews (https://sustainabledevelopment.un.org/vnrs/) ✓ Existing sustainability research (e.g., *Nature* Collection on Progress towards the Sustainable Development Goals, https://www.nature.com/collections/bhfffjiadc) ✓ National and regional development plans and international cooperation agreements (e.g., Paris agreement, Kunming-Montreal global biodiversity framework) ✓ Data from surveys or initial consultations with communities, governments, and businesses ✓ Literature from Web of Science and Google Scholar ✓ Expert knowledge and stakeholder engagement
2	*Defining metacoupling systems*	✓ Telecoupling toolbox (https://telecouplingtoolbox.org/), which is developed to map and identify systems, flows, agents, causes, and effects in telecoupling research ✓ Other geospatial software tools (e.g., Geographic Information Systems to map and visually define the spatial boundaries of the focal, adjacent, and distant systems ✓ Network analysis techniques and visualization tools	✓ Geospatial administrative boundaries datasets, such as: Natural earth data, https://www.naturalearthdata.com/ GADM maps and data, https://gadm.org/ ✓ Spatially explicit system boundaries datasets, such as: Protected and conserved areas, https://www.protectedplanet.net/en Urban areas, the Global Urban Boundary (GUB, https://data-starcloud.pcl.ac.cn/iearthdata/14) ✓ Expert knowledge and stakeholder engagement

3	*Quantifying cross-system flows*	✓ Statistical data-based approach ✓ Data mining and crowdsourcing approaches ✓ Remote sensing (e.g., nighttime light remote sensing for estimating human migration, use FRACE satellites to track water movement) ✓ Big data tools (e.g., geotagged text, photos) ✓ Modeling approaches (e.g., hydrological models, gravity model, species distribution models) ✓ Input-output analysis and life cycle assessment	✓ National and international trade databases, such as: UN Comtrade, https://comtrade.un.org/; FAOSTAT, https://www.fao.org/faostat/en/#home; ✓ Global Multi-Regional Input Output (MRIO) databases, such as: WIOD, https://www.rug.nl/ggdc/valuechain/wiod/?lang=en; EORA, https://worldmrio.com/ ✓ Migration and Tourism Statistics **(**e.g., UN Department of Economic and Social Affairs, World Tourism Organization) ✓ Financial Flow Data (e.g., Foreign Direct Investment (FDI) data, remittance data from the World Bank, aid data from OECD) ✓ Remote sensing derived big geospatial datasets ✓ Other datasets from diverse sources such as public surveys, internet of things, and statistics ✓ Expert knowledge and stakeholder engagement
4	*Analyzing SDG interactions linking effects of flows*	✓ Qualitative methods, such as: Expert judgment; Narrative modeling; Systematic literature review; ✓ Quantitative approaches, such as: Statistical correlation analysis Network analysis Agent-based models System dynamic models	✓ Quantified flows from Step 3 ✓ Time-series SDG indicators and data, such as: SDSN SDG Index and Dashboards, https://dashboards.sdgindex.org/chapters/part-2-the-sdg-index-and-dashboards/ The World Bank indicators, https://databank.worldbank.org/source/world-development-indicators ✓ Other contextual metrics (e.g., environmental footprints) ✓ Case study evidence ✓ Expert knowledge and stakeholder engagement

5	*Integrated SDG progress assessment and SDG pathways modeling*	✓ Index-based approaches ✓ SDG Index and Dashboards ✓ Big data-driven approaches ✓ Integrated assessment models ✓ Scenario-based approaches (e.g., SSP-RCP) ✓ Other developed tools (e.g., iSDG model) ✓ Machine learning forecasting algorithms and AI tools	✓ Time-series SDG indicators and data, for example, SDSN SDG Index and Dashboards, https://dashboards.sdgindex.org/chapters/part-2-the-sdg-index-and-dashboards/ ✓ SDG Big data, for example, Remote sensing-based SDG Big data, https://www.cbas.ac.cn/en/resources/ ✓ Socioeconomic and climate projections, such as: Shared Socioeconomic Pathways (SSP) Scenario Database, https://iiasa.ac.at/models-tools-data/ssp ✓ Expert knowledge and stakeholder engagement
6	*Stakeholder engagement and SDG policies and actions development*	✓ Stakeholder analysis matrices ✓ Diverse workshops (e.g., policy co-design workshops and Industry-Academia-Research workshops) ✓ Structured communication techniques (e.g., Delphi method to build consensus among experts and stakeholders) ✓ Integrated public consultation (e.g., through social media, web-based forms, online platforms, on-the-ground fieldwork)	✓ Existing laws, regulations, and governance structures at local, regional, national, and international levels ✓ Communication materials (e.g., synthesized reports, data visualizations, and policy briefs from the previous steps, tailored for different stakeholders) ✓ Feedback from local communities (e.g., on-the-ground knowledge about the feasibility and cultural acceptability of proposed actions) ✓ Indigenous knowledge and practices ✓ Expert knowledge and stakeholder engagement