SDG 12: Responsible Consumption and Production

A review of research needs

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Summary

Sustainable Development Goal (SDG) 12 calls for responsible consumption and production, essentially decoupling economic growth from unsustainable resource use and emissions and improving the management of hazardous substances and waste. In particular it calls for implementation of the 10-Year Framework of Programmes on Sustainable Consumption and Production (SCP), for efficient use of natural resources, for cutting food and other waste, for responsible management of chemicals, for sustainable public procurement and for companies to adopt more sustainable practices.

This study demonstrates the use of a methodology combining literature review with an exploratory expert workshop to identify research needs related to SDG goals and targets, in this case a selection of targets under SDG 12 and a related target from SDG 8 (see table 1). The targets were selected as they pointed most clearly to research questions that could contribute in important ways to the achievement of the SDGs.

Based on the selected targets, we identified three key themes: (i) issues cutting across efforts to advance SCP; (ii) sustainable natural resource management; and (iii) reducing food waste and loss. Although the focus was on the Swedish context, the literature review in particular sought to identify research needs in both developing and developed country contexts.

Given the broad scope of SDG 12 and the field of SCP, this study should be seen more as a proof of concept rather than as a comprehensive list of research needs related to SDG 12.

Findings

Some general challenges were identified, along with specific research needs related to SDG 12 under each of three themes. Below is a selection of these.

General challenges

- The qualitative rather than quantitative nature of SDG 12 makes it difficult for countries to measure their achievements
- The global total and per capita material footprint of consumption continues to increase, although many regions have been successful in reducing domestic material consumption. Political efforts need to shift from increasing efficiency to decreasing overall consumption, and from identifying problems to finding solutions
- Upscaling of good SCP examples has been difficult, and more research is needed on how
- Consumers, businesses and public-sector decision-makers lack knowledge about SCP, and there is need to bridge different actors' knowledge as well as to better bridge science and concrete applications.

Theme 1: Cross-cutting issues

Systemic issues

- Integrating knowledge about the whole supply chain, from production to consumption

SDG 12 targets, and those covered in this study (bold)

SDG 12: Ensure sustainable consumption and production patterns	
12.1	Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
12.2	**By 2030, achieve the sustainable management and efficient use of natural resources**
12.3	**12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses**
12.4	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
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities
12.8	**By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature**
12.a	Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production
12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
12.c	Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities
SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
8.4	Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

- Limitations imposed by the economic system on sustainability efforts, including by the private sector
- More sustainable business models suited to circular economy.

Consumption and consumer behaviour

- Making it easier for consumers to make more sustainable choices
- Possible impacts of a shift in consumption away from goods and towards services
- Pathways for effective norm diffusion
- Linkages between consumption patterns and health issues, e.g. mental health, diet-related disease
- Those policy instruments and legal frameworks that are most conducive to (and most inimical to) a sustainable consumption transformation
- New marketing practices and the changing media landscapes for cultural and social norm change.

Monitoring and indicators

- Improving institutional and technical capacity to monitor SCP
- More assessment and benchmarking
- More convergence of reporting systems to reduce reporting burden and align global and national indicators.

Theme 2: Natural resources management

- Current trends and future prospects for global resource use and sustainable resource management
- Interactions between climate change mitigation and sustainable resource management
- The socioeconomic implications of transitioning to more resource efficient economies and societies
- Links between sustainable resource management, conflict, security and migration
- Consumption as the main driver of increased material use
- How to act on opportunities and challenges for resilience as an objective of natural resource management in developing countries
- Bridging between natural resource management research, policy and practical needs.

Theme 3: Food waste and loss

- Taking into account the diversity of stakeholders and an integrated whole-supply-chain approach
- How to support action in producer countries through enhancing scientific and technological capacity
- Focus on research for reducing post-harvest losses in developing countries
- Opportunities for productive, profitable, sustainable use of food and crop waste and residues
- Capturing the potential of big data
- Keeping agricultural research up to date with the global, regional and local impacts of climate change, water shortages and other shocks

- Research into resistant crop varieties, pest control, better packing and transport, and low-cost storage technologies
- Strategies for tackling consumption waste
- Consumer behaviour – making reduction of food waste appealing
- Enabling factors for food re-distribution
- Improving data on food wastage.

