Stockholm Environment Institute

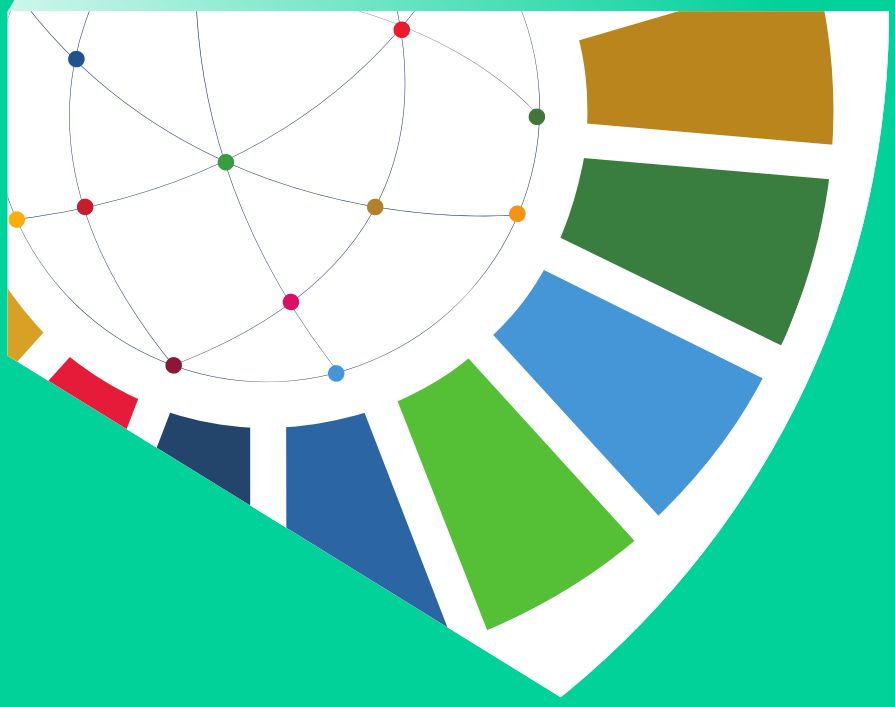
SDGs and the environment in the EU: A systems view to improve coherence

Report commissioned by the European Environment Agency

Report
October 2019

Nina Weitz[a]
Henrik Carlsen[a]
Kristian Skånberg[a]
Adis Dzebo[a]
Vincent Viaud[b]

[a] Stockholm Environment Institute
[b] European Environment Agency



Stockholm Environment Institute
Linnégatan 87D 115 23 Stockholm, Sweden
Tel: +46 8 30 80 44 www.sei.org

Author contact: Nina Weitz
nina.weitz@sei.org
Editing: Caspar Trimmer
Layout: Richard Clay

Stockholm Environment Institute is an international non-profit research and policy organization that tackles environment and development challenges.
We connect science and decision-making to develop solutions for a sustainable future for all.
Our approach is highly collaborative: stakeholder involvement is at the heart of our efforts to build capacity, strengthen institutions, and equip partners for the long term.
Our work spans climate, water, air, and land-use issues, and integrates evidence and perspectives on governance, the economy, gender and human health.
Across our eight centres in Europe, Asia, Africa and the Americas, we engage with policy processes, development action and business practice throughout the world.

Acknowledgements

This work was supported by the European Environment Agency under the Framework Contract “Provision of expert assistance on forward-looking analysis, sustainability assessments and systemic transitions” (EEA/IEA/16/003). The opinions expressed in the report are those of the authors only and do not necessarily represent the European Environment Agency’s official position.

This work benefited from the contributions of Owen White, Paula Orr and William Sheate (Collingwood Environmental Planning). The authors thank Lorenzo Benini, Nikolaj Bock, Luca Coscieme, André Jol, Lars Mortensen and Frank Wugt Larsen (EEA) for their comments and support during the preparation of this work, Aaron Atteridge and Aaron Maltais (SEI) for reviewing and providing helpful comments to earlier versions of this report, and Caspar Trimmer (SEI) for editing.

Contents

Executive summary **5**

1. Systems thinking for SDG implementation **8**

1.1 The added value of a systemic approach 8

1.2 Current research on SDG interactions 9

1.3 The SDG Synergies approach 10

2. Applying the SDG Synergies approach **12**

2.1 A proof of concept 12

2.2 Selecting the targets 12

2.3 Assessing the interactions 13

3. Selected findings **15**

3.1 Overview of SDG interactions in the EU 15

3.2 Which environmental targets have the greatest potential to foster progress on the broader 2030 Agenda in the EU? 16

3.3 What direct trade-offs and synergies with other SDGs could result from progress on environmental targets in the EU? 21

3.4 What are indirect effects, across the network of SDGs, of making progress on environmental targets in the EU? 25

4. Reflections **29**

4.1 Future research needs 30

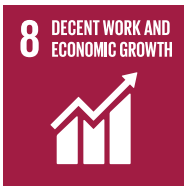
References **32**

Appendix **34**

Distribution of types of interaction 34

Promoting and restricting influence per goal or target 34

List of the Sustainable Development Goals and targets selected for analysis

SDG	Official description[1]
	End poverty in all its forms everywhere
	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
	Ensure healthy lives and promote well-being for all at all ages
	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
	Achieve gender equality and empower all women and girls
	Ensure availability and sustainable management of water and sanitation for all
	Ensure access to affordable, reliable, sustainable and modern energy for all
	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
	Reduce inequality within and among countries
	Make cities and human settlements inclusive, safe, resilient and sustainable
	By 2030, achieve the sustainable management and efficient use of natural resources
	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
	Integrate climate change measures into national policies, strategies and planning
	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
	By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

1 UN (2015).

Executive summary

The 2030 Agenda for Sustainable Development calls on governments and other actors to pursue 169 separate but interlinked targets, organized under 17 Sustainable Development Goals (SDGs). The United Nations has stressed that the 2030 Agenda should be viewed as an integrated, indivisible whole, and that all of the targets – be they of an economic, social or environmental nature – are equally important.

This poses both challenges and opportunities for successful implementation of the SDGs, which policy-making will need to take into account. In the real world, progress on one target can restrict or even undermine progress on another, and these trade-offs need to be mitigated, or at least anticipated. Conversely, progress towards one target can facilite, support or even automatically generate progress on others, and taking advantage of the synergies can accelerate progress and allow more cost-efficient implementation.

How the targets interact is highly dependent on contexts and circumstances. Because policy-making for the 2030 Agenda is by definition future-oriented, it is impossible to foresee with confidence how targets will interact as progress is made, and quantitative data is not available. Therefore, methods and approaches that enable policy-making (and other strategic decision-making) to account for the interactions based on the best available knowledge are badly needed, given the urgency of transformative change in line with the 2030 Agenda (UN 2018).

In 2018, researchers at Stockholm Environment Institute (SEI) together with the European Environment Agency (EEA) carried out a research project to identify and characterize critical interactions among the SDG targets that could be particularly relevant to environmental policy-makers in the EU. The project included the first regional-scale application of SDG Synergies, a practical analytical approach to better understand interactions and their potential policy implications in a given context. The analysis focused on three policy questions, and on interactions between eight targets from the "environmental" SDGs (12–15) and the other 13 goals:

- Which environmental targets have the greatest potential to foster progress on the broader 2030 Agenda in the EU?
- What direct trade-offs and synergies with other SDGs could result from progress on environmental targets in the EU?
- What are indirect effects, across the network of SDGs, of making progress on environmental targets in the EU?

The project was intended primarily as a proof of concept – of applying the SDG Synergies approach at a regional level, and of its potential usefulness for environmental policy-makers in the EU – rather than a definitive analysis with policy recommendations. Importantly, the initial assessment of how selected targets and goals would interact at the EU level was done by a small group of researchers based on expert judgement and brief literature review. As the rest of the analysis builds on this assessment, in past exercises intended to guide policy in the real world it has been done with stakeholder involvement or built on a more thorough scientific/expert analysis.

Nevertheless, some key findings related to the three policy questions are summarized below, in order to illustrate the kinds of insight SDG Synergies can offer to policy-makers with different tasks related to SDG implementation. Throughout the report, boxes further substantiate and illustrate the salience of the insights provided by this type of analysis.

Which environmental targets most promote progress on the whole 2030 Agenda?

The SDG Synergies approach makes it possible to rank targets based on their "synergistic potential" – the degree to which progress on the target promotes progress on the whole 2030 Agenda in a given context (such as the EU). This could be useful information in, for example, drafting a national Agenda 2030 implementation strategy, when prioritizing action with limited resources.

The analysis suggests that Target 12.4 (on chemicals and waste management) and Target 13.1 (on climate adaptation) have the most synergistic potential among the eight environmental targets studied. However, looking at all 21 goals and targets studied, the synergistic potential of the environmental targets is generally lower than that of several of the other goals, most notably SDG 16 (Peace, Justice and Strong Institutions), SDG 5 (Gender Equality) and SDG 17 (Partnerships for the Goals).

When prioritizing goals and targets with high synergistic potential overall, policy-makers need to bear in mind that they can still have some negative interactions, and take potential trade-offs into account. However, the analysis found that such negative links were rare in the case of Target 12.4 and Target 13.1, so prioritizing them appears to be a low-risk strategy yielding significant synergies.

Potential synergies and trade-offs associated with environmental targets in the EU

Individual government departments, agencies or businesses will naturally be focused on delivering the goals and targets that fall within their remit. For instance, environment agencies will be concerned with SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life below Water) and SDG 15 (Life on Land). Understanding how these goals and targets interact with others beyond the actor's remit can lead to more successful, cost-efficient implementation – exploiting potential synergies, addressing potential trade-offs, and seeking cross-sectoral cooperation to facilitate it.

We explore the implications of prioritizing eight environmental targets, in terms of how they interact with the other SDGs. The analysis suggests that progress on these environmental targets would be mutually supportive with progress on six SDGs: SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals). The environmental targets have more challenging relationships with SDG 1 (No Poverty), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities) and SDG 11 (Sustainable Cities and Communities). Progress on all six of these could make it more difficult to achieve several environmental targets; and progress on several environmental targets could restrict progress on these six SDGs as well as SDG 2 (Zero Hunger). Progress on the environmental targets could strongly restrict progress towards SDG 7, SDG 8 and SDG 9 in particular.

Exploring how interactions ripple through the network of targets

The value of a systemic approach is that it is possible to look beyond how pairs of targets interact directly. Using network analysis techniques, SDG Synergies makes it possible to capture more complex system effects, such as how the indirect influence one target can have on another target, mediated by a third target, and how these indirect (so-called second-order) interactions influence progress across the network of goals and targets.

By taking into account such indirect effects, occurring deeper in the network, decision-making has a better chance of success, because it can reveal less obvious synergies and potential trade-offs between goals and targets.

As an example, looking only at first-order (direct) interactions, progress on Target 13.2 (on climate mainstreaming) seems to make it easier to progress on the eight environmental targets. Progress on Target 13.2 also supports progress on SDG 7 (Affordable and Clean Energy). However, progress on SDG 7 can hinder progress on several environmental targets, if technologies and infrastructure needed for renewable energy put stress on ecosystems. Without careful management, this can somewhat offset the positive direct influence of Target 13.2 on the other environmental targets. It is worth noting two aspects here, however. First, over time, the environmental benefits of

switching to renewable energy would likely far outweigh the short-term environmental costs of installing the technologies and infrastructure (McCollum et al. 2018). Second, this analysis could not take into account the exact baselines from which implementation starts, or the long-term implications of continuing business-as-usual – which in this case could be worse than the damage from installing renewable energy technology and infrastructure.

Key messages

- A systems perspective can support more coherent, efficient implementation of the 2030 Agenda.

- SDG Synergies is a practical approach for analysing systemic interactions among SDG targets in a given context that could be applied at both EU and member state level.

- SDG Synergies:
  - uses both scientific evidence with stakeholder knowledge and perspectives
  - looks beyond direct interactions between pairs of targets and offers a nuanced analysis of how multiple interactions might play out in a given context.

- This report offers illustrative results from applying the SDG Synergies approach at EU level, with a focus on targets particularly relevant to environmental policy.

1. Systems thinking for SDG implementation

This report demonstrates how the SDG Synergies approach could be used to better understand how progress towards different goals and targets of the 2030 Agenda for Sustainable Development in the European Union could affect progress in other parts of the Agenda. It presents an illustrative analysis of how Sustainable Development Goals (SDGs) targets of particular relevance to environmental policy-makers could influence progress on a range of other goal areas – although carried out by a small group of experts, rather than the range of stakeholders normally involved in an SDG Synergies process.

