INTRODUCTION
A FRAMEWORK FOR UNDERSTANDING SUSTAINABLE DEVELOPMENT GOAL INTERACTIONS

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THE SUSTAINABLE DEVELOPMENT GOALS

Implementation of the 2030 Agenda for Sustainable Development, adopted by world leaders in September 2015 at a historic United Nations Summit and underpinned by 17 Sustainable Development Goals (SDGs) and their associated 169 targets, began on 1 January 2016. The SDGs are expected to guide governments as they work to address some of the most pressing challenges facing humanity.

The SDGs were developed following the United Nations Conference on Sustainable Development in 2012 ('Rio+20') and build on the Millennium Development Goals (MDGs) adopted in September 2000 as part of the UN Millennium Declaration. The SDGs provide a more holistic and integrated approach to development than the MDGs, thus continuing the legacy of the Brundtland Commission (UN, 1987) and the Rio Declaration on Environment and Development (UN, 1992). They are designed to be universal and therefore apply to all countries – poor, rich and middle-income alike – and to all segments of society. Although each focuses on a different topic area, the SDGs are meant to be integrated, indivisible and collectively support a development agenda balancing the economic, social and environmental dimensions of sustainability. (see blue text below)

While not legally binding, the SDGs do provide a globally endorsed normative framework for development. Governments and other stakeholders are expected to establish national and regional plans for their implementation. The 2030 Agenda is neither a blueprint for specific action nor for navigating the complexities and trade-offs that will undoubtedly emerge during implementation.

OVERALL AIM OF THE SDGS

The Sustainable Development Goals (SDGs) promote human dignity and prosperity while safeguarding the Earth's vital biophysical processes and ecosystem services. They recognise that ending poverty and inequality must go hand-in-hand with strategies that support sustainable economic growth, peace and justice; address fundamental social needs, including education, health, social protection, and job opportunities; and do all this while also tackling climate change and enhancing environmental protection. Detailed information on the 17 SDGs and their associated 169 targets is available at https://sustainabledevelopment.un.org/?menu=1300.

BACKGROUND

Although governments have stressed the integrated, indivisible and interlinked nature of the SDGs (UN, 2015), important interactions and interdependencies are generally not explicit in the description of the goals or their associated targets. In 2015, the International

Council for Science (ICSU) identified some interactions across SDGs at the goal and target-level (ICSU and ISSC, 2015). This report goes further, by exploring the important interlinkages within and between these goals and associated targets to support a more strategic and integrated implementation. Specifically, the report presents a framework for characterising the range of positive and negative interactions between the various SDGs, building on the work of Nilsson et al. (2016), and tests this approach by applying it to an initial set of four SDGs: SDG2, SDG3, SDG7 and SDG14. This selection presents a mixture of key SDGs aimed at human well-being, ecosystem services and natural resources, but does not imply any prioritisation.

While the scientific community has emphasised the need for a systems approach to sustainable development (e.g. GEA, 2012; PBL, 2012; SEI, 2012; Stafford Smith et al., 2012), policymakers now face the challenge of implementing the SDGs simultaneously with the aim of achieving progress across the economic, social and environmental dimensions worldwide.

This work provides a starting point to addressing this challenge. It has been led by ICSU with the support of several internationally renowned scientific institutes, including the Institute for Advanced Sustainability Studies (IASS), the Kiel based Future Ocean cluster, the International Food Policy Research Institute (IFPRI), the French National Research Institute for Sustainable Development (IRD), the International Institute for Applied Systems Analysis (IIASA), Monash University, the New Zealand Centre for Sustainable Cities, and the Stockholm Environment Institute (SEI). It is based on the premise that a science-informed analysis of interactions across SDG domains, and how these interactions might play out in different contexts, can support more coherent and effective decision-making, and better facilitate follow-up and monitoring of progress. Such an analysis will also make it possible to better highlight inequalities concerning progress made, which will in turn make it easier to identify corrective measures as well as help to avoid unintended side-effects.

WHY ARE INTERACTIONS IMPORTANT?

