Comment

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Three foci at the science-policy interface for systemic Sustainable Development Goal acceleration

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The integrated and indivisible nature of the SDGs is facing implementation challenges due to the silo approaches. We present the three interconnected foci (SDG interactions, modeling, and tools) at the science-policy interface to address these challenges. Accounting for them will support accelerated SDG progress, operationalizing the integration and indivisibility principles.

The 2024 Summit of the Future aimed to accelerate efforts to meet existing international commitments. The 2030 Agenda for Sustainable Development is the pre-eminent international commitment to be achieved by 2030, comprising 17 Sustainable Development Goals (SDGs) with the underpinning principles of integration, indivisibility, and universality. However, these principles have yet to be prominent in SDG implementation. Since countries are not on track to achieve all SDGs[1], accelerating efforts is crucial in the time remaining to 2030 and for informing a post-2030 sustainable development agenda[2]. The SDGs' integrated nature challenges the traditional silo implementation approaches. Thus, we present the three interconnected foci (i.e., SDG interactions, modeling, and tools) to support accelerated SDG progress and operationalize integration and indivisibility principles.

SDG interactions

SDG interactions refer to the complex and dynamic relationships between SDGs. They can be unidirectional or bidirectional, and their strength in each direction might vary. Actions and policies to pursue one goal can have synergies or trade-offs for achieving the others (Box 1)[3]. Thus, accounting for SDG interactions and aiming to strengthen synergies and mitigate trade-offs in policymaking is crucial. Doing so can guide toward more systemic, coherent, and effective SDG implementation. Accelerating sustainable development efforts requires shifting focus from achieving specific SDGs in the short term to a more holistic system-wide approach. Current studies identify more synergies than trade-offs among SDGs, which are dynamic and context-specific[4]. While trade-offs may be fewer, they are important considerations from a policy perspective (Box 1), e.g., based on just transition approaches.

SDG interactions are currently well understood at global and national scales but not at subnational scales due to limited data and research. Knowledge of their temporal and spatial dynamics is also restricted. Further, leaving no one behind requires a better understanding of SDG interactions for underrepresented groups. Current SDG interaction studies often rely on anecdotal evidence, statistical analysis, or models. Thus, understanding the mechanisms behind underlying SDG interactions is crucial to identifying levers for accelerating systemic changes and SDG progress. Knowledge of interactions is unevenly distributed across SDGs due to limited data and coherent methodology (Box 1). The consistent SDG data protocols and methods can address this issue[5]. Another gap is understanding the interaction between SDGs and other intergovernmental frameworks (e.g., the Paris Agreement and the Global Biodiversity Framework). Coupling the 2030 Agenda with other intergovernmental processes can leverage co-benefits and minimize conflicts, accelerating progress toward a more sustainable future.

The current scientific insights of SDG interactions are highly policy-relevant and sufficient to inform systemic prioritization of actions to accelerate SDG progress. However, a stronger focus on actionable guidance could strengthen their policy use. There is enough knowledge about changes needed to achieve SDGs but not how, particularly in different political and social contexts. A way forward is to bring together different research communities working on specific subfields and to combine quantitative and qualitative approaches[6] for identifying interventions for decision-makers. A deeper integration of various approaches is needed to better represent different dynamics.

Providing sound recommendations requires contextualized SDG interaction analyses, accounting for their spatial and temporal characteristics, including opportunities for policy interventions, sound governance, and stakeholders' actions. Policymakers' priorities are

BOX 1

Examples of interactions between Sustainable Development Goals (SDGs) and gaps

SDG interactions depend on actions and policies: Achieving climate action (SDG13) through large-scale land-based mitigation can negatively impact food security (SDG 2), water (SDG 6), or biodiversity (SDGs 14 and 15). However, reducing energy demand and enhancing sustainable agricultural practices can also ensure food security with positive impacts on water, soil, land, and biodiversity. SDG interactions can also be indirect or occur through complex feedback chains.

Importance of addressing SDG trade-offs: Pursuing a fossil fuel-based development pathway negatively impacts environmental goals, which can accumulate and escalate over time. Instead, a shift towards renewable energy may result in short-term trade-offs, such as missed opportunities for economic growth through resource extraction or the loss of livelihoods of dependent communities. However, this pathway could also unlock investments, green economies, and employment opportunities over the longer term.