Systems thinking is vital in SDG implementation. The 17 goals and 169 targets cover a broad range of policy areas and inevitably they will interact with each other in different ways in different contexts. Understanding how those interactions might play out can inform smarter planning, priority-setting and cross-sectoral collaboration that reflects the interconnectedness of the 2030 Agenda.

The analysis of interactions with environmental SDG targets looks at three important policy questions: Which environmental targets have the greatest potential to foster progress on the broader 2030 Agenda in the EU? What direct trade-offs and synergies with other SDGs could result from progress on environmental targets in the EU? And what are indirect effects, across the network of SDGs, of making progress on environmental targets in the EU?

1.1 The added value of a systemic approach

Attaining the SDG goals and targets will largely depend on successfully tackling trade-offs and leveraging synergies within this broad agenda (Pradhan et al. 2017). The United Nations has stressed that the 2030 Agenda should be viewed as an indivisible whole regarding its implementation (UN 2015).

In the policy sphere, both policy integration and policy coherence have been on the agendas of multilateral actors (e.g. the Organization for Economic Co-operation and Development, OECD; UN Environment, UNEP); European actors (e.g. the European Commission); and national agencies for some time. For example, at the EU level, all proposed legislation goes through an impact assessment that must include a description of potential environmental, social and economic impacts. However, such systems thinking to generate policy-relevant information has rarely been applied to guide SDG implementation.

Supporting policy coherence

For governance to be effective in achieving the 2030 Agenda, public policies should be coherent with one another and evidence-based (CEPA 2018). A solid knowledge base that considers how making progress on the different SDGs interact is badly needed, in order to prevent policies unintentionally reinforcing unsustainable patterns.

Research on interactions related to the SDGs is motivated by two understandings. The first is that policy-making and other decision-making that takes into account both interactions among the SDG goals and targets, and of the SDGs with other policy agendas, has a better chance of long-term success. The second is that innovative methods and tools can enhance capacity to adopt systems thinking on the SDGs, both within governments and among other actors. A science-informed analysis of interactions can support more coherent and effective decision-making, follow-up and monitoring, and stimulate knowledge gathering, learning processes and multi-stakeholder partnerships in support of effective goal implementation (ICSU 2017).

Priority-setting that respects the whole

Given that governments have limited resources, they must give priority to certain actions and policy areas in their implementation of the SDGs. At the same time, they have committed to making progress on the whole 2030 Agenda. Systemic analysis can inform priority-setting that satisfies these two aims by identifying those areas where action can best support overall SDG progress and avoid unproductive conflicts between goals.

Thanks to advances in areas like cross-impact analysis and network analysis, systemic study of the SDGs can also look into relationships between groups of targets that would be too complex for most human minds to process (Panula-Ontto et al. 2018; Weimer-Jehle 2006). Such analysis is useful at the early stages of policy-making because it brings to light interactions that might otherwise come as a surprise further down the line in SDG implementation.

Organizing cross-sectoral collaboration

Governments and other actors have many competing priorities and interests. While the need for policy integration and coherence has been recognized for decades, progress has been limited in practice. This is at least partly explained by a lack of trust, ownership and mutual learning among the actors involved (Weitz et al. 2017).

Most public administrations are not optimally organized to deal with the kinds of multi-sectoral, multi-scale, multi-actor, transdisciplinary and intergenerational issue that characterize implementation of the SDGs (Weitz et al. 2018). Effective implementation requires the involvement of a range of different policy areas and stakeholders. Systemic analysis can help to identify the best constellations of actors to collaborate on specific issues to their mutual advantage, and which actors need to negotiate trade-offs due to conflicting interests.

Without a systemic view, actors might be aware of some of the direct interactions of their targets with those of others; but systems analysis can present a much fuller picture, supporting both policy coherence and productive collaboration.

Identifying needs for policy innovation

Progress towards the SDGs is likely to require new policy instruments, or new uses of existing instruments, as well as new business models and innovative technologies. By highlighting challenges to progress on the SDGs, informing where change is needed to unlock progress, the findings of systemic analysis can help guide innovation and partnerships between, for example, the public sector and industry, to drive SDG progress.

1.2 Current research on SDG interactions

The 2030 Agenda has raised the bar for how, in practice, interactions between different goals should inform policy-making. Accounting for how all 169 targets interact in sometimes complex ways is an overwhelming task to most decision-makers. The onus is on the academic community to find pragmatic, yet scientifically sound, approaches that enable more systemic thinking in SDG planning.

Many studies have been published aiming to create an integrated understanding of the SDGs. A forthcoming review of this literature by researchers at Stockholm University and SEI (Bennich et al. Forthcoming) suggests that these studies approach interconnectedness in different ways. For example, some look at interactions between all targets, goals or indicators, while others focus on subsets. Some apply their analysis to the global level, others to a specific context like a country or sector. Importantly, their criteria for “interaction” – and therefore the objects of study – differ: do targets “interact” because on paper they address the same topic, because their indicators have historically correlated, or because progress on them impacts progress on other targets? The

methods and approaches to data collection and analysis applied also range from quantitative modelling to case study research and stakeholder consultation.

1.3 The SDG Synergies approach

This report demonstrates the kind of insights available from applying the semi-quantitative SDG Synergies approach, developed by researchers at Stockholm Environment Institute. The SDG Synergies approach is designed not just to facilitate systemic analysis of interactions between sets of policy targets and goals, but also to ensure the analysis reflects the real-world context, including the political context, in which implementation will happen (Weitz et al. 2019).

SDG Synergies combines qualitative assessment of target interactions – informed by scientific evidence and/or broad-ranging stakeholder involvement – with quantitative network analysis. This enables it to look beyond simple interactions between pairs of targets and analyse more complex, systemic relationships, and express them in ways that are easy to grasp and to communicate. The SDG Synergies approach helps to cut through the complexity of dealing with large numbers of target interactions, and to capture in a nuanced way how progress towards one target could affect progress in a broad range of targets and associated policies, in a specific setting (Barquet et al. 2019).

The approach was first presented in a paper in the journal *Sustainability Science*: "Towards systemic and contextual priority setting for implementing the 2030 Agenda" (Weitz et al. 2018). Applications in Mongolia, Sri Lanka and Colombia have helped to further develop and refine it. The current study represents the first attempt to apply the SDG Synergies approach at a regional level.

A common language and transparency

The approach's qualitative analysis of interactions starts with a guiding question. The nature of the interactions is expressed using a common, easy-to-understand seven-point scale, ranging from the most positive to the most negative influence. The scores are entered into a "cross-impact matrix" and justifications for the scores documented (see section 2).

In this way, SDG Synergies allows direct comparison between qualitatively different interactions, as well as making it easy to track, question and revise the assumptions underlying the analysis. The use of a seven-point scale of interactions also means the analysis can be far more nuanced than approaches using a simple binary scoring – positive vs negative, or synergies vs trade-offs.

A learning process

The SDG Synergies approach benefits from transdisciplinary participation. The more sectors and stakeholder groups are represented, the greater the chance that critical interactions will not be overlooked, and that they will be fairly and realistically scored. Applying SDG Synergies can thus bring together actors and sectors that tend to operate in silos, promoting mutual learning and understanding, as well as reinforcing the interlinked nature of SDG implementation. It also increases the likelihood of broad acceptance and ownership of the results.

These outcomes can be just as valuable as the analytical outputs (Weitz et al, 2019). SDG Synergies thus strikes a meaningful balance, generating policy-relevant information on complex issues, based on existing knowledge of the actors who will be involved in implementation.

Adapting to context

How interactions play out depends on the context, including differences in geography, governance and technology (Nilsson et al. 2016). Generic analyses that exclude context are therefore of limited use for policy-making. Flexibility is built in to the SDG Synergies approach, so it can be adapted for the specific context; for example, in the selection of targets, goals or indicators to be analysed and policy questions addressed; the stakeholders invited to participate; the scale at which interactions are considered; the amount of data brought into the process as evidence in the assessment of interactions.

All in all, the SDG Synergies approach offers decision-makers a systemic view of the SDGs, highlighting how interactions between different targets can shape the outcomes of policy choices. Compared to traditional sectoral approaches to policy-making, it equips policy-makers with a more robust information basis as they plan for implementation of the indivisible 2030 Agenda.

2. Applying the SDG Synergies approach

2.1 A proof of concept

The objective of the present study was to demonstrate how the SDG Synergies approach could offer new insights for 2030 Agenda implementation at the level of the European Union. (It has previously only been applied at national and subnational level.) This exercise focused on SDG targets of particular interest to environmental policy-makers, and how progress on those targets might influence progress on the broader agenda in the EU. As it was intended chiefly as a proof of concept, the whole exercise – including the choice of targets and goals and the scoring of interactions – was carried out mainly by experts at SEI. The results might be quite different if relevant EU stakeholders had been involved. This section briefly describes how the approach was applied, while section 3 presents some illustrative results.

2.2 Selecting the targets

If the assessment of interactions is done qualitatively, the SDG Synergies approach is best suited to analysing interactions between up to 40 variables (goals or targets).[2]

The following criteria guided the selection of targets and goals considered in the proof of concept exercise:

- Put special emphasis on targets and/or goals of particular relevance to environmental policy-makers in the EU
- Include targets or goals from all 17 SDGs
- No more than 25
- Selected targets should reflect the core identity of the SDG they belong to
- Selected targets should span rather than focus the issues
- Selected targets should cover the most relevant issues for environmental policy-makers in the EU addressed by that SDG.

Based on these criteria, researchers at SEI proposed a selection of 21 targets and goals, and this was refined in consultation with colleagues at the EEA.

The final selection included two targets for each of the "environmental" SDGs:[3] SDG 12 (Ensure sustainable consumption and production patterns), SDG 13 (Take urgent action to combat climate change and its impacts), SDG 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) and SDG 15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss):

Target 12.2 on sustainable management and efficient use of natural resources
Target 12.4 on environmentally sound management of chemicals and wastes
Target 13.1 on climate adaptation and disaster resilience
Target 13.2 on mainstreaming climate action into policy and strategies
Target 14.2 on protecting and restoring marine ecosystems
Target 14.4 on sustainable fishing
Target 15.1 on conserving and restoring terrestrial and freshwater ecosystems
Target 15.5 on protecting biodiversity and natural habitats.

These are refered to in this report as "environmental targets", although we do not suggest this is a generally applicable conceptualization or labelling of these or of any other SDG targets.

2 This limit is due to the time involved in qualitatively assessing the individual interactions. With larger sets of goals or targets the analysis quickly becomes more complicated; if all 169 targets were included, almost 30 000 pair-wise interactions would need to be assessed.

3 While these goals are more explicitly focused on environmental issues, all of the goals are relevant to environmental protection.

It was decided to consider SDGs 1–11, 16 and 17 at the level of goals.[4]

See page 4 for the selected set, and their full names. For a complete list of all SDGs and their associated targets see UN (2015).

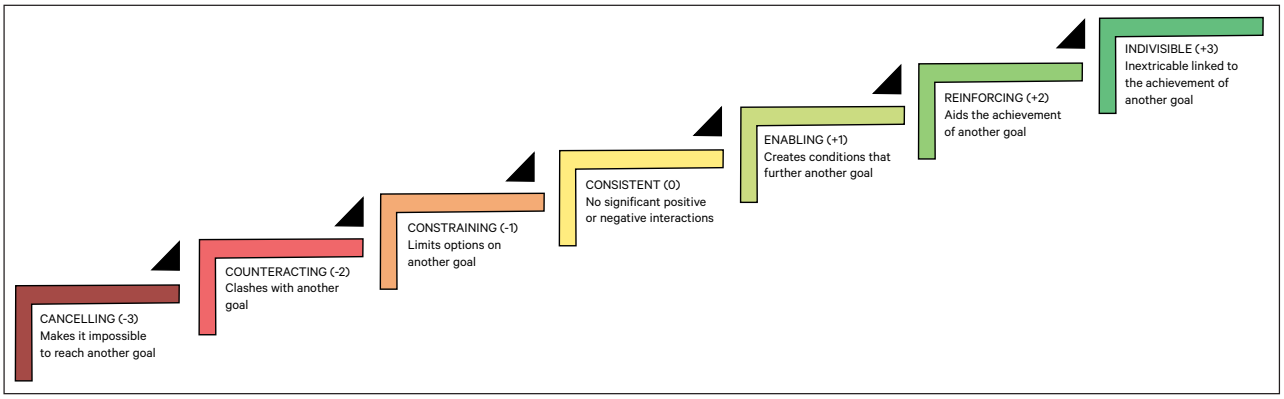
2.3 Assessing the interactions

Direct interactions between pairs of goals and targets were then scored in relation to a guiding question: *In the EU context, if there is progress on Goal/Target X, how would Goal/Target Y develop?*

Evidently, there may be many different ways to achieve progress on a given goal or target. Scoring is therefore somewhat of a judgement call and depends on the information available about the context and what policy options are feasible. This point is discussed further in section 4. In the assessment presented in this report it was not possible to be too detailed about means of achieving progress, given the regional scale and the objective to present a proof of concept and not analytical results.