1 Introduction

This study forms part of the project Formas Agenda 2030, which aimed to identify research needs related to the 17 Sustainable Development Goals (SDGs) and to explore options for making structural changes in research policy and funding in order to foster further progress towards the SDGs. The project involved literature reviews and exploratory workshops focusing on three SDGs as examples: SDG 12: Responsible Consumption and Production, SDG 14: Life Below Water and SDG 17: Partnerships for the Goals.

Based on a literature review and workshop discussions, this study identifies research needs related to four targets under SDG 12, along with a target from SDG 8 that is closely related (see table 1). The reasons for selecting these targets are set out below. The study focuses on needs related to three themes, which are based on the studied targets and relevant to the Swedish context: cross-cutting issues for SDG 12, natural resource management, and food waste and loss.

The research needs identified are related to two functions: characterising the challenges of meeting the targets, and providing solutions. These are two of the three roles for science, technology and innovation in implementing the SDGs defined by Nilsson (2016). Research needs relating to the third proposed role, strengthening public institutions and society, are discussed in more depth in the main report (Persson et al. 2018, in Swedish).

SDG 12 calls for "responsible consumption and production". It aims at decoupling economic growth from environmental damage and natural resource exploitation. Its eight targets include implementation of the 10-Year Framework of Programmes on SCP, efficient management and use of natural resources, cutting various types of waste, and responsible management of wastes and chemicals. It also calls for adoption of sustainable practices in companies and in public procurement.

Consumption and production are essential to the global economy. Anthropogenic harm to the environment and human health is almost entirely the result of production and consumption activities. At the same time, food security, poverty alleviation, medicine, infrastructure, welfare and services all depend on productive activities and the wealth they generate. Thus most, if not all, of the SDGs are thus intricately linked with SDG 12.

The total and per capita material footprint of humanity continued to increase between 2000 and 2010. This footprint is unequally distributed, being much higher in OECD countries (UN, 2017), while the environmental and resource impacts related to producing the goods and services consumed may be distributed all over the world, depending on trade links. Thus, addressing unsustainable consumption and production patterns requires a systems approach supported by cooperation between supply chain actors, awareness-raising and education (Reisch et al. 2016, p.6).

A sustainable consumption policy agenda has emerged gradually at the international level to support national and regional activities, through Agenda 21 (from the 1992 Rio Summit), the UNEP-led Marrakech process (2003) and the 10-Year Framework of Programmes on

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8.4	Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

Sustainable Consumption and Production[1]. The Swedish policy agenda around SCP is described in Box 1 below.

The growing importance of SCP at the international policy level is evident. The fact that SCP has its own SDG is already significant, as is the fact that the UN 10-Year Framework of Programmes on Sustainable Consumption and Production (10YFP) is expressly mentioned in SDG targets 8.4 and 12.1. Another example is the most recent UNCTAD Global Guidelines for Consumer Protection, which cite sustainable consumption as an express objective and recognise consumers' right "to promote just, equitable and sustainable economic and social development and environmental protection" (UNCTAD 2016, p.6).

1.1   Method and approach

This study should be seen as a test of the concept of and method for identifying research needs related to SDG goals and targets. The scope of the study did not allow for an exhaustive or in-depth assessment of the state of knowledge.

The method used involved three steps. The first step was to identify important themes among the targets under SDG 12, in order to reduce the number of targets and to find broader knowledge areas or themes that relate to several targets. The criteria and approach for selecting these key themes are described below.

The second step was to conduct a literature review, seeking research needs already explicitly or implicitly identified in the literature. To get an overview of the research based and recent trends for each topic, we first consulted synthesis reports and general assessments such as International Resource Panel reports for natural resource management (UNEP 2016; UNEP 2017); FAO and World Resources Institute for food waste (Lipinski et al. 2013; FAO 2015). More in-depth knowledge and analysis was gathered through database searches for more focused materials, particularly peer-reviewed journal articles.

The third step was to organise an expert workshop with experts from the fields of science, policy and practice in order to identify high-priority research needs and how to meet them. The workshop was held on 8 May 2018 in Stockholm.