The 2030 Agenda for Sustainable Development is often referred to as an integrated agenda and its advocates frequently describe it as an 'indivisible whole'. What does this mean in practice? First, in contrast to the conception of the Rio 'pillars' of economic development, social development and environmental protection, the three dimensions of sustainable development are described in the introductory sections of the 2030 Agenda as intertwined, cutting across the entire Agenda. These interactions also featured strongly in the deliberations of the Open Working Group that developed the SDGs. In fact, while most of the 17 SDGs have a clear starting point in one of the three pillars, most actually embed all three dimensions within their targets. For example, SDG2

"End hunger, achieve food security and improved nutrition and promote sustainable agriculture" contains targets with social (e.g. malnutrition and vulnerability), economic (e.g. agricultural productivity and agricultural trade) and environmental dimensions (e.g. genetic diversity and climate resilience). Second, there are significant interactions between SDGs. Continuing with the example of SDG2, a commonly discussed set of interactions lies in the nexus between food, water and energy (Weitz et al., 2014) as reflected in the linkages between SDG2, SDG6 and SDG7. For instance, water is required in the energy sector for cooling in thermal power plants and for generating hydro-electricity; energy is required for residential and industrial water usage, and for pumping water for irrigation; and water is needed for all food and bioenergy production. Third, because of the strength of these linkages, achieving targets under these goals can lead to trade-offs between competing interests: for example, food production may compete with bioenergy production for the same land or water. Finally, the SDG2 targets interact with a much broader set of targets and goals, such as those preventing childhood death (target 3.2), reducing food waste (target 12.3), encouraging sustainable business practices (target 12.6), conserving marine areas (target 14.5) and ensuring rights to control over land and natural resources (target 1.4).

Articulating and understanding the many interlinkages helps to explain why the 2030 Agenda must indeed be treated as an 'indivisible whole'. However, in that phrase there is a hidden presumption that the interactions between goals and targets are – for the most part – mutually supporting: in order to make progress in one area, progress must also be made in others. Yet, both the research community and policymakers have already highlighted that there can be conflicts and trade-offs between goals (PBL, 2012; IRP, 2015; LeBlanc, 2015).

Given budgetary, political and resource constraints, as well as specific needs and policy agendas, countries are likely to prioritise certain goals, targets and indicators over others. As a result of the positive and negative interactions between goals and targets, this prioritisation could lead to negative developments for 'non-prioritised' goals and targets. An example is the potential prioritisation of SDG2, whose progress might well lead to adverse impacts for several of the SDG15 targets (on terrestrial ecosystems), for example by converting rainforest to agriculture. Even if countries continue under business-as-usual conditions for agricultural production, terrestrial ecosystems could deteriorate below current levels within a short timeframe. Moreover, due to globalisation and increasing trade of goods and services, many policies and other interventions have implications that are transboundary in nature, such that pursuing objectives in one region can impact on other countries or regions' pursuit of their objectives. For example, there could be increased deforestation in some countries as a result of enforced logging bans in other, often neighbouring, countries, or there could be changes in national trading policies that impact

on the availability of goods and services in other countries. Similarly, pursuing a policy for biofuels in one region can drive up prices of food crops else-where and thus foster hunger for the poorest – yet, sustainable development of biofuels could also encourage investment and market developments that improve overall food security (Osseweijer et al., 2015; Kline et al., 2016).

In the policy arena, most discussions about coherence and interlinkages in the 2030 Agenda have focused on either simply establishing that there is a link, or discussing the existence of trade-offs and synergies between topic areas (representing whether an interaction is broadly beneficial or adverse) and the need to map them and identify ways to alleviate or remove trade-offs or their costs, as well as maximise synergies (e.g. PBL, 2012; IRP, 2015).

However, interactions between SDGs currently have a weak conceptual and scientific underpinning, and there is a clear need for approaches and tools that can support analysis of the nature and strengths of these interactions, and the extent to which they constrain or enable policy and action. Indeed, there is a need to develop guidance and tools that can help policymakers, investors and other actors to identify and manage the benefits and risks of achieving the various goals and targets. In particular, it is important to deploy a more nuanced view of interactions, and to move the discourse beyond the simple notion of trade-offs and synergies. Attempts have been made in recent years. For example, Weitz et al. (2014) and Coopman et al. (2016) applied an approach for interlinkages with three categories – supporting, enabling and relying (with sub-categories). International agencies have also published increasingly advanced approaches to identifying and evaluating interactions (e.g. UNESCO, 2016; UN, 2016).