Scoring was done using a hybrid quantitative-qualitative seven-point scale first developed by the International Council for Science (now the International Science Council, ISC) with researchers at SEI (see Figure 1). It ranges from c*ancelling* (-3)*, counteracting* (-2)*,* and *constraining* (-1) to *enabling* (+1)*, reinforcing* (+2) and *indivisible* (+3) on the positive side (Nilsson et al. 2016). A score of 0 is *consistent*, meaning there is no significant interaction. As shorthand, the positive interactions (+1 to +3) are referred to here as "promoting" and the negative (-3 to -1) as "restricting".

Figure 1. A seven-point scale for assessing SDG interactions. Weitz et al (2017), adapted from Nilsson et al (2016)



The selected targets and goals were arranged in a matrix, with each appearing in both the horizontal (x) and vertical (y) axes.

The 420 interaction scores were entered in the relevant cell of the matrix. It is worth noting that interactions should be scored separately in both directions; the influence progress on Target X has on Target Y may be quite different to the influence Target Y has on Target X.

Reflections on data and quality checking

As noted above, the scoring was done by researchers at SEI and EEA, based on expert judgement and brief literature reviews of, for example, key EU documents. This was considered appropriate for a proof-of-concept exercise.

4 All 17 goals must be represented in an analysis in order to see how the goals or targets in focus relate to the whole agenda. Analysis of interactions at the level of goals is necessarily less detailed than at the level of specific targets. Mixing goals and targets allows for a systemic analysis that is both comprehensive and simultaneously more detailed and contextualized in the areas of particular interest. No target results are aggregated to the level of goals, and the goals and targets should be seen as individual variables given equal weight in the network analysis. A different or broader selection might yield different results, including for system dynamics. See section 4.1

The choice of knowledge inputs to the scoring depends on the purpose of the exercise. It can be done based on secondary sources and expert judgement alone, but these have limitations, especially when the purpose is to inform policy-making. In that case it is important also to tap the knowledge of stakeholders (especially from relevant government departments).

It is important to note that there is no scientific consensus on how progress on targets interacts (ICSU 2017). Also, circumstances (e.g. political landscape, or technological options) change, so even if there were to be scientific consensus in a given moment, how targets interact is also prone to change. Finally, as it is stakeholders, not scientists, who will be primarily involved in implementation, their subjective views and sense of ownership will have a strong influence over any subsequent policy responses. (For more discussion of this issue see section 4.)

To ensure the scoring was as robust as possible in our exercise, two assessments of each interaction were done independently and in parallel. The two assessments agreed on around 80% of scores. Following discussion of the rationales behind the inconsistent scores and further analysis, 96% of the scores were aligned. An additional researcher was asked to make an independent assessment of the remaining 17 interactions, and EEA staff cross-checked the scores. The justifications for each score were documented for the sake of full transparency.

It is hardly surprising that there should be some disagreement about the interactions, especially given the wide range of contexts and policy directions taken across the EU and the variety of ways the same target or (in particular) goal can be interpreted and acted on. Disagreement or uncertainty in scoring can even be seen as a result in itself, suggesting that different futures and pathways are possible or that additional research about the interaction is needed.

Reaching consensus was particularly challenging on the following interactions:

- How progress on Target 12.2 (resource use), Target 15.1 (terrestrial and freshwater ecosystems) and Target 15.5 (biodiversity) would affect progress on SDG 11 (Sustainable Cities and Communities)
- How progress on Target 15.1 would affect progress on Target 13.1 (climate adaptation)
- How progress on Target 15.5 (biodiversity) would affect progress on SDG 2 (Zero Hunger).

Analysing the results

Some useful information can be obtained directly from the cross-impact matrix, for example the distribution of promoting and restricting interactions, how each target influences and is directly influenced by the other goals and targets, and whether progress on some targets implies many trade-offs.

Network analysis was also used to rank their “synergistic potential” (i.e. the extent to which progress on them promotes progress on all the other goals and targets) and to better understand how all the targets fit together, how a subset of targets interact with the rest of the network, and how effects ripple from one target to another throughout the network.

The analysis helped to answer our three policy questions:

- *Which environmental targets have the greatest potential to foster progress on the broader 2030 Agenda in the EU?*
- *What direct trade-offs and synergies with other SDGs could result from progress on environmental targets in the EU?*
- *What are indirect effects, across the network of SDGs, of making progress on environmental targets in the EU?*

The mathematical details of the network analysis applied can be found in Weitz et al. (2018).

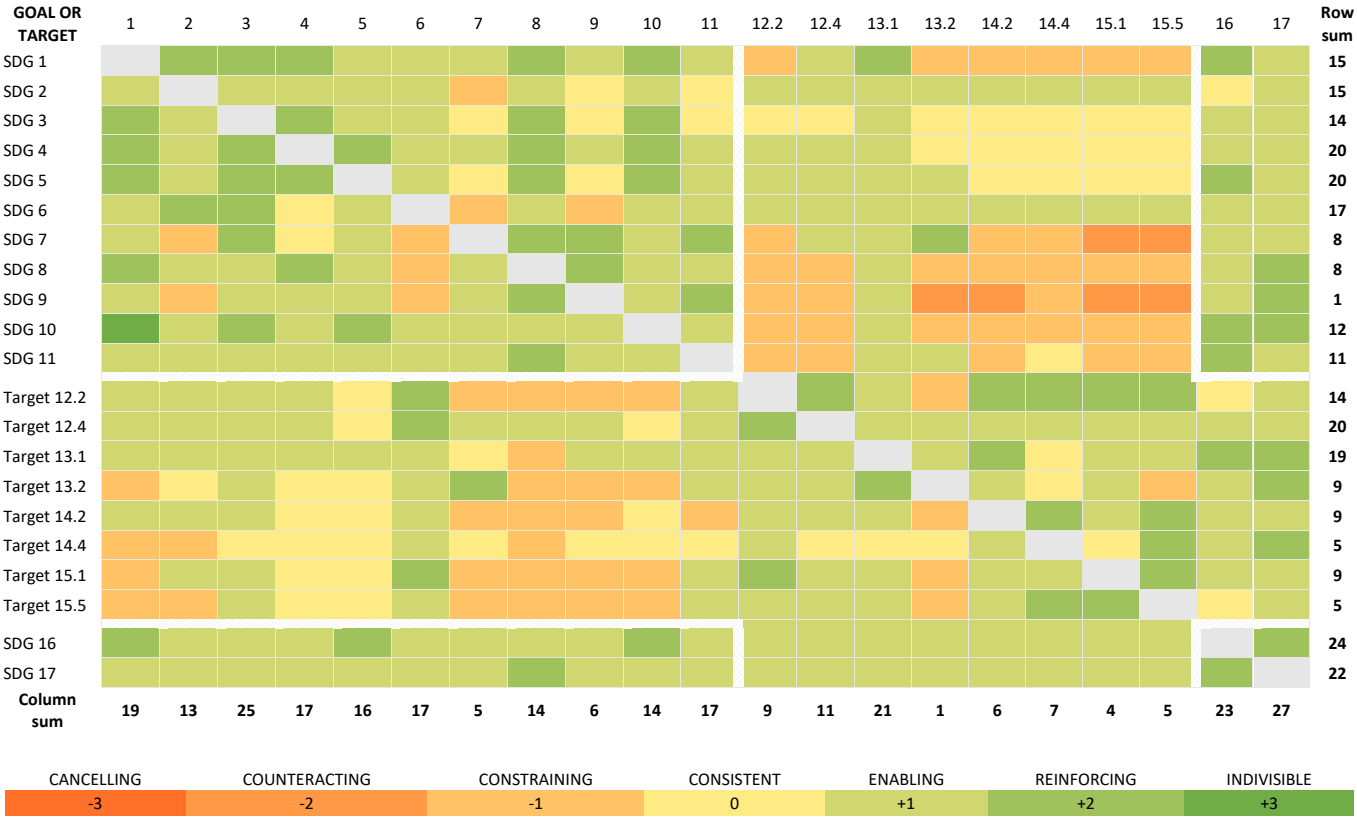
3. Selected findings

3.1 Overview of SDG interactions in the EU

The cross-impact matrix resulting from the scoring process (Figure 2) gives a quick overview of direct, pairwise interactions between the 21 selected goals and targets in the EU.

For example, looking along the row for Target 12.2 (sustainable management and use of natural resources) it shows that Target 12.2 was assessed as reinforcing progress on SDG 6 (Clean Water and Sanitation); as enabling progress on SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education); as consistent with progress on SDG 5 (Gender Equality); as constraining progress on SDG 7 (Affordable and Clean Energy); and so on.

Figure 2. Cross-impact matrix with interactions between 21 targets and goals



Looking at the *column* for Target 12.2, we can see it was assessed as constrained by progress on SDG 1; enabled by progress on SDG 2; consistent with progress on SDG 3; and so on.

Summing the scores in each row also gives a quick overall indication of which targets and goals have the most positive (or negative) effect on progress towards the other 20. (Note that the ranking in section 3.2 also takes into account some indirect interactions, and so does not exactly match the totals in Figure 2.) The same can be done for the columns for an indication of how progress towards a given goal or target is influenced by progress on the others.

For example, the scores in the matrix suggest that in the EU, progress on SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals) would promote progress on all of the other targets and goals (with summed scores of +24 and +22, respectively). Conversely, progress on SDG 9 (Industry, Innovation and Infrastructure) could impede progress on several other goals and (particularly environmental) targets, resulting in a summed score of only +1.

Figure 3. Ranking of goals and targets based on their calculated net positive influence on all others

Note: The ranking accounts for both first-order and second-order interactions

1  SDG 16: Peace, Justice and Strong Institutions

2  SDG 5: Gender Equality

3  SDG 17: Partnerships for the Goals

4  SDG 4: Quality Education

5  Target 13.1: Climate adaptation

6  SDG 1: No Poverty

7  Target 12.4 Chemicals and waste management

8  SDG 6: Clean Water and Sanitation

9  SDG 10: Reduced Inequalities

10  SDG 3: Good Health and Well-being

11  SDG 2: Zero Hunger

12  Target 12.2: Natural resource management

The anticipated promoting influence from SDG 16 and SDG 17 is, for example in relation to SDG 1 (No Poverty), due to lower corruption, more transparent institutions, increased participation in decision-making, and reduced violence contributing to lower poverty rates. The anticipated negative influences from progress on SDG 9 are discussed below.

The "traffic light" colour coding in the matrix offers a very intuitive way to visualize the interactions between the SDGs.

Overall, the assessment found that in the EU less than 20% of the interactions between the selected goals and targets were restricting, whereas around 70% were promoting. Six rows and six columns in the matrix hold no negative links at all. (For more detail on the share of different types of interaction and the promoting and restricting influence for each goal and target, see the Appendix.)

Despite the mostly positive interactions, the matrix shows that some restricting interactions were identified. These are potential trade-offs that will need to be dealt with in policy-making. A handful interactions were assessed as counteracting, meaning progress on one target would clash with progress on another. However, around 70 were assessed as constraining (-1), the weakest type of restricting interaction on the scale, meaning that progress towards a target would limit the options for progressing on another. As an example, progress on Target 15.1 (conserving and restoring terrestrial and freshwater ecosystems) might constrain wide-scale deployment of renewable energy infrastructure. Notably, several of the environmental targets were assessed as both strongly restricting of and restricted by progress on several other goals and targets, in particular Target 15.5 (on protecting biodiversity and natural habitats) and SDG 8 (Decent Work and Economic Growth).

3.2 Which environmental targets have the greatest potential to foster progress on the broader 2030 Agenda in the EU?

A government with limited resources needs to prioritize actions and investments in implementing the 2030 Agenda, while still delivering on the whole agenda. Knowing where actions have the greatest potential to support progress on a large number of targets can be extremely helpful. One straightforward type of analysis that can be done with SDG Synergies is to rank the targets according to their net positive influence on all the other targets and goals.