The discussions in the workshop were informed by, but not limited to, the preliminary findings of the literature review. The first part of the workshop comprised small group discussions to identify knowledge gaps related to the targets. The second was a brainstorming session to elicit input on how Swedish (and EU) research and innovation policy could contribute to Agenda 2030. In this report, we are concerned with the outputs of the first part of the workshop. It has chiefly been incorporated into the discussion on cross-cutting issues.

1.1.1   Challenges and limitations

SDG 12 has a very broad scope, making an exhaustive review of the potentially relevant literature inherently difficult. The stepped process in the review – starting with syntheses and general assessments and then moving to more specific literature – was intended to reduce this difficulty.

The SDG targets are the result of international negotiations, and as such may not reflect local or national sustainable development priorities. Thus, a review such as this might miss research needs that fall within the broad area of a goal at the national or local level.

Finally, two key limitations should be kept in mind when considering the results presented here. The first is that we were only able to review a part of the relevant literature. It is possible that other sources would have revealed other or more important research needs, or could help to fill some of the needs we identify. The second is that a review of this nature can only identify "known unknowns" in relation to SDG 12; there may well be "unknown unknown" research needs that will only be revealed with time.

1.1.2   Criteria for selecting targets and identifying key themes

All three of the goal-focused reviews under this project applied the same criteria for selecting the targets and themes to focus on:
- Targets should be those where lack of knowledge or research is a critical barrier to success; this meant that, for example, targets on implementing an international political agreement were excluded
- Targets that address similar issues and share a knowledge domain were clustered together
- The number of selected targets should be manageable within the limited scope and resources of the study
- The themes could interpret or expand on the contents of the targets themselves, to i) adapt them to a Swedish context, and ii) look at the more general sustainability issues implied by the goal but not necessarily reflected by the targets.

For the review of SDG 12, we focus on themes emerging from four targets under SDG 12, along with a closely related target that sits under SDG 8 (see table 1). The first theme is cross-cutting issues relevant to most SDG 12 targets and research on SCP, but not currently addressed by any one target. For example, we note that no target under SDG 12 addresses economic, social and cultural aspects determining consumption and consumer behaviour. In the Swedish context, there is active research and extensive policy debate on sustainable consumption and consumer behaviour, and thus we add this theme despite it not figuring strongly under SDG 12.

The other two themes are more explicitly linked to the selected targets: natural resource management (NRM), most closely linked to target 12.2, and food waste and loss, most closely linked to targets 12.3 and 8.4.

This approach of focusing on themes emerging from the targets, rather than directly on the targets themselves, reflects the need for targeted research across a range of topics, as well as the increasing importance of covering SCP in an "integrated and systemic manner" (Blok et al. 2015, p.4). The review identifies research needs within both developing and developed country contexts.

2 The state of research on SDG 12

Sustainable consumption and production is a relatively new research field, that "is not yet very well structured, and . . . its boundaries are still fluid" (Vergragt et al. 2014, p.8). In its Fifth Assessment Report (2014) the Intergovernmental Panel on Climate Change (IPCC) stated that greenhouse gas emissions can be substantially reduced through changes in consumption patterns. At the same time, the report also stated that the evidence base and level of agreement within the scientific community on this statement was lower than for the rest of the report. This made a clear call to the research community to strengthen the evidence base. Today, SCP has grown into a multidisciplinary field. It attracts natural scientists, environmental economists and psychologists, as well as sociologists, philosophers, innovation researchers, political scientists, historians and other researchers in the humanities, who all contribute diverse perspectives.

In recent years SCP has come to include the notion of sustainable lifestyles, adding the topic of individual behavior to study of the components of our production and consumption systems.

BOX 1. SWEDEN'S SCP POLICY

In 2016, the Swedish government presented a strategy for SCP focused on what the state can do in collaboration with municipalities, business and civil society and to help consumers consume more sustainably (Ministry of Finance Sweden 2016). The strategy focuses on the following areas: enhanced knowledge and deepened collaboration; promotion of sustainable consumption patterns; streamlining resource use; improving information on companies' sustainability efforts; phasing out harmful chemicals; consumers protection; and food, transport and housing.