Uneven understanding of SDG interactions: There are considerable knowledge gaps concerning peace, political institutions, diversity, age-structure changes, and gender-related issues, whereas climate and health (e.g., COVID) have been given more attention. This gap also holds for the empirical understanding of SDG interactions at different spatial scales, including transboundary spillover effects.

BOX 2

Modeling methodologies for Sustainable Development Goals (SDGs) and their limitations

SDG modeling methodologies: A wide range of methods for modeling SDGs includes (complex adaptive) system dynamics, social simulations (agent-based models), network analysis, and economic input-output and computational general equilibrium models, each model type answering specific questions.

Underrepresented SDGs in models: Gender equality (SDG 5), Life below water (SDG 14), Peace, justice and strong institutions (SDG 16), and partnerships for the goals (SDG 17) are some critical SDGs underrepresented in the current models. Also, qualitative scenarios, governance, and social dimensions are lacking, and crucial factors, e.g., population dynamics and gender considerations, are overlooked, presenting a fragmented view.

Modeling dilemmas: There is also an inherent decision model practitioners need to make concerning whether (or not) to focus modeling exercises on a limited set (or nexus) of SDGs, which they represent in an integrated manner. Limiting the focus of models would risk missing the bigger picture of synergies and trade-offs across other SDGs. However, focusing on a specific set of SDGs could provide in-depth knowledge and better solution options. Thus, both methods are valuable and provide complementary insights. Depending on the study purpose, covering all SDGs and focusing on a limited set of SDGs are not mutually exclusive if the interlinkages between SDGs, including the study's boundaries and limitations, are well-communicated.

SDG model intercomparison: Making different SDG modeling comparable requires adequate community standards (e.g., data sovereignty, data and modeling protocols, structure, definitions, metadata, and informed consent) to facilitate data exchange across models and scales (i.e., global vs. local and top-down vs. bottom-up). Furthermore, next-generation models could combine existing quantitative and qualitative methods to model different sectors to develop a simple but detailed enough model to represent all SDGs.

shaped by the dynamics and urgency of their problems. Thus, policy-oriented SDG interaction assessments can improve the choice and design of policies to respond to these challenges. These assessments' findings and their practical interpretation and communication can inform policymakers and make them aware of incentives and barriers related to different policies. They can use this knowledge to embed SDG interactions in policies based on adequate interventions.

SDG modeling

SDG modeling involves mathematical, statistical, or computational approaches to analyze and project the impact of policies and actions related to SDGs[7]. For this, scenarios offer plausible future narratives and can present different pathways and outcomes. Scenarios are projected with quantitative models to study the effects of various measures, their timing and regionality, and associated synergies, trade-offs, and enabling conditions. The resultant quantitative pathways highlight that SDGs cannot be achieved by 2030 under business as usual, and additional policies and measures are needed[8]. The lessons from model-based pathways could support choosing better strategies and policies for accelerating SDG progress.

Many models have been developed to support SDG policymaking. These models range from sectoral to integrated assessment models (IAMs)[8], covering various methodologies (Box 2). While IAMs historically focused on climate change, they are increasingly investigating other relevant SDG aspects[9]. Doing so contributes to more holistic policy debates in the climate sphere and synergistic policy

interventions[10]. However, current scenario modeling needs to reflect the complexity of SDGs. Recent modeling studies at global[8] and national[11] scales have advanced by partially covering all 17 SDGs. Underrepresenting SDGs in models may also lead to biased outcomes (Box 2). Further, most IAMs provide highly aggregated results at a world-region scale, often lacking short-term actionable strategies for policymakers and specific actors at (sub)national scales. Also, normative considerations in scenario modeling fail to represent specific actors' divergent interests and viewpoints, offering limited actionable insights. Addressing these limitations, the Nature Futures Framework explains how different normative considerations might be systematized[12]. Moreover, scenario modeling also needs to link quantitative and qualitative methods, combining social science insights on the societal and political dynamics with quantitative modeling of techno-economic ones[11].