The cross-impact matrix shows all the pairwise interactions between the targets. As described above, simply summing up the scores in each row gives an indication of each target's influence on the whole agenda (at least as it is represented by the selected goals and targets). Part of the unique value of the SDG Synergies is its ability to look beyond direct pairwise interactions to reflect some of the complexity of how nodes in a network influence each other. This overall influence can be referred to as a target's "synergistic potential". Figures 4–6 take into account both "first-order" (direct) and "second-order" (indirect) interactions (i.e. how Target A's influence on Target B affects progress on Target C). Second-order interactions are discussed in more depth in section 3.4. Figure 3 shows all 21 targets and goals ranked according to their synergistic potential.

As Figure 3 shows, the two environmental targets found to have the strongest synergistic potential for SDG progress in the EU were Target 13.1 (on climate adaptation) and Target 12.4 (on responsible chemical and waste management). Ensuring progress on these targets appears to be a low-risk strategy for driving progress on the SDGs, because they restrict progress on very few other goals or targets. Other environmental targets rank low and have a mix of promoting and restricting influence on other targets and goals.

Figure 4 looks in more depth at Target 12.4 and how it influences the other 20 goals and targets considered.[5] As can be seen, it actually has no negative interactions with any goal or target. It promotes progress on 18 other goals and targets, particularly SDG 6 (Clean Water and Sanitation) and Target 12.2 (on sustainable management and use of natural resources).

Figure 4. How progress on Target 12.4 (on responsible chemical and waste management) influences progress on the other goals and targets

Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above).

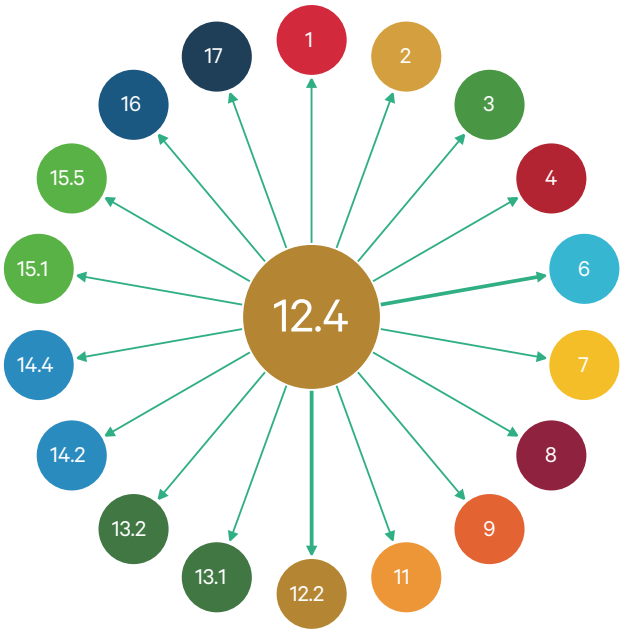


Figure 5. How progress on Target 13.1 (climate adaptation) influences progress on other goals and targets

Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above).

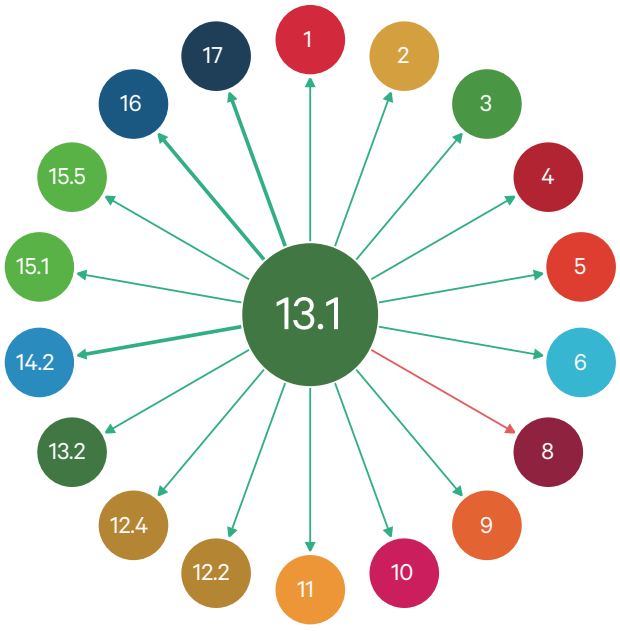


Figure 3 (continued)

13 SDG 11: Sustainable Cities and Communities

14 Target 13.2: Mainstreaming climate action

15 Target 15.1: Terristrial and freshwater ecosystems

16 Targetr 14.2: Marine ecosystems

17 SDG 8: Decent Work and Economic Growth

18 SDG 7: Affordable and Clean Energy

19 Target 15.5: Biodiversity and habitats

20 Target 14.4: Sustainable fishing

21 SDG 9: Industry, Innovation and Infrastructrue

5 Note that in this and the following figures, only first-order interactions are considered.

Turning to Target 13.1, Figure 5 shows that it was found to restrict progress on one goal, SDG 8 (Decent Work and Economic Growth), while promoting progress on 17 other goals and targets, particularly Target 14.2 (on protecting and restoring marine ecosystems), SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals).

BOX 1. HOW UNLEASHING SYNERGISTIC POTENTIAL COULD PLAY OUT IN THE REAL WORLD

This kind of analysis of goals and targets can seem rather abstract. It is important to remember that the numbered goals and targets reflect real-world processes, which are specific to a given context. Here we examine how some of the interactions identified in the analysis might look in actual implementation.

In the following we illustrate how progress on Target 12.4 (on chemical and waste management) and Target 13.1 (on climate adaptation), which have high potential to promote SDG progress overall, can interact with Target 12.2 (on responsible management and use of natural resources) and Target 14.2 (on protecting and restoring marine ecosystems).

In the EU, progress on Target 13.1 means fulfilling the EU Strategy on Adaptation to Climate Change (European Commission 2013), which aims to make Europe more climate-resilient. The strategy has three key objectives: promoting action by member states; climate-proofing action at EU level; and assisting better informed decision-making.

Improving the management of chemicals and waste is embedded in the EU's broader agenda for achieving a circular economy and decoupling economic growth from resource use and environmental degradation (European Commission 2016b). More specifically, Target 12.4 relates to the EU's Waste Framework Directive (European Commission 2008), which aims to reduce waste, and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), which aims to protect human health and the environment from hazardous chemicals (European Commission 2006).

Both Target 12.4 and Target 13.1 further tie in to international frameworks, and progress on the two targets would thus contribute to SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals). This international dimension is important to consider, given the borderless nature of climate impacts and the relevance of developments outside the EU for the region's resilience and capacity to adapt, and vice versa (European Commission 2008).[6]

Policy developments within the EU related to plastics illustrate well the interaction between the most promoting targets (12.4 and 13.1) and some of those that are most positively influenced by them (12.2 and 14.2). In Europe, almost 26 million tonnes of plastic waste is generated every year and less than 30% is recycled. Further, much of the plastic waste ends up in the oceans: up to 500 000 tonnes every year in the EU (European Commission 2018). While only a fraction of global marine litter, it still has negative implications for vulnerable marine areas in the EU. Reducing the consumption of plastic bags and other single-use plastic items, increasing recycling rates and improving waste collection systems are some of the policy options put forward in the EU to reduce plastic pollution and help protect and restore marine and coastal ecosystems (European Commission 2018).

6 This international dimension was not part of the analysis.

Shredded plastic for recycling © MONTY RAKUSEN / GETTY

Much plastic waste is also exported from the EU. This suggests that progress on Target 12.4 through implementation of the new EU Plastics Strategy (European Commission 2018) would also strengthen international institutions and partnerships, as progress hinges on their successful collaboration.

With most plastic today still produced from petrochemicals, plastic production and after-use of plastics account for greenhouse gas emissions equivalent to about 400 million tonnes of CO_2 globally every year (European Commission 2018). Increasing the share of more sustainable alternatives could therefore also strengthen the EU's resilience to climate-related hazards and natural disasters (Target 13.1).

Although the link is weaker, some measures that improve resilience and adaptive capacity to climate disasters – for example to protect against tidal flooding and storms – could also enable better management and protection of marine and coastal ecosystems. However, this depends very much on the specific measures taken, as they could also harm natural ecosystems; as in many other cases, *how* progress is made towards a target can affect its influence on progress towards other goals and targets.

The European Commission estimates that implementation of their proposed measures to reduce discharge of waste at sea could result in up to 300 000 tonnes less waste being generated annually, and as long as plastic is not replaced by equally environmentally harmful materials, this illustrates how progress on Target 12.4 can strongly support progress on Target 12.2.

Being able to harness the full synergistic potential of one target can often be contingent on progress on others. Figure 6 shows how other targets and goals promote progress on Target 13.1 (on climate adaption). Particularly important are reducing poverty (SDG 1) and mainstreaming climate action into national policy and planning (Target 13.2). Income is a key factor in increased climate resilience and adaptive capacity among vulnerable populations (Hallegatte et al. 2016). Climate mainstreaming is assumed to promote progress on adaptation because climate change adaptation and mitigation are linked, both in the UNFCCC negotiations and in the subsequent mainstreaming and integration of policies at the regional (EU) and national levels (Berkhout et al. 2015). Again, depending on the approach taken to progress each, the interactions can look different.

Figure 6. How progress on other goals and targets influence progress on Target 13.1 (climate adaptation)
Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above). Only first-order interactions considered.

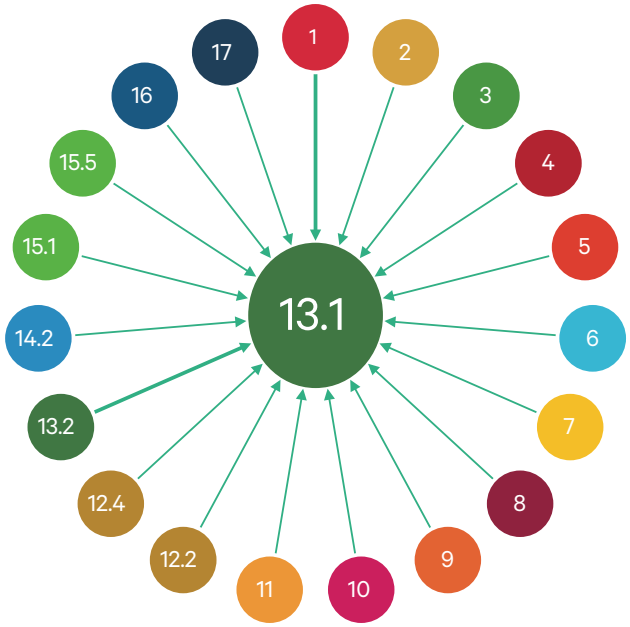
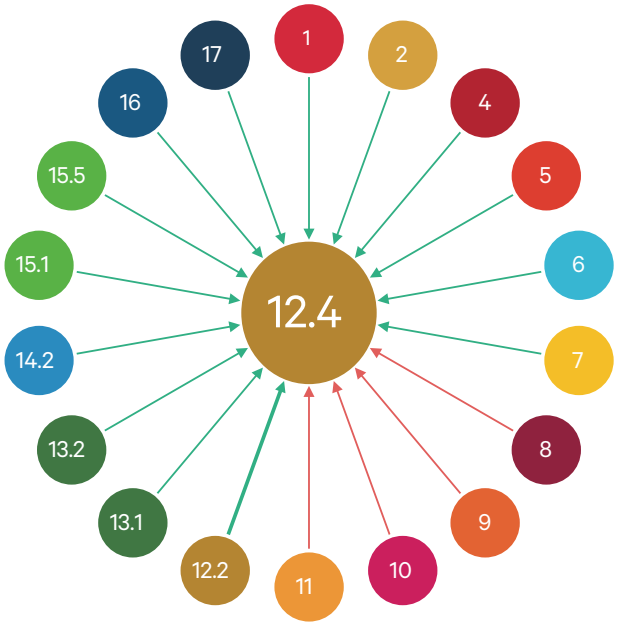


Figure 7. How progress on Target 12.4 (on responsible chemical and waste management) is influenced by progress on other goals and targets
Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above). Only first-order interactions considered.