Thinking carefully about SDG interactions and more specifically about the range of different types of interaction is important because they may have very different implications in terms of implementation action. The nature and dynamics of the interactions need to be better understood before policy can be formulated, including the setting of context-specific (such as national or local) targets and indicators. Such analyses should be conducted with a view to providing a useable knowledge base for both policy-level decision support and the design of implementation strategies.

In short, there is a lack of information on this topic and more research is needed. For this reason, ICSU (2016) and Nilsson et al. (2016) have developed a tool, or framework, whereby interactions between SDGs and targets are classified on a seven-point ordinal scale, indicating the nature of the interaction with other targets, and the extent to which the relationship is positive or negative (see graphic p. 24). This framework has been applied throughout the individual chapters of the current report.

GOALS SCORING

INDIVISIBLE
The strongest form of positive interaction in which one objective is inextricably linked to the achievement of another. Reduction of air pollution (12.4) is indivisible from improved health and reducing non-communicable diseases (3.4).

+3

Outdoor and indoor air pollution is responsible for 7 million deaths annually, as well as respiratory and cardio-vascular disease but also increases in perinatal deaths. In 2012, ambient (outdoor) air pollution was responsible for 3 million deaths, representing 5.4% of the total deaths. Worldwide, ambient air pollution is estimated to cause about 25% of the lung cancer deaths. Major urban centers in low and middle-income countries are the most exposed to this burden. (WHO, 2016).

REINFORCING
One objective directly creates conditions that lead to the achievement of another objective. Increasing economic benefits from sustainable marine resources use (14.7) reinforces the creation of decent jobs and small enterprise in e.g. tourism (8.5 and 8.9)

+2

Sustainable and diversified strategies for using the marine resource base open up opportunities for small enterprises in fisheries or other harvesting and associated value-addition activities, as well as activities related to tourism. Many SIDS and LDCs that are rich in these resources also have poor, vulnerable and marginalized coastal communities.

ENABLING
The pursuit of one objective enables the achievement of another objective. Developing infrastructure for transport (9.1) enables participation of women in the work force and in political life (5.5)

+1

Affordable public transport promotes social inclusion, more equal access to different parts of the city, and enabling employment for marginalized groups. In many places, women do not have access to a car and depend on public transport, walking or bicycling to get around, to work places and to social or political activities (NCE, 2016; GSDR, 2016)

CONSISTENT
A neutral relationship where one objective does not significantly interact with another or where interactions are deemed to be neither positive nor negative. By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution (14.1) is consistent with target 3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.

0

There is no significant interaction between the two targets.

CONSTRAINING
A mild form of negative interaction when the pursuit of one objective sets a condition or a constraint on the achievement of another. Conserving coastal areas (14.5) and development of safe affordable housing and basic services (11.1) may constrain each other

-1

Establishing protection areas in the coastal zone and expanding urbanization, infrastructure or transport risks spatial competition especially in densely populated areas. Integrated coastal zone management and marine spatial planning tools are readily available to mitigate spatial competition.

COUNTERACTING
The pursuit of one objective counteracts another objective. Ensuring access to safe, nutritious and sufficient food can counteract sustainable water withdrawals (6.4) and reduction of chemicals releases (12.4)

-2

Increasing productivity in agriculture is a necessary (but not sufficient) condition to improve food security. In many places, this might entail increased and/or better irrigation as well as increased use of agro-chemical inputs.

CANCELLING
The most negative interaction is where progress in one goal makes it impossible to reach another goal and possibly leads to a deteriorating state of the second. A choice has to be made between the two. Developing infrastructure (9.1) could be cancelling the reduction of degradation of natural habitats in terrestrial ecosystems (15.1)

-3

In underdeveloped regions, developing roads, dams, and power grids might be a high priority, although it will cause some unavoidable fragmentation of habitats and compromising the integrity of the natural ecosystem, leading to risks to biodiversity as well as social risks.