Filling the above-highlighted gaps requires models representing all SDGs and developing a broader range of scenarios. However, doing so will be technically challenging because of difficulties in quantifying some SDGs[13] and modeling dilemmas (Box 2). To resolve this, a way forward is a transdisciplinary collaboration with stakeholders and Indigenous communities and codeveloping inter-comparable Sustainable Development Pathways representing all SDGs (Box 2). Such pathways and quantitative results also provide narratives of societal transformation, which social sciences and other disciplines can analyze. Besides, these pathways must clearly explain the effort required to meet SDGs, including investment needs and implications of different financial schemes, emphasizing urgency and solution options.

The current scenario modeling provides sufficient (but only partial) knowledge of the actions required to accelerate SDG progress. More efforts are needed to effectively translate and communicate model results to policy-makers in a way that enables them to design effective interventions. Furthermore, co-producing models and scenarios that consider policymakers' needs would enhance the uptake of their results during policymaking.

SDG tools

SDG tools translate findings from SDG interactions and models into easily accessible information to support more integrated systemic policy-making for achieving SDGs. Different tools have been developed for targeted users, including SDG monitoring, SDG interaction analysis and visualization[14], and SDG assessment. Many sectoral tools can also be applied to specific SDGs. An overview of available SDG tools and their purposes would be valuable for users to choose suitable tools for their needs[15]. Currently, SDG tools are available to track SDG progress, raise educational awareness, inform policymakers on SDG interactions, and promote public communication. A limited set of tools are developed to guide integrated SDG planning and decision-making. Still, their function in providing pathways for SDG achievement needs to be improved.

A major challenge for existing SDG tools is timely reflecting state-of-the-art scientific knowledge through periodic updates. Also, SDG tools should interpret the results, including stakeholder-specific actions for making SDG progress. Co-desing and demand-driven tool development can address these gaps. New SDG tools are needed to address areas and target users yet to be covered. A 'suite' of tools would be most appropriate to effectively cater to all stakeholders' needs and purposes and reflect SDGs' complexity.

Understanding how SDG tools are used in practice, codeveloping them with the users, and incorporating citizen science and Indigenous knowledge can help address the abovementioned challenges. In terms of usability and accessibility, a way forward is to enrich the interpretability, reliability, and robustness of the results, ensure transparency and traceability of data, and enhance applicability to context and scale. Further, awareness of available SDG tools needs to be raised among the users. Tools should be actionable, collaborative, simple, inclusive, diverse, user-friendly, and transparent to be policy-relevant. However, all these aspects may not go together, and there needs to be a balance. Thus, a 'suite' of tools might be more effective when it consists of tailored tools to specific needs, providing insights into smaller, more manageable chunks of information.

Looking towards the future

Under current trends, many SDGs cannot be achieved by 2030. Therefore, a transformative systemic approach that accounts for SDG's underpinning principles is needed. Our three interconnected foci operationalize SDG's integration and indivisibility principles, supporting integrated decision-making. Future research should combine these three foci to enhance scientific methods and understanding and the communication and dissemination of science-based policy. Further, calls for system-based solutions and integrative policy-making and planning should be one key consideration for the post-2030 agenda on sustainable development[2], building on the advancements made since 2015. However, decision-making also depends on values, power, institutions, incumbency, and political economy. Thus, accelerating SDGs also requires comprehensive and integrative ways of thinking and more coherent policy frameworks across scales, engaging with new voices and diverse ways of knowing and fostering trust and cooperation.

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Author contributions

P.P., N.W., V.D., F.J.S, and K.H. conceived the study. P.P., N.W., V.D., T.B., H.C., and A. W. developed the workshop methodology. P.P. wrote the main commentary based on the inputs during the SDG workshop at the University of Groningen. P.P., N.W., V.D., G.M.A., C.A., G.A., F.A., F.A., T.B., T.G.B., F.B., M.C., H.C., F.C., M.C., M.N.D., J.H.P.D., S.D., E.G., L.J.M., K.H., Y.H., W.J., S.K., N.M.K., U.A.K., T.K., S.K., J.L., C.L., J.L., H.L.-C., G.P.-H., M.P., R.K.P., C.P., A.R., V.S., F.J.S., B.S., N.S., D.V., A.W., E.W., B.W., O.W., R.W., C.W., C.W., Q.X., J.Y., Z.Y., X.Z., and C.Z. edited and reviewed the commentary.

Competing interests

The authors declare no competing interests.

Additional information

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