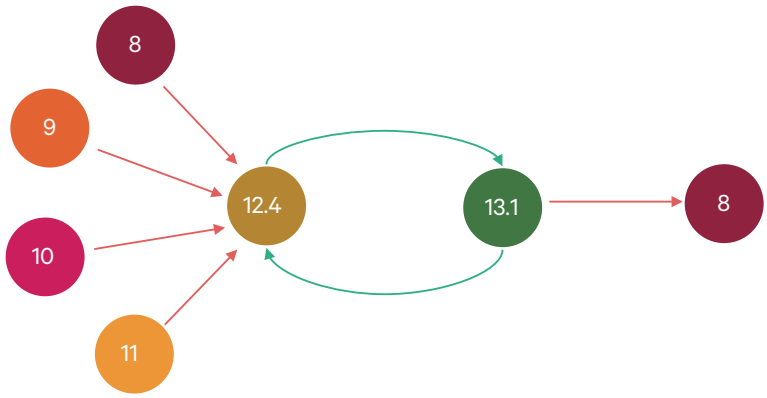


Looking at Target 12.4 (on chemicals and waste management; Figure 7), Target 12.2 (on management and use of natural resources) was considered particularly promoting, because sound management of chemicals and waste is one component of more sustainable resource management. On the contrary, it was assessed that progress on SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities) and SDG 11 (Sustainable Cities and Communities) could make it more difficult to achieve Target 12.4.

Figure 8 shows that Targets 12.4 and 13.1 are mutually promoting, but progress on both is restricted by, or restricts, progress on five other goals (via first-order interactions). In order to unleash the synergistic potential of these two targets on the SDGs in the EU, EU policy-makers will need to consider these restricting interactions. They also need to consider how progress on synergistic targets can restrict progress on some other goals or targets.

Situations where one goal or target potentially restricts progress towards another can in many cases be resolved or mitigated. A more circular economy in line with the EU Action Plan for the Circular Economy (European Commission 2015) could, for example, alleviate some of the

Figure 8. Restricting interactions related to Target 12.4 (on responsible chemical and waste management) and Target 13.1 (on climate adaptation)
Note: Restricting interactions (red arrows) related to the mutually reinforcing targets 12.4 and 13.1 are shown. Only first-order interactions considered.



negative interactions with Target 12.4 and Target 13.1. While traditional economic development has generated more and more waste, a transition to a more circular economy would in many cases build a more resilient economy that is also better adapted to the stresses climate change could put on the EU's provisioning of natural resources. This example also touches on the one goal that was identified as being hindered by progress on the most synergistic targets: SDG 8 (Decent Work and Economic Growth). The relationship is intricate, but investments in both climate adaptation and, to a lesser extent, chemical and waste management are costly and are expected to be funded through public expenditure, as a public good. Thus in the short term (i.e. before 2030), large public investments could make it more difficult to decouple economic growth from greenhouse gas emissions (Kasman and Duman 2015; Schandl et al. 2016), though in the longer term such a transition would be in line with SDG 8's call for "*sustained and sustainable* economic growth". A similar time-dependent relationship between SDG 9 and the environmental targets is discussed below.

3.3 What direct trade-offs and synergies with other SDGs could result from progress on environmental targets in the EU?

While governments have committed to delivering on the whole 2030 Agenda, individual implementing agencies and government departments will necessarily focus on only a handful of targets. However, a systemic perspective can still be useful. An actor who is aware of which other SDGs promote or restrict progress on their priority targets is in a better position to factor in, and even mitigate, the potential negative influences, and to try and exploit potential synergies in their implementation plans, as well as to coordinate with other relevant actors.

A specialized agency with an environmental mandate will prioritize one or more of the "environmental goals" (SDGs 12–15), whatever their synergistic potential revealed by systemic analysis. Here we look specifically at the critical potential trade-offs and synergies connected to progress on these environmental targets in the EU, identified using the SDG Synergies approach.

As Figures 9 and 10 show, the eight environmental targets, collectively, promote progress on all the other goals to varying degrees, but they also exert some restricting influence on seven goals. In turn, the environmental targets are collectively promoted by all the other goals, but are also restricted by six goals. Goals 1, 7, 8, 9 and 10 both restrict and are restricted by the environmental targets to some degree.

Figure 9. How progress on eight environmental targets influences the other SDG goals and targets in the EU

Notes: Green arrows show aggregate promoting influence; red arrows show aggregate restricting influence. Arrow thickness indicates the intensity of the influence calculated as the sum of the eight environmental targets' influence on each goal.

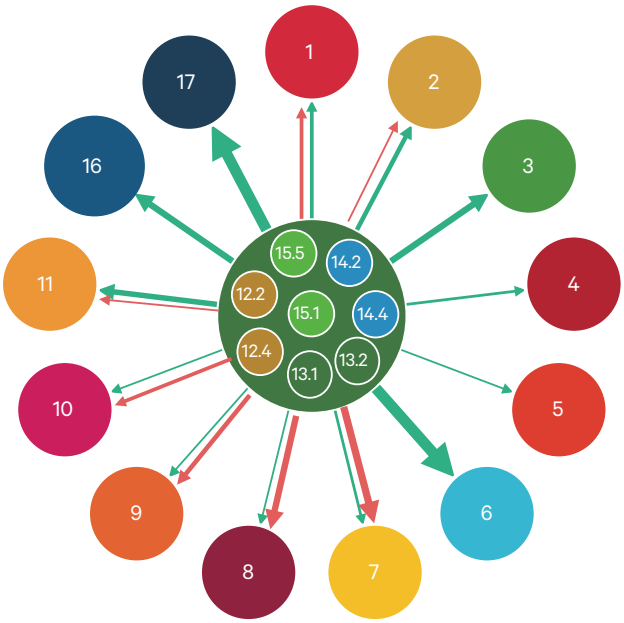


Figure 10. How progress on the other goals influences eight environmental targets in the EU

Notes: Green arrows show aggregate promoting influence; red arrows show aggregate restricting influence. Arrow thickness indicates the intensity of the influence calculated as the net sum of each goal's influence on the eight environmental targets

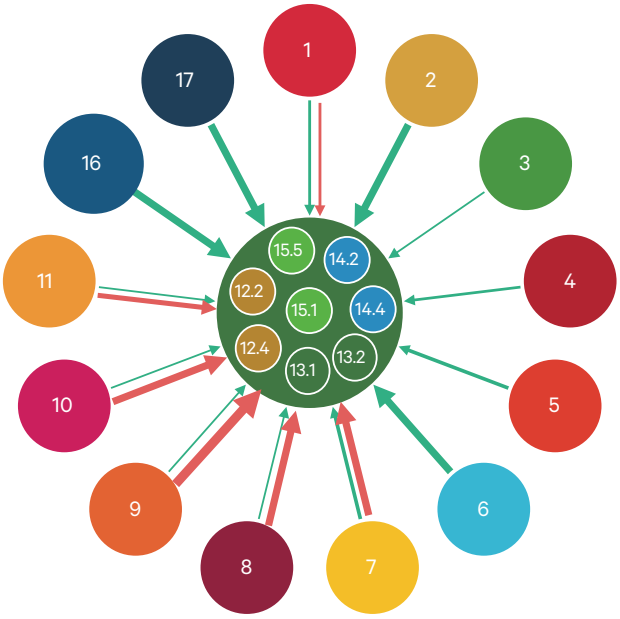
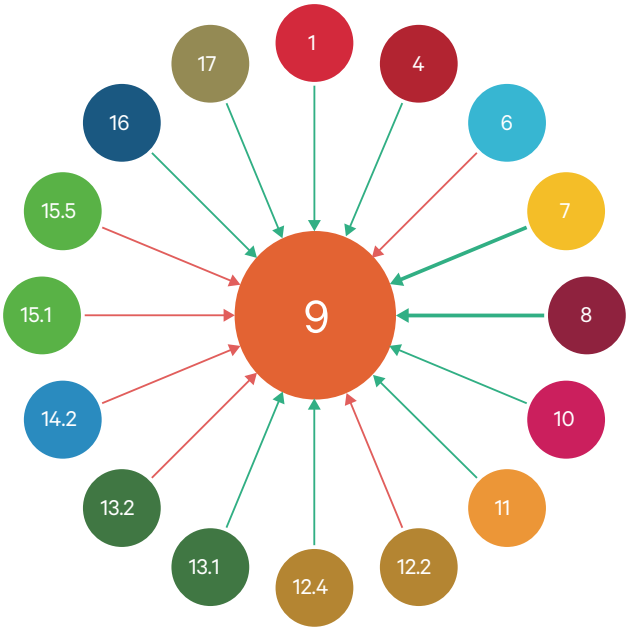


Figure 11. How progress on SDG 9 influences the other goals and targets

Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above). Only first-order interactions considered.

Figure 12. How progress on the other goals and targets influences progress on SDG 9

Note: Only goals and targets where the influence is restricting (red arrows) or promoting (green arrows) are shown; consistent (neutral) interactions are omitted. Arrow thickness reflects the intensity of the influence, using the seven-point scale (see above). Only first-order interactions considered.



In our analysis, SDG 9 (Industry, Innovation and Infrastructure) emerges as one of the most challenging goals from the perspective of the environmental targets. As shown in Figure 11, SDG 9 was assessed as hindering progress on all the environmental targets except Target 13.1 (on climate adaptation). Figure 12 shows that progress on five of the environmental targets hinders progress on SDG 9. This relationship is further explored below.

Challenging interactions between the environmental targets and SDG 9

Our socio-economic system, with industry, innovation and infrastructure at the core, would be impossible without ecosystems and the services they provide (Raskin 2005). The importance of sustainable, energy-efficient transport and mobility systems and the principle of free movement of goods in the EU's internal market for a competitive EU economy illustrates the centrality of industry, innovation and infrastructure. Further, innovation can drive economic growth, job creation, labour productivity and resource efficiency (Eurostat 2019). As stated in the report *The European Environment: State and Outlook 2015* (EEA 2015), most pressures on natural capital in the EU are linked to the production and consumption systems that provide for our material well-being.

Progress on SDG 9 (Industry, Innovation and Infrastructure) and its associated targets would entail measures such as investment in sustainable infrastructure to support economic development, an increase in industry's share of employment and GDP, better access to financial services and markets, and upgrading of industry and infrastructure to make them more sustainable. This will require consumption of a range of natural resources, which in many cases are already in short supply or difficult to source sustainably (UNEP 2011). Since the current economic system does not properly price in the risks and costs of degradation of the natural environment (TEEB 2010), there are likely to be short-term trade-offs between such resource- and land-intensive targets on the one hand, and targets seeking to protect natural resources, ecosystems, fish stocks and biodiversity, and to advance climate measures on the other. SDG 9 reflects an ambition to resolve or mitigate these.

BOX 2: MANAGING THE TRADE-OFF IN THE REAL WORLD: THE CASE OF STEEL

Steel is one issue that exemplifies potential trade-offs and their implications in the EU. Steel is a central resource for an industrial society and thus for realizing SDG 9. The global demand for steel is expected to increase with economic growth and its production already accounts for about 7% of global CO2 emissions, making steel production the single largest sector in terms of industrial emissions (Pérez-Fortes et al. 2014). To meet the SDGs, Paris Agreement and EU targets for reducing emissions to near zero by 2050, while having a thriving EU steel industry, will be impossible without a systemic switch to steel recycling (Åhman et al. 2018). The EU Emissions Trading Scheme (EU ETS) is the central policy framework for regulating emissions from steel production and sets a general cap on emissions.

The outstanding question is how to make the transition to a sustainable steel industry in practice. In Sweden three companies, focused on iron ore mining, steel production and power supply, respectively, have joined forces to develop a process for fossil-free steel production called Hydrogen Breakthrough Ironmaking Technology (HYBRIT) (Åhman et al. 2018). European steelmakers are also exploring similar processes. These initiatives move beyond carbon capture and storage to avoiding emissions in the first place.

© EGON69 / GETTY

Public policy will be needed to create an enabling environment for such industrial transitions in line with the SDGs. Regulations, taxes and subsidies, green procurement, green marketing and interventions focusing on consumer preferences are examples of public policy that can incentivize emissions reductions. While consumer preferences may have limited impact on heavy industries like steel production, it could have more of an impact on other sectors under SDG 9; the rules implemented by Sweden's road administration to promote progress towards climate neutral infrastructure are one example (Åhman et al. 2018).

Moreover, the costs and benefits of such transitions need to be fairly shared. The EU has a strong rationale to develop technology for fossil-free steel production as this could give a competitive advantage in the long term. However, it will also need to handle related issues of trade competitiveness and carbon leakage, for example.

SDG 9's targets call for "resilient infrastructure" and "sustainable industrialization" and for states to "upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes". This wording shows that SDG 9 wants economies to better internalize negative effects from industrialization and infrastructure development in the long term, and initiatives like HYBRIT (see Box 2) are examples of how this could be done in practice.