BEYOND TRADE-OFFS AND SYNERGIES – A SEVEN-POINT SCALE

The framework identifies categories of causal and functional relations underlying progress or achievement of goals and targets. The scale ranges from -3 to +3, from instances where progress on one target acts to cancel progress on another to where progress on one goal is inextricably linked to progress on another. Complementing the scale are a number of key dimensions (time, geography, governance, technology, directionality) that describe the interactions and define the context in which they occur. Most interaction scores depend on these dimensions – and putting in place the right policies and technologies might shift the score to a more positive one.

To be more specific, positive interactions are assigned scores of either +1 ('enabling'), +2 ('reinforcing'), or +3 ('indivisible'), while interactions characterised by trade-offs are scored with -1 ('constraining'), -2 ('counteracting'), and -3 ('cancelling'). Thus, the magnitude of the score, in whichever direction, provides an indication of how influential a given SDG or target is on another. For instance, a value of +1 corresponds to an 'enabling' relationship, wherein the achievement of one objective (such as providing electricity access in rural homes, SDG7) creates conditions for furthering another (such as child and adult education, SDG4). Meanwhile a higher score of +3 corresponds to an 'indivisible' relationship, wherein one objective is inextricably linked to the achievement of another. For example, ending all forms of discrimination against women and girls (target 5.1) is absolutely necessary for ensuring women's full and effective participation in society (target 5.5). As an example of a negative interaction, the relationship between on the one hand boosting a country's economic growth (target 8.1) and on the other reducing waste generation (target 12.5) might be assigned a score of -2 ('counteracting'), since the former potentially clashes with the latter (unless mechanisms are put in place to prevent this, such as circular economy strategies that include effective waste prevention or substantially increasing recycling rates). Finally, for SDGs and targets exhibiting no significant positive or negative interactions, a score of 0 ('consistent') is assigned. Because interactions can manifest at the broad goal level, the more detailed target-level and even at the level of individual development actions, the framework has been designed to be applicable across multiple geographic scales (local to global), and for determining the impacts of planned actions as well as for evaluating the wider implications of actions that have already taken place.

Not all linkages between SDGs and targets will fall neatly into one of the seven points on the scale, but the scale does provide a sufficiently wide range to classify most relationships.

Choosing the level at which to apply the scale (goal, target or action) depends on the purpose of the assessment. In some cases,

having reached a target, the issue is then whether this will directly affect another policy area or target under the same goal or under another goal. The focus then shifts to the physical interaction – how one set of conditions in society or the environment affects our ability to attain another set of objectives. In other cases, the issue could be how policy instruments, actions or investments put in place to pursue one SDG target would affect the ability to pursue another policy area. The latter reflects standard impact assessment procedure, and can be used to mitigate negative interactions already in the project or policy formulation stage.

In practice, it will usually be a combination of examining instruments and targets that is required to identify an effective strategy. For example, the introduction of a fuel tax to promote energy efficiency (target 7.3) will have certain distributional (SDG10) consequences, such that lower income or rural populations are disproportionately affected by the tax, although improved energy efficiency in itself may not have such consequences. It should be possible both to simulate implementation strategies with integrated assessment models that test the relationship and monitor empirically the nature of interactions during implementation in reality. Over time, with the support of the scientific community, those in charge of monitoring the SDGS should be able to develop an ever improving dataset for systematically monitoring progress.

It should be noted that the position of a given interaction on the seven-point scale is rarely absolute. The position and nature of the interaction depend on the context within which the interaction occurs. It should also be clear that a good development action is one where all negative interactions are avoided or at least minimised, while at the same time maximising significant positive interactions; but this by no means suggests that policymakers should avoid attempting progress in those targets and goals that are associated with significant negative interactions – it merely suggests that in these cases policymakers should tread more carefully when designing policies and strategies.

KEY DIMENSIONS THAT SHAPE INTERACTIONS

A number of dimensions can be used to contextualise the assessment of specific synergies and trade-offs, providing deeper insights into elements and areas that the SDG- and target-level interactions depend on. These include directionality, place-specific context dependencies, governance, technology and timeframe. Each is now discussed in turn, with examples given to aid the explanation. In case-study analysis, it is important to discuss these contextual considerations at the same time as the assigned score. Understanding what interactions depend on, or whether they are intrinsic, is key to mitigating negative

interactions and maximising positive ones. In other words, changes in these dimensions can often enable a shift from a negative to a more positive interaction, or vice versa. Also, an analysis of a given interaction should, if possible, include an assessment of the uncertainty given the current state of knowledge.