Measures described in the strategy include: establishing a forum bringing together actors who can contribute to more eco-smart consumption and lifestyles (now established – https://www.forummiljosmart.se/); supporting education on consumption impacts in schools; promoting and "nudging" eco-smart behaviour; mapping out and promoting the sharing economy; improving eco-labelling; keeping goods in use longer, e.g. through tax breaks for and information about repair services, and introducing sustainability requirements for more categories of good; promoting circular economy, including by analysing effective policy instruments; revising the national waste management plan; requiring better reporting by businesses on sustainability, penalizing false "green" claims in marketing; an action plan on toxin-free everyday environment; steps to combat over-indebtedness; a food strategy; efforts on energy use in housing; investments in public transport and cycling; and a proposed tax on air travel (Ministry of Finance Sweden 2016). The focus and measures proposed in the strategy are in line with the targets under SDG 12.

The consumer has not traditionally been considered a major actor in strategies to achieve the EQOs. In 2012 the Swedish Environmental Protection Agency (SEPA; Naturvårdsverket) identified changes to patterns of consumption – in order to reduce impacts from producing, transporting and storying goods and services consumed in Sweden – as important area to achieve the Generational Goal and the EQOs, but in 2015 the experience and capacity to

analyse the role of consumption in the follow-up of the objectives remained limited (SEPA 2015).

The SEPA further stated that it agreed with research concluding that political action is needed to help consumers and market forces move towards more sustainable consumption patterns. In line with this, another report commissioned by the SEPA concluded that the field of sustainable consumption is characterised by a plethora of ideas and strategies but few policy instruments have been introduced that have had a tangible effect on consumption patterns (Persson et al. 2015).

The SEPA report presented a review of policy instruments for sustainable consumption implemented in Sweden. A CO_2-differentiated vehicle tax, a "green car" rebate, and congestion charges in Gothenburg and Stockholm were found to have significant effects on consumption behavior. More generally, the report concludes that policy tools (economic or regulatory) that only focus on reducing consumption should be coupled with policy tools for research and development to stimulate technological development of more sustainable alternative goods and services (SEPA 2015)

The SEPA has stressed the need for alternative ways of measuring welfare and exploring the role of the tax, education and trade systems in making a shift to sustainable consumption (SEPA 2015). It further identified a number of research needs for more energy-efficient consumption patterns including research on the links between energy usage, behaviour and feedback mechanisms that change behaviour; research on automatic adjustment of energy consumption; and research on the consequences of having an increased number of active energy consumers and co-producers.

The research conducted has many times been needs-driven and searched for methods and tools that enable stakeholders to understand how consumption can be made more sustainable (Algehed 2015). It is often argued that systems thinking and collaboration among stakeholders along supply chains is necessary to further our understanding of SCP.

During the workshop, participants collectively identified a set of stakeholders/sectors that should ideally be included in transdisciplinary discussions on SCP research agendas. While not an exhaustive list, these include: industry and business players (e.g. strategy departments, marketing and social media); entrepreneurs; production-side players; arts and humanities (e.g. design, sociology, history); scientists, mathematicians and economists; public health actors; international trade; policy-makers; and youth.

In Sweden research on SCP has focused on the impact of consumption and production processes on humans and nature; on identifying a sustainable level of consumption and production; on consumption behaviours of individual consumers; on the design and production of more sustainable goods; on marketing and promotion of sustainable consumption and lifestyles; and on how policy tools can promote sustainable consumption and production (Algehed 2015).

It has been argued that SDG 12 and its targets are "too ambitious to be fulfilled" and that the lack of quantitative targets makes it difficult for states to measure their achievements (ICSU

and ISSC 2015, p.59). The need for monitoring methods and indicators for the SDG 12 targets is discussed under Theme 1 below.

The *Sustainable Development Goals Report 2017* (UNDESA 2017) notes that total and per capita material footprints continue to grow, although many regions have been successful in reducing their "domestic material consumption" (the amount of material used per unit of production).

It has been observed that current political efforts tend to focus on increasing the efficiency of existing technologies and processes, and reducing the negative effects of individual products. However, some argue that this approach does not consider the fundamental issue of decreasing aggregate consumption of scarce or polluting resources (Reisch et al. 2016, p.7), partly because governments are not usually willing to introduce heavy consumer regulation (Blok et al. 2015, p.3; Vergragt et al. 2014, p.11). There is thus need to shift political efforts from increasing efficiency to decreasing aggregate consumption.

Another challenge is taking good SCP examples to scale. It has been argued that while it is important to advance SCP knowledge and practice, it is also key to look into the issue of upscaling and spreading successful examples globally (Blok et al. 2015, p.8). Key questions for research here include how to best disseminate best practices among individuals, organisations and countries; as well as finding out the key facilitating factors for successful upscaling and expansion (Blok et al. 2015, p.10).

Finally, it has been argued that international policy-makers need "stronger, more unambiguous and more coordinated evidence from social science research" to help them in policy-making, and more funding is required for such research. However, in order to increase the amount of such funding, behavioural scientists should also work to make their research more relevant and accessible to these policy-makers (Reisch et al. 2016, p.7).

3   Theme 1: Cross-cutting issues

The first theme encompassed a number of common issues that should be given attention in SCP research: whole-system perspectives, consumption patterns and consumer behaviour, and how to measure and monitor progress towards sustainable consumption. Below we present insights from the literature review and the expert workshop on these issues.

3.1   System perspectives

Agenda 2030 emphasises the need for coherent policies and understanding of how different goals, and different processes, interact. The often long and complex supply chains that characterise contemporary global trade mean that the systems that link consumption and production can span thousands of miles, and those links can be very hard to discern. Hence the sustainable consumption and sustainable production agendas are often isolated from each other.

These production-to-consumption systems are influenced by a wide range of actors and processes, who may never communicate or be aware of their interdependencies. As a result, there is a move towards more interdisciplinary and transdisciplinary (i.e. involving both academic and non-academic stakeholders) research in the field of SCP.

Workshop participants noted a critical gap in synthesising and communicating SCP research, particularly when it comes to whole-system approaches. They also called for more sharing of practices, both North–South and South–North. While the North may have more knowledge in the areas of efficiency and safety, people in countries with lower incomes have often developed have more sustainable ways to consume that the North could learn from.

3.1.1 Economic systems

Research topics suggested in the workshop included how economic and finance systems influence and constrain companies' behaviour, and how they need to change in order to foster more sustainable business practices. Participants suggested study of: the barriers to more sustainable investment by companies and pension funds; how to implement a shift in taxation from labour to resources; and how to integrate economy and environment in the norms regulating finance and economy.

It was also suggested that research look at how current economic systems hinder sustainable consumption, production and lifestyles. Particular research topics suggested included: the limitations of voluntary private sector-led initiatives; possible rebound effects of changes aimed at making the economic system more sustainable; and new metrics of value that take into account value for society, not just economic value.

3.1.2 Business models

Participants also called for closer links between the scientific and business communities. Some of their suggested research questions included: how firms can set science-based goals; how they can find models to reduce their environmental impacts; ways for companies to reduce waste and also earn income from excess goods and process residues; how to boost transparency and traceability in supply chains; how to demonstrate that sustainability can be profitable.

3.2 Consumption patterns and consumer behaviour

3.2.1 Consumer behaviour and sustainable lifestyles

The workshop participants suggested that a strong focus is needed on research to better understand consumption and consumers. On the level of individual consumers, they argued that for accurately targeted and effective policies, it is important to have a good idea of the different consumer groups; for example, gender, age, lifestyle.

Another potential research question was about what hinders and what facilitates or encourages more sustainable consumption choices. How can consumers be encouraged to move towards collaborative consumption (sharing, borrowing, exchanging products), particularly of resource-intensive products such as cars and tools – and what can be done to shift perceptions that sharing and renting are overly complicated compared to purchasing

goods directly? When should sustainable consumption policy focus on changing consumer behaviour rather than on making sure more sustainable products are available and mainstreamed?

The participants agreed on the need for more producer-focused research. This included initiatives such as Trase, where transparency on the environmental and social impacts of production, and how they are linked to consumption, increases pressure on producers and businesses to adopt more sustainable practices. They also called for more research on the role of transparency and information in driving sustainable production and consumption. They also noted the important role schools can play in education for sustainable development, and called for more research on continuous learning on sustainable lifestyles and consumption. The participants called for more research into the effectiveness of current SCP policy consumer measures. For example, they called for mapping of interventions, and assessment of how far they genuinely support SCP in real life. Does the shift from consumption of goods to consumption of services (e.g. collaborative consumption) live up to its promise of reducing consumption impacts – could it even be having a negative impact?

They also wanted to see more research into how to increase the role of citizens in measuring and sharing information on their consumption, and how to encourage more innovative ideas on sustainable lifestyles and consumption. They wondered how it is possible to link the SCP agenda with health agendas, such as diet-related diseases and mental health.

Finally, the participants sought more clarity on the limitations of sustainable consumption measures: what goods, services and consumption patterns cannot be brought into circular economy or otherwise made more sustainable? What lifestyle choices are compatible with circular economy? What types of consumption cannot be dematerialised?

3.2.2   Governance, law and policy instruments

Workshops participants also suggested that more research is needed into the role – both positive and negative – policy and legal frameworks and societal structures can play in shifting towards SCP.

For example, they called for more research into how policy measures could influence economic activity in more sustainable directions and even bring about a sustainability transformation. They noted a need to understand formal and informal incentive structures and the role of different economic actors. They also called for research into obstacles such as inertia and unsustainable social structures that prevent change; rebound effects and perverse incentives, along with how to understand, measure and reform fossil fuel subsidies.

Participants suggested research on the drivers of increasing demand for goods and services with high environmental impacts (e.g. air transport), and what policy measures can help to better manage or reduce this demand.

Considering the public sector as a consumer, participants called for research on barriers to more sustainable public procurement, and how to break down these barriers and establish better, more sustainable public procurement systems.

On the topic of circular economy, participants proposed that research is needed into which policy instruments are most effective in keeping toxins out of resource and waste flows. They called for a review of review of existing circular systems, and research into how to reshape regulatory frameworks to support circular economy, given that they tend now to be adapted to a more linear model.

They also suggested research into how to use legal and regulatory frameworks for businesses to encourage more sustainable business practices; for example, setting sustainability criteria for stock market listing. For the media, it was suggested that stricter rules are required, for example on marketing to children, as well as clearer marking of advertising copy to distinguish it from editorial copy.

On institutional structures, participants noted that given the intersectoral nature of SCP, research was needed into the best models for collaboration, within government, between different governance levels and with non-government stakeholders – and which are best suited to particular contexts and conditions. They also called for research into how well measures taken by Swedish municipalities to influence citizens' consumption patterns correspond to the factors that actually affect consumer behaviour identified in scientific research. They also suggested research into how to integrate supply- and demand-side policies most efficiently.

Finally, they called for research into the optimal SDG indicators for measuring progress on SCP and incentivising action. What new indicators would be needed?

3.2.3   Cultural and social norms and behaviours

One suggested topic of study was how cultural and social factors are linked to consumption. In particular, research could look at: the role of media, marketing and other communications; how to make the sustainability transition both feasible and attractive to society at large; and the potential role of social networks (including via social media) in analysing norm changes and promoting sustainable consumption.

Other research areas suggested included the risks of backlash to measures intended to promote more sustainable lifestyles; how to compete with messages encouraging excessive consumption; how to change consumption patterns without relying solely on economic incentives; the relationships between consumption and health (mental and physical), well-being and happiness (linking SDG 12 to SDG 3, 7, 13, 14 and 15); and how to spread messaging about sustainable consumption and lifestyles beyond the middle class globally, to filter into norms, cultures and life aspirations.

Gender was also raised as a topic, in particular a need for more research on the differences in consumption patterns between genders. This could help ensure equity and lead to more so as to inform other associated topics, e.g. marketing.

3.3 Monitoring and indicators

Monitoring progress on SDG 12 is critical for learning that can catalyse a transition to SCP (Blok et al. 2015, p.2), and is thus a clear research need. However, a study by Statistics Sweden and the Chilean Ministry of