However, in the short term (2030 is only 11 years away!), investment in resource-intensive infrastructure and industrial projects can cause higher greenhouse gas emissions and therefore challenges the mainstreaming of climate measures (Target 13.2) into national policy and planning, and can negatively impact marine and land-based ecosystems (Rockström et al. 2009).

One example of this type of trade-off is wind power expansion, which is being promoted in EU member states through the EU's energy policy and is predicted to increase over the next 20 years (Söderholm and Pettersson 2011). In Sweden, for example, the government has prioritized investment in wind power infrastructure in order to meet the goals and requirements of the EU's Renewable Energy Directive (Rudberg et al. 2013).

Wind power is one of the cleanest forms of energy, and the EU's policies to promote are driven both by the climate mitigation potential and the wish to secure energy supply. Onshore wind farms have

aroused concerns over noise and visual disturbance, land use and impacts on wildlife. Ecosystems can be impacted through vegetation or forest clearing with possible habitat loss for some species, and there are direct impacts on birds and bats that are killed by the turbine blades (see e.g. Rudberg et al 2013). Because of these concerns, and the general lack of inexpensive land near population centres, offshore wind power is likely to represent much of the increase in coming years (Bilgili et al. 2011). Offshore wind farms have advantages in terms of efficiency as well arousing less public opposition on aesthetic grounds. However, they require new technological solutions and tend to be more costly to install and maintain. Furthermore, much is still unknown about the effects on the environment – negative or positive (Bailey et al. 2014).

The relationships between SDG 9 and the environmental targets are far more extensive and more complicated than can be covered here. Progress in the areas covered by SDG 9 will depend on healthy ecosystems and the services they provide for infrastructure and industrial development, and progress on SDG 9 will be crucial to the long-term health of these ecosystems. In the short term, however, progress on SDG 9 could add pressure on ecosystems, and more stringent regulation to protect ecosystems could therefore restrict progress on SDG 9.

3.4 What are indirect effects, across the network of SDGs, of making progress on environmental targets in the EU?

First-order, second-order and rippling effects

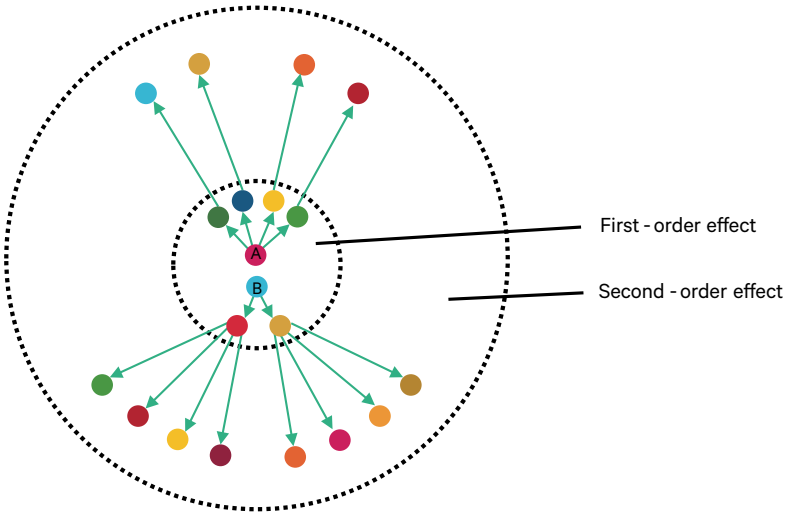
First-order interactions refers to the direct interactions between pairs of goals or targets. SDG Synergies analysis starts with an assessment of all the pairwise first-order interactions between a selection of goals and targets, carried out by stakeholders and/or experts.

Second-order interactions are how a first-order interaction affects a range of other goals and targets. These can be quite different, for example if a positive first-order interaction intensifies a negative second-order interaction. When second-order interactions were taken into account in ranking our selection of goals and targets by synergistic potential, SDG 10 rose from 12th to 9th place, while Target 12.4 fell from 5th to 7th place (see section 3.2)

Figure 13 illustrates the basic idea. For the sake of simplicity, it only includes promoting interactions and of equal strength. If we look at the first-order interactions Target A appears to have the most synergistic potential, having a promoting influence on four targets compared with Target B's two.

Figure 13. Conceptual figure illustrating the difference between first-order and second-order effects

Note: For the sake of simplicity, only promoting interactions of equal strength are shown, and the second-order effect is not discounted. Green arrows show promoting influence.



However, the picture is different when it comes to second-order interactions. Because the two targets that Target B directly promotes each promote four other targets, Target B has promoting influence on a total of ten other targets (compared to eight for Target A). (This is rather oversimplified, as the algorithm used in SDG Synergies discounts the influence the further it gets away from the original first-order interaction.)

It is, of course possible and sometimes useful to look beyond second-order interactions to how the influence of progress on one target ripples through the whole network. However, it gets very messy and it is more often useful to look at limited sets of interactions.

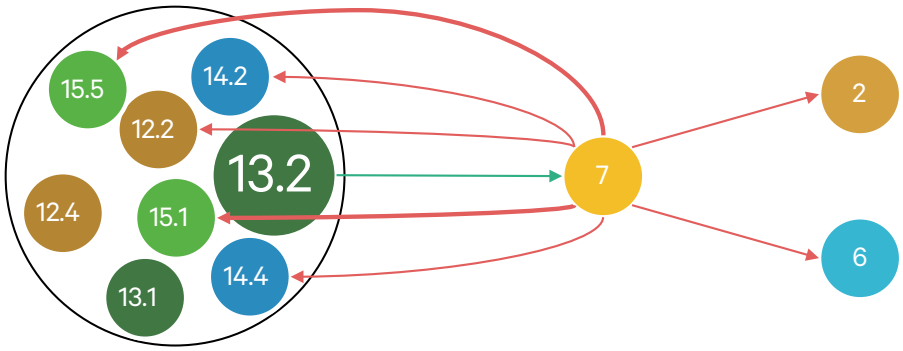
By looking beyond first-order interactions, a decision-maker is provided with information that can help avoid unintended effects emerging further down the line. To illustrate this we start from the entry point of Target 13.2 (on climate mainstreaming).[7] Figure 14 shows how this target has a promoting effect on SDG 7 (Clean Energy). However, SDG 7 in turn restricts progress on SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), and five of the environmental targets.

Progress on climate mainstreaming promotes progress on SDG 7 (Affordable and Clean Energy), but progress on SDG 7 restricts progress on SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation) and five of the environmental targets.

An actor in charge of action on climate mainstreaming should bear in mind both the intended and unintended effects in other areas that can follow from progress. This example further shows how first-order interaction (the influence of progress on Target 13.2 on progress on SDG 7) gives a limited picture of a goal or target's systemic properties. While Figures 14 and 15 illustrate this idea only to the second order of interactions, the effect continues to ripple throughout the network of goals and targets.

If we consider only first-order effects, Target 13.2 promotes progress on all the environmental targets except Target 15.5 (on protecting biodiversity and habitats). Taking into account second-order effects provides a more nuanced picture, showing how Target 13.2 can potentially restrict all the environmental targets by promoting SDG 7 (Clean Energy). Careful governance of energy infrastructure development will be needed in order for climate mainstreaming not to have negative effects on natural resource use and marine and terrestrial ecosystems down the line. These effects risk being overlooked in decision-making based on first-order interactions only.

Figure 14. Second-order effect from progress on Target 13.2 (climate mainstreaming)



7 Note that this example looks only at one of the goals that Target 13.2 influences (SDG 7). The net positive influence of Target 13.2 does not change much when accounting for second-order interactions, because many negative second-order links is not a typical pattern for Target 13.2.

For an even more nuanced understanding, however, we can look at the individual targets under SDG 7. For example, the dynamics discussed above are more representative of Target 7.1 (on energy access) and Target 7.2 (on renewable energy) than Target 7.3 (on energy efficiency), and overall the negative effect is likely to be small. It is important to note that the analysis describes the nature of interactions, not severity of impacts, and impacts depend on how progress is made and governed. With various technological and social innovations available, a well-governed transition can potentially turn negative links positive.

BOX 3: RIPPLE EFFECTS IN THE REAL WORLD

While global energy demand is projected to grow globally by a factor of three over the coming century, primary energy demand in the EU is projected to continue to decouple from GDP and is on a downward trend (European Commission 2016a). The natural resource base remains a direct input to the energy sector as well as to infrastructure, in particular for power transmission and distribution. Energy infrastructure is an important factor in the EU, since it has been depleted in many high-income countries in recent decades (Nilsson et al. 2013).

Mainstreaming climate change measures into national policy, strategy and planning (Target 13.1) almost certainly make progress on energy targets easier and strongly support international targets for renewables and energy efficiency (McCollum et al. 2018). For example, the EU's 2030 climate and energy framework includes a cut in greenhouse gas emissions, an increased share of renewable energy in the energy mix, and improvements in energy efficiency. Before any new climate policies are proposed, the European Commission assesses their expected economic, social and environmental consequences, and this includes projections of energy and emission trends, energy dependence, and different pathways to cutting emissions.

© MISCHA KEIJSER / GETTY

Progress on climate mainstreaming (Target 13.2) is thus assumed to promote progress on SDG 7 (Clean Energy), and it is also expected that a shift to renewables and increased energy efficiency would make progress on many other goals and targets easier, including climate mainstreaming.

However, the impacts of energy extraction, conversion and consumption can be far-reaching (McCollum et al. 2018). For example, SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation) would not benefit from progress on SDG 7 if expansion of renewables entails large-scale bioenergy production competing with land for food production and water, and could have implications for global food prices (McCollum et al. 2018).

Furthermore, a better-connected energy network in the EU could allow more EU countries to benefit from wind power from the North Sea, solar energy from southern Europe and biomass from eastern Europe, but this would come at a heavy short-term cost. The European Commission estimates that upgrading Europe's energy infrastructure will require €200 billion, and that building new power grids and other infrastructure projects would have negative environmental impacts (European Commission 2019). There are thus several potential trade-offs between environmental targets and progress on SDG 7, at least in the short term.

In the longer term, a shift towards renewable energy and greater energy efficiency would slow the depletion of many types of natural resource and would generally support environmental targets (McCollum et al. 2018). However, shifting to large-scale use of bioenergy or hydropower could add stress on terrestrial and inland freshwater ecosystems with strong negative effects if not governed well. For example, minerals will be required and without efficient recycling, targets seeking to protect natural resources, conserve ecosystems and biodiversity will be constrained. Ocean-based energy production, like offshore wind farms, can compete spatially with marine and coastal habitats and protected areas (Bailey et al. 2014).

4. Reflections

Limited resources and competing interests mean that goverments and other actors face difficult choices in how to prioritize implementation of the 2030 Agenda. The SDG Synergies approach offers practical support in making these decisions, by means of clear, flexible and context-specific analysis of how progress on different goals and targets could affect progress on other parts of the agenda, and the agenda as a whole.

A conversation starter

All planning is a future-oriented exercise, and there is little evidence available to indicate how exactly progress on the various SDG goals and targets will interact in a specific context. Rather than being paralyzed by the lack of data, the SDG Synergies approach is meant to systematize and analyse existing knowledge and assumptions, facilitating a structured conversation.

Moreover, the 2030 Agenda does not prescribe how the goals and targets are to be met. For all of them, many different approaches are possible; the interactions and their outcomes will naturally depend on the specific choices taken, and on the different contexts – not least the baselines from which "progress" is being made. The issue of climate adaptation, for example, which features centrally in one of our cases, can mean many different things in practice, with very different outcomes in different contexts. Identifying a typical, generic interaction between two targets or goals is therefore not possible.

The results presented here hopefully offer some ideas about how interactions might play out in the EU. However, the analysis is intended primarily as a proof-of-concept for using the SDG Synergies approach for a regional-level analysis, looking specifically at the EU. The small group of experts who assessed the interactions for the purpose of the study of course do not represent the existing knowledge among key stakeholders in SDG implementation in the EU. They will have complementary views on how targets are likely to interact. Therefore, only a selection of results have been presented, with the aim of illustrating the kinds of insight that can be generated with this approach. It would not be appropriate to make policy recommendations based on this analysis, but below we discuss how the types of result that have been generated can be interpreted.

Priority-setting

As was demonstrated in section 3.2, the SDG Synergies approach can highlight targets that have the strongest synergistic potential; those where progress has the best chance of supporting progress on multiple other goals and targets. The results suggest that there are many more promoting than restricting interactions between the SDGs in the EU, and that some of the environmental targets are important promoters of progress towards other targets and goals, as well as being associated with some critical trade-offs.