DIRECTIONALITY

Interaction between two SDGs or targets can be unidirectional, bidirectional, circular or multiple. A unidirectional relationship means that objective A affects B, but B does not affect A. For example, electricity access (target 7.1) is needed for powering clinics and hospitals for the delivery of essential health care services (target 3.8), but health care services in clinics and hospitals are not needed for providing electricity access. On the other hand, a bidirectional relationship means that A affects B, *and* B affects A. For example, providing more access to transport today (target 11.2) is likely to lead to higher greenhouse gas emissions (target 13.2), thus exacerbating climate change, while measures taken to reduce greenhouse gas emissions can constrain transport access. In the case of bidirectionality, interactions can also be symmetrical (where the impact is similar in type and strength) or, more commonly, asymmetrical, where A affects B more, or in different ways, compared to how B affects A. In a circular relationship A affects B, which affects C, which in turn affects A. In a multiple relationship A affects B, C, D etc.

A comprehensive approach that takes into account directionality can be pursued whereby SDG targets are presented in a matrix and juxtaposed, and all potential interactions are analysed and scored, including A to B and B to A.

PLACE-SPECIFIC CONTEXT DEPENDENCY

Some relationships are generic across borders while others are highly location-specific; and the scale of the analysis can have a significant effect on results. For example, the issue of trade-off between bioenergy (target 7.2) and food (SDG2), which has gained significant attention in policy debates (see for example, Rosegrant et al., 2008) does not appear prominently in northern European countries such as Sweden or Finland (Ericsson et al., 2004). On the contrary, farmers and forest owners can both benefit from the diversification of markets, because it makes their supply chains less vulnerable as a whole. As a result, farmers may invest more and both food systems production and energy systems are stronger (Kline et al., 2016).

However, such geography-dependent relationships can have significant spill-over effects, due to international trade. Hence, even if bioenergy in the Nordic countries is not considered to affect their food security, a change in their food export patterns in response to increased national bioenergy production would still impact food security globally, through changes in trade and international prices of agricultural commodities. This dependency

is not limited to natural conditions, but can include level of development, configuration of political and economic interests, social and cultural attitudes, and many other aspects.

Thus, what constitutes a positive interaction and a negative interaction can differ from one context to another and from one scale to the next. Hence scientific evidence in one area that does not hold for a different scale or target area may appear highly contradictory at first glance. But using the SDGs as a knowledge management grid could help to clarify what evidence refers to what context, and how knowledge can be generalised.

GOVERNANCE DEPENDENCY

In some cases, the negative nature of a relationship can be the result of poor governance. For example, industrialisation (target 9.2) has sometimes been associated with infringement of rights (target 1.4), where commercial actors have taken over lands used by local communities without consultation or compensation and with the exclusion of those communities from work opportunities. However, this negative interaction is not necessarily intrinsic to the industrial activity itself, but rather derives from inadequate governance. Negative impacts on local communities are more likely to occur, or tend to be stronger, when institutions and rights are weak.

TECHNOLOGY DEPENDENCY

In some cases, while a strong trade-off may exist, there may be technologies that, when deployed, will significantly mitigate this trade-off, or even remove it. One example is growth in mobility (namely personal motorised transport) which, at present, conflicts with climate change mitigation efforts. In the future, however, the transition towards zero-emission cars fuelled by renewable electricity could largely remove this trade-off. However personal vehicle impact on land-use change will remain.

TIME-FRAME DEPENDENCY

Some interactions develop in real time, while others show significant time lags. For example, increases in fertiliser use will boost agricultural productivity that season (target 2.4), thereby increasing food availability and contributing to food security over the short term. Similarly, harvesting remaining fish stocks can have important food security (target 2.1), nutrition (target 2.2) and poverty alleviation (target 1.1) benefits in the short term, possibly to 2030. However, these practices might well have longer-term adverse impacts on several SDGs, ranging from SDG14 on the sustainable use of oceans to SDG2, SDG15 and SDG1, among others. Moreover, some interactions may be restricted in time to the actual period of intervention (i.e. when the intervention ceases, the interaction stops), while others are irreversible or take a very long time to dissipate (i.e. until the affected systems recover). Irreversible impacts are well known in land and ocean ecosystems, such as species extinction, collapsed fisheries or eutrophication (e.g. in the Baltic Sea, Lindegren, 2009; HELCOM, 2010).