Targets that have a high synergistic potential should be explored in more detail, in terms of their potential to bring about transformative change across the whole SDGs framework. The concrete actions that best support progress on these targets (in ways that promote their synergistic potential) need to be identified, and potential trade-offs and restricting effects from other goals and targets mitigated. Not progressing on these targets would be a missed opportunity to promote progress on the 2030 Agenda in the EU.

It is worth noting that ranking and prioritization of targets and goals according to their synergistic potential is not the same as saying which it is more important to achieve. There is also good reason to prioritize efforts that support targets and goals that are not substantially supported by progress on other goals and targets. These can easily be identified based on the cross-impact matrix, and the column-sums already give an indication (not accounting for second-order effects).

Trade-offs, synergies and collaboration

SDG Synergies analysis can also shed light on the systemic implications of pursuing progress on a single target (or set of closely related targets). As most SDG implementation will be the responsibility of actors with thematically limited mandates, this kind of systemic perspective can usefully reveal unexpected trade-offs with other policy areas, as well as potential synergies. The results presented here suggest that, for example, actors responsible for the environmental targets need to be wary of difficult interactions with SDG 9 (Industry, Innovation and Infrastructure).

The trade-offs and synergies identified also point to areas where policy innovation might be needed. Assessing the impacts of potential trade-offs and synergies and finding ways to mitigate, resolve or exploit them should be a priority of EU policy-makers. Turning restricting influence into promoting influence can have large positive effects on many other targets, and if not possible to resolve, at least the trade-offs can be anticipated and planned for.

The ways that actors with responsibility for, or interest in, different targets interact today does not necessarily match how the targets themselves interact. Because actors often operate in silos, shared interests or conflicts are not always apparent. Systemic analysis like that presented here can be used to map what cross-sectoral arrangements could help unlock progress on the SDGs. Because the interactions are not symmetrical (Target A can promote Target B while Target B restricts Target A), cross-sectoral working groups that mirror critical interactions (both positive and negative) can be a meaningful way forward, though of course they may not always be feasible for political reasons. Additional network analysis can be done to identify clusters of highly interacting targets.

Policy change through learning

An important feature of the SDG Synergies approach is the involvement of the stakeholders who are in a position to act on the results. Stakeholders' understanding of the interactions shape their views on what challenges and opportunities the trade-offs and synergies imply, and consequently what policy options are available to deal with them (Nilsson and Weitz in press). Thus, changes in stakeholders' understanding are important for inducing policy change, and facilitating the space and structure for understanding the relationships and interactions between SDG targets is a key value of the approach. Past experiences with applying the SDG Synergies approach with a high degree of stakeholder engagement suggest that it has broadened policy-makers' perspectives beyond their own sector and helped to build consensus on policy decisions.

In addition to stakeholder engagement, embedding the exercise in a longer planning or policy review process at the highest level of government improves the chances that it will lead to actual policy change. Such processes can provide more space for subsequent cross-sectoral investigations and negotiations based on the results (Barquet et al. 2019).

4.1 Future research needs

A truly systemic view?

The analysis presented here barely scrape the surface of what is possible with systems and network analysis. Ongoing research at SEI is, for example, identifying scenarios that show, based on historical correlations, where countries are headed on the SDGs without transformative changes to how society, economy and environment interact, and which SDGs are likely to take the hit. This way, different alternative scenarios for progressing on the SDGs can be presented to decision-makers and the trade-offs associated with each scenario compared.

Another limitation to the systemic view offered here comes from the target selection. First, the identification of SDGs 12–15 as more relevant to environmental policy-makers is somewhat artificial. The selection serves the purpose of illustrating the approach and does capture many of the issues which occupy the days and mandates of environmental policy-makers, but different

conceptualizations ascribe different labels to the goal and essentially all of the goals are relevant to environmental protection. Secondly, a truly systemic view requires inclusion of all goals and ideally targets, but would simply be too cumbersome, given the need to assess each individual interaction qualitatively. SEI is exploring ways to better represent all 169 targets in the analysis, including ways of aggregating indicators at goals level. Aggregation, however, has to be balanced with the benefit of keeping the assessment fully transparent, with qualitative assessments trackable and a straightforward mathematical machinery.

Acknowledging differences between member states

This study was the first time that the SDG Synergies approach has been applied at a regional scale. The scores assigned to each of the first-order interactions were based on some fairly broad assumptions about what progress on each of the goals and targets might look like at EU level. The analysis did not address in any detail *how* that progress might have been achieved, though some of the assumptions which have been used to illustrate interactions in the real world throughout this report draw on the justifications of the scores given in the analysis exercise.

Most of the detailed policy choices dictating how Agenda 2030 is implemented will be taken by individual member states, with unique political, economic, social and technological contexts. To inform policy for a specific member state, such an analysis would need to be done at the national level, and with relevant national stakeholders.

This does not mean that regional-scale analyses are not useful in themselves. However, how to better represent differences between territories making up the region is a research question for the future. For example, it might be possible to adjust the scores based on how regional countries are currently performing on the different goals and targets. This would build on the idea of decreasing marginal utility. Thus, we might assume that if countries in the region were close to achieving targets under SDG 6 (Clean Water and Sanitation) and SDG 5 (Gender Equality), then progress on SDG 6 would have a smaller promoting influence on SDG 5 than if they had a long way to go.

Working with subjectivity in decision-making

Decision-making is in reality strongly influenced by personal values, ideological biases and other cognitive factors, but in the search for more evidence-based decision-making, such "subjectivity" is often viewed as a shortcoming (Barquet et al. 2019). However, the SDG Synergies approach instead accepts and works with this subjectivity. It relies on the existing knowledge and perspectives of key stakeholders in SDG decision-making, and provides transparency on the assumptions and rationales that will influence decisions about our future. Thus the approach responds to recent calls for integrating human behaviour into decision-making models that assess complex human-ecological systems, and for understanding how context shapes thinking for the design and implementation of policies (Barquet et al. 2019).

A global agenda

A number of studies have looked at how SDGs interact at the global level (Le Blanc 2015; Pradhan et al. 2017). To our knowledge none have, however, looked at how progress on the goals in different countries actually fits together at the global level. No country or region is implementing the SDGs in isolation and trade-offs and synergies in SDG implementation may exist between different EU member states, or between progress in the EU and in the rest of the world (Sachs et al. 2017). Better understanding of how progress in one place influences progress in another is needed to ensure global progress and to respect not just the principle of treating the SDGs as an indivisible whole, but also the principle of universality.

References

Åhman, M., Olsson, O., Vogl, V., Nyqvist, B., Maltais, A., Nilsson, L. J., Hallding, K., Skånberg, K. and Nilsson, M. (2018). *Hydrogen Steelmaking for a Low-Carbon Economy: A Joint LU-SEI Working Paper for the HYBRIT Project*. EESS report no 109, SEI Working paper WP 2018-07. Stockholm Environment Institute and Lund University. https://www.sei.org/publications/hydrogen-steelmaking/

Bailey, H., Brookes, K. L. and Thompson, P. M. (2014). Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. *Aquatic Biosystems*, 10(1). 8. DOI: 10.1186/2046-9063-10-8

Barquet, K., Trimmer, C., Sturesson, A., Joyce, B. and Jambal, D. (2019). *Piloting the SDG Synergies Approach in Mongolia*. Stockholm Environment Insitute, Stockholm. https://www.sei.org/publications/sdg-synergies-mongolia/

Bennich, T., Weitz, N. and Carlsen, H. (Forthcoming). Deciphering the scientific literature on SDG interactions: a review and reading guide (working title).

Berkhout, F., Bouwer, L. M., Bayer, J., Bouzid, M., Cabeza, M., et al. (2015). European policy responses to climate change: progress on mainstreaming emissions reduction and adaptation. *Regional Environmental Change*, 15(6). 949–59. DOI: 10.1007/s10113-015-0801-6

Bilgili, M., Yasar, A. and Simsek, E. (2011). Offshore wind power development in Europe and its comparison with onshore counterpart. *Renewable and Sustainable Energy Reviews*, 15(2). 905–15. DOI: 10.1016/j.rser.2010.11.006

CEPA (2018). *Principles of Effective Governance for Sustainable Development*. UN Economic and Social Council Official Records, 2018, Supplement no. 24, E/2018/44-E/C.16/2018/8, para. 31. United Nations Committee of Experts on Public Administration. https://publicadministration.un.org/en/Intergovernmental-Support/CEPA/Principles-of-Effective-Governance

EEA (2015). Protecting, conserving and enhancing natural capital. In *The European Environment: State and Outlook 2015 (SOER 2015), Synthesis Report*. EEA. European Environment Agency, Copenhagen. https://www.eea.europa.eu/soer-2015/about

European Commission (2006). Regulation concerning the registration, evaluation, authorisation and restriction of chemicals (REACH). (EC) No. 1907/2006, 18 December 2006.

European Commission (2008). Directive on waste and repealing certain directives. 2008/98/EC, 19 November 2008.

European Commission (2013). *An EU Strategy on Adaptation to Climate Change, COM(2013) 216 Final*.

European Commission (2015). *Closing the Loop: An EU Action Plan for the Circular Economy, COM(2015) 614 Final*

European Commission (2016a). *EU Reference Scenario 2016: Energy, Transport and GHG Emissions, Trends to 2050*. Directorate-General for Energy, Directorate-General for Climate Action, Directorate-General for Mobility and Transport. https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

European Commission (2016b). *Next Steps for a Sustainable European Future – European Action for Sustainability, COM(2016) 739 Final*

European Commission (2018). *A European Staretgy for Plastics in a Circular Economy, COM (2018) 28 Final*

European Commission (2019). Infrastructure. Energy. 2019. https://ec.europa.eu/energy/en/topics/infrastructure/overview

Eurostat (2019). SDG 9: Industry, innovation and infrastructure. Statistics Explained. 2019. https://ec.europa.eu/eurostat/statistics-explained/index.php/SDG_9_-_Industry,_innovation_and_infrastructure

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D. and Vogt-Schilb, A. (2016). *Shock Waves: Managing the Impacts of Climate Change on Poverty*. Climate Change and Development Series. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/22787

Hedlund, J., Fick, S., Carlsen, H. and Benzie, M. (2018). Quantifying transnational climate impact exposure: New perspectives on the global distribution of climate risk. *Global Environmental Change*, 52. 75–85. DOI: 10.1016/j.gloenvcha.2018.04.006

ICSU (2017). *A Guide to SDG Interactions: From Science to Implementation*. International Council for Science (ICSU), Paris

Kasman, A. and Duman, Y. S. (2015). CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*, 44. 97–103. DOI: 10.1016/j.econmod.2014.10.022

Le Blanc, D. (2015). Towards integration at last? The Sustainable Development Goals as a network of targets. *Sustainable Development*, 23(3). 176–87. DOI: 10.1002/sd.1582

McCollum, D. L., Echeverri, L. G., Busch, S., Pachauri, S., Parkinson, S., et al. (2018). Connecting the Sustainable Development Goals by their energy inter-linkages. *Environmental Research Letters*, 13(3). 033006. DOI: 10.1088/1748-9326/aaafe3

Nilsson, M., Griggs, D. and Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature News*, 534(7607). 320. DOI: 10.1038/534320a

Nilsson, M., Lucas, P. and Yoshida, T. (2013). Towards an integrated framework for SDGs: Ultimate and enabling goals for the case of energy. *Sustainability*, 5(10). 4124–51. DOI: 10.3390/su5104124

Nilsson, M. and Weitz, N. (in press). Governing trade-offs and building coherence in policy-making for the 2030 Agenda. *Politics and Governance*, 7(4).

Panula-Ontto, J., Luukkanen, J., Kaivo-oja, J., O'Mahony, T., Vehmas, J., et al. (2018). Cross-impact analysis of Finnish electricity system with increased renewables: Long-run energy policy challenges in balancing supply and consumption. *Energy Policy*, 118. 504–13. DOI: 10.1016/j.enpol.2018.04.009

Pérez-Fortes, M., Moya, J. A., Vatopoulos, K. and Tzimas, E. (2014). CO2 capture and utilization in cement and iron and steel industries. *Energy Procedia*, 63. 6534–43. DOI: 10.1016/j.egypro.2014.11.689

Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future*, 5(11). 1169–79. DOI: 10.1002/2017EF000632

Raskin, P. D. (2005). Global scenarios: Background review for the Millennium Ecosystem Assessment. *Ecosystems*, 8(2). 133–42. DOI: 10.1007/s10021-004-0074-2

Rockström, J., Steffen, W., Noone, K., Persson, Å., Iii, F. S. C., et al. (2009). A safe operating space for humanity. *Nature*. 23 September 2009. DOI: 10.1038/461472a

Rudberg, P., Weitz, N., Dalen, K. and Kielland Haug, J. J. (2013). *Governing Growing Wind Power: Policy Coherence of Wind Power Expansion and Environmental Considerations in Sweden, with Comparative Examples from Norway*. Working paper 2013-04. Stockholm Environment Institute

Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D. and Teksoz, K. (2017). *SDG Index and Dashboards Report 2017: International Spillovers in Achieving the Goals*. Bertelsmann Stiftung and Sustainable Development Solutions Network, New York. https://www.sdgindex.org/reports/sdg-index-and-dashboards-2017/

Schandl, H., Hatfield-Dodds, S., Wiedmann, T., Geschke, A., Cai, Y., et al. (2016). Decoupling global environmental pressure and economic growth: scenarios for energy use, materials use and carbon emissions. *Journal of Cleaner Production*, 132. 45–56. DOI: 10.1016/j.jclepro.2015.06.100

Söderholm, P. and Pettersson, M. (2011). Offshore wind power policy and planning in Sweden. *Energy Policy*, 39(2). 518–25. DOI: 10.1016/j.enpol.2010.05.065

TEEB (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of NAture: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*

UN (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. A/RES/70/1. United Nations. https://sustainabledevelopment.un.org/post2015/transformingourworld

UN (2018). *The Sustainable Development Goals Report 2018*. United Nations, New York. https://unstats.un.org/sdgs/report/2018/

UNEP (2011). *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*. Report of the Working Group on Decoupling to the International Resource Panel. UN Environment, Nairobi

Weimer-Jehle, W. (2006). Cross-impact balances: A system-theoretical approach to cross-impact analysis. *Technological Forecasting and Social Change*, 73(4). 334–61. DOI: 10.1016/j.techfore.2005.06.005

Weitz, N., Carlsen, H., Nilsson, M. and Skånberg, K. (2018). Towards systemic and contextual priority setting for implementing the 2030 Agenda. *Sustainability Science*, 13(2). 531–48. DOI: 10.1007/s11625-017-0470-0

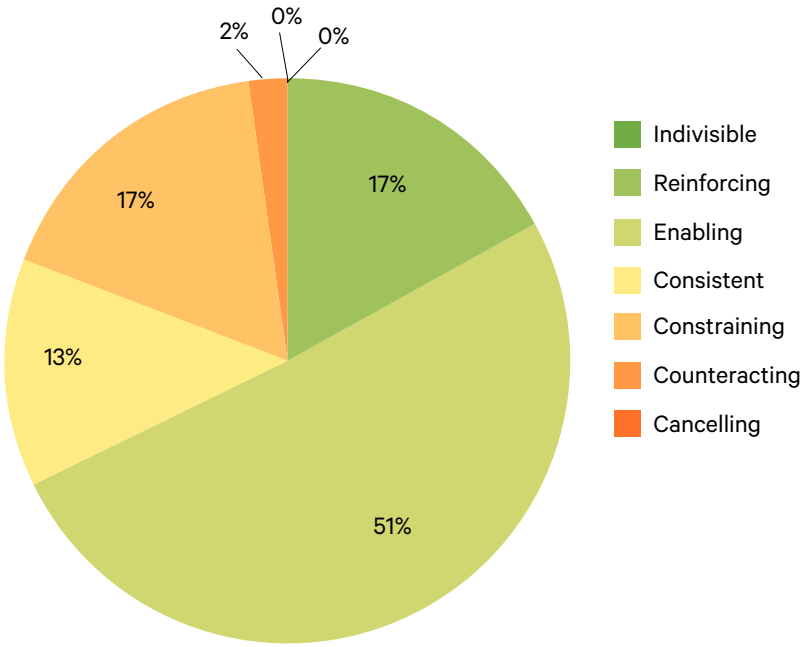
Weitz, N., Carlsen, H. and Trimmer, C. (2019). *SDG Synergies: An Approach for Coherent 2030 Agenda Implementation*. SEI brief. Stockholm Environment Institute. https://www.sei.org/publications/sdg-synergies-factsheet/

Weitz, N., Strambo, C., Kemp-Benedict, E. and Nilsson, M. (2017). Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. *Global Environmental Change*, 45. 165–73. DOI: 10.1016/j.gloenvcha.2017.06.006

Appendix

Distribution of types of interaction

Figure A1. Distribution of different types of interaction among the 21 goals and targets in the regional analysis



Promoting and restricting influence per goal or target

The row-and column sums for each goal or target are useful to reveal the overall pattern of which targets strongly or weakly promote SDG progress and which are strongly or weakly promoted by progress on other targets. They do not, however, reveal what the scores are composed of and a high-ranking goal or target can still restrict progress on some goals or targets, for example. Such links are important information for decision-making around SDG implementation and complement the rankings. Figures A2 and A3 show the composition of promoting and restricting links for each of the 21 targets and goals.

Figure A2. How each goal or target influences the other 20
Note: Promoting influence shown in green, restricting in red.

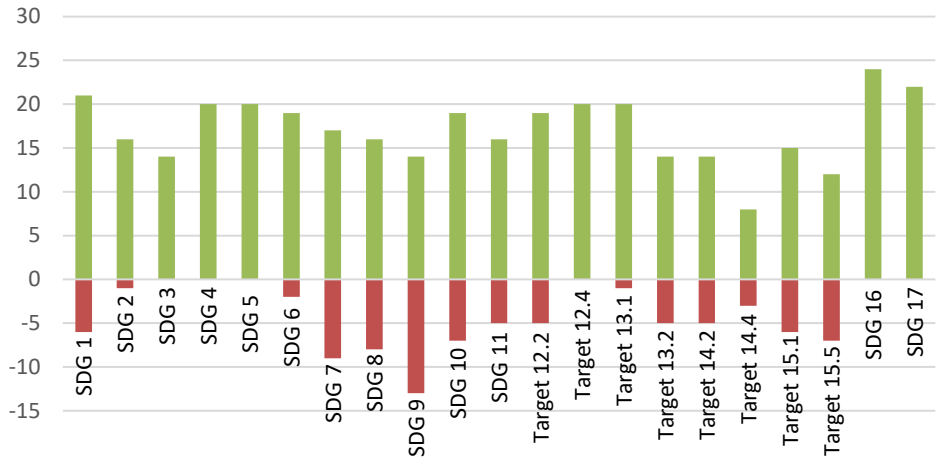
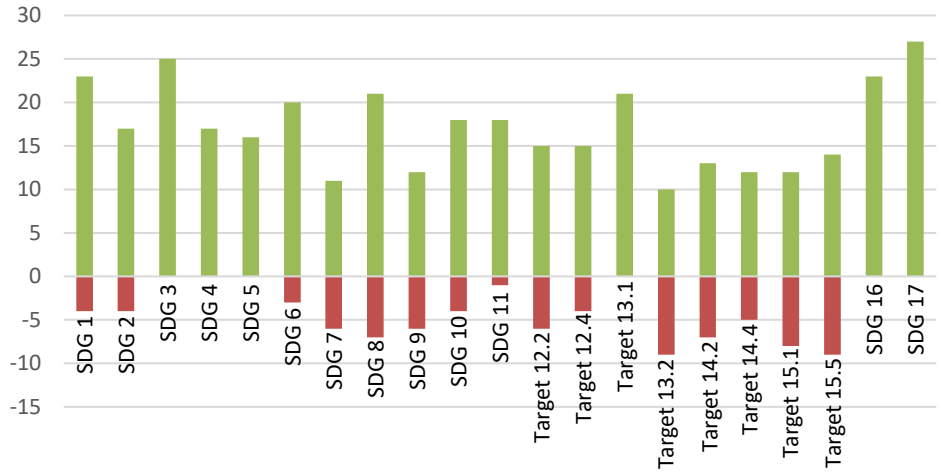


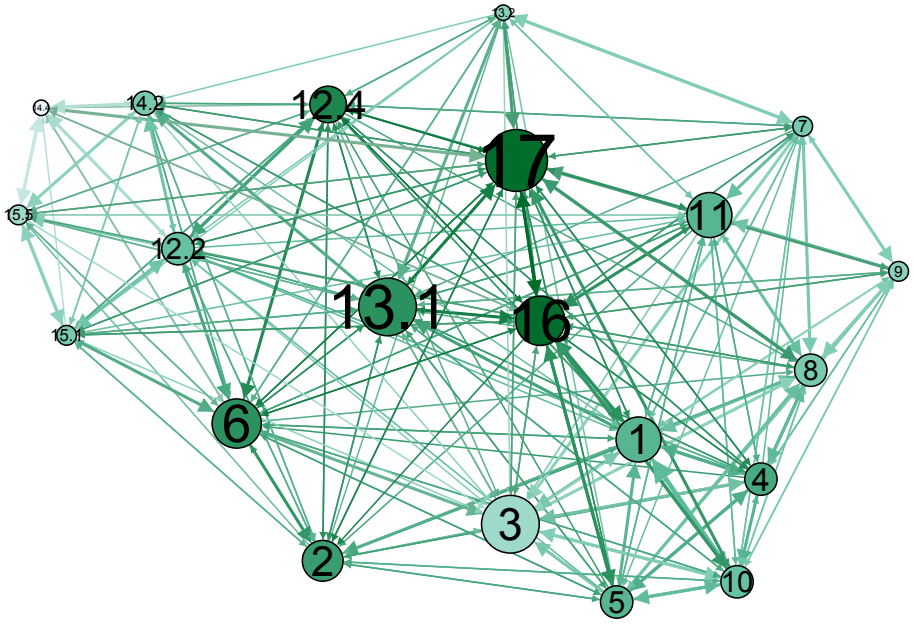
Figure A3. How each goal or target is influenced by the other 20
Note: Promoting influence shown in green, restricting in red.



Positive subnetwork

Figure A4 shows the subnetwork of promoting links only. Given the large share of promoting links between the SDGs in the EU, this network is quite dense and giving an overview is difficult. It does tell us, though, that SDG 17, SDG 16, Target 13.1 (climate adaptation), SDG 6 and Target 12.4 (chemicals and waste management) both strongly promote progress on the other goals and targets and are strongly promoted by progress on the other goals and targets.

Figure A4. Subnetwork showing all promoting interactions
Note: Dot (node) size reflects the strength of the goal or target's promoting influence on the other 20 goals and targets. The darker the colour of the dot), the more it is positively influenced. Arrows show the direction of influence.



Visit us

SEI Headquarters
Linnégatan 87D Box 24218
104 51 Stockholm Sweden
Tel: +46 8 30 80 44
info@sei.org

Måns Nilsson
Executive Director

SEI Africa
World Agroforestry Centre
United Nations Avenue
Gigiri P.O. Box 30677
Nairobi 00100 Kenya
Tel: +254 20 722 4886
info-Africa@sei.org

Philip Osano
Centre Director

SEI Asia
10th Floor, Kasem Uttayanin Building,
254 Chulalongkorn University,
Henri Dunant Road, Pathumwan, Bangkok,
10330 Thailand
Tel: +66 2 251 4415
info-Asia@sei.org

Niall O'Connor
Centre Director

SEI Tallinn
Arsenal Centre
Erika 14, 10416
Tallinn, Estonia
info-Tallinn@sei.org

Lauri Tammiste
Centre Director

SEI Oxford
Florence House 29 Grove Street
Summertown Oxford
OX2 7JT UK
Tel: +44 1865 42 6316
info-Oxford@sei.org

Ruth Butterfield
Centre Director

SEI US
Main Office
11 Curtis Avenue
Somerville MA 02144-1224 USA
Tel: +1 617 627 3786
info-US@sei.org

Michael Lazarus
Centre Director

SEI US
Davis Office
400 F Street
Davis CA 95616 USA
Tel: +1 530 753 3035

SEI US
Seattle Office
1402 Third Avenue Suite 900
Seattle WA 98101 USA
Tel: +1 206 547 4000

SEI York
University of York
Heslington York
YO10 5DD UK
Tel: +44 1904 32 2897
info-York@sei.org

Chris West
Acting Centre Director

SEI Latin America
Calle 71 # 11–10
Oficina 801
Bogota Colombia
Tel: +57 1 6355319
info-LatinAmerica@sei.org

David Purkey
Centre Director

SEI Stockholm Environment Institute

sei.org

@SEIresearch @SEIclimate