THE ROAD TO POLICY COHERENCE

By systematically assessing the interactions and relationships between SDGs and targets, this report aims to support horizontal coherence across sectors. Coherence can be defined as *"an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives"* (Nilsson et al., 2012:396). However, it is also important to keep in mind the other dimensions of policy coherence (OECD, 2016, see graphic). These additional dimensions, that become visible during implementation, concern alignment between and across countries, across levels of government, across governance mechanisms, and across the implementation continuum.

HORIZONTAL AND VERTICAL INTERACTIONS AND COHERENCE RELATIONSHIPS

SECTORAL COHERENCE	TRANSNATIONAL COHERENCE	GOVERNANCE COHERENCE	MULTILEVEL COHERENCE	IMPLEMENTATION COHERENCE
from one policy sector to another	from one jurisdiction to another (PCD)	from one set of interventions to another	from global/international agreements to national and local policy	from policy objective through instrument design to practice

An important type of coherence relationship exists across transnational jurisdictions. This ties in directly to the policy coherence for development agenda (OECD, 2016) – observing to what extent the pursuit of objectives in one country has international repercussions or affects the abilities of another to pursue its sovereign objectives.

In addition, coherence relationships need to be observed across multiple levels of government. Here, in the context of the 2030 Agenda, there may be a mismatch between the goals and targets established at the global level, and the agenda as interpreted at national level and acted upon at the local level.

Coherence can also be examined across governance interventions. For example, policymakers and planners put in place different legal frameworks, investment frameworks, capacity development mechanisms and policy instruments that may or may not pull in the same direction. In fact, it is often the case that while new policies and goals can be easily introduced, institutional capacities for implementation are not aligned with the new policy designs, because the former are commonly more difficult to develop (OECD, 2016; Gupta and Nilsson, 2017).

Finally, coherence relationships should be considered along the implementation continuum: from policy objective, through instruments and measures agreed, to implementation on the ground. The latter often deviates substantially from the original policy intentions, as actors make their interpretations and institutional barriers and drivers influence their response to the policy (Pressman and Wildavsky, 1973; Nilsson et al., 2012).

FIRST APPLICATION OF THE SCALE

Subsequent chapters apply the framework as presented here to key interactions for SDG2, SDG3, SDG7 and SDG14. This selection presents a mixture of key SDGs aimed at human well-being, ecosystem services and natural resources, but does not imply any prioritisation.

The chapters follow a similar structure. Each starts by presenting an overview of interactions between a single SDG (the 'entry goal' focus of the chapter) and the other 16 SDGs, staying at goal level. Taking into account all the underlying targets of the entry goal, a set of key interactions is then identified between the entry goal targets and those of numerous other SDGs, principally interactions within the range of the highest magnitude or strongest impacts based on available scientific literature and expert knowledge. Using the typology and seven-point scale described earlier, the chapter then provides an assessment of the selected target-level interactions and the context in which they *typically* occur. Illustrative examples from different world regions show how these linkages manifest in practice. Policy options are identified for how to maximise positive interactions and minimise negative interactions between now and 2030, and beyond. Each chapter concludes with a list of key knowledge gaps related to the interactions studied.

The scoring approach described here offers a means by which multidimensional, complex and wide-ranging scientific evidence can be 'translated' and summarised in the form of an interpretive framework. The end product is such that evidence gathered from scientific research can be fed into deliberations between policymakers for different topic areas in an accessible, understandable and directly comparable form.

The report does not aim to present a fully comprehensive analysis of all possible interactions for a given SDG and its underlying targets. Rather, the aim is to illustrate, by focusing on a subset of the key interactions, how the scoring framework can be applied in practice. Going forward, a comprehensive analysis of this type could, and should, be carried out on all SDGs. It is hoped that this report inspires the development and synthesis of empirical research on interactions across all the SDGs in different parts of the world, and among different scientific and policy communities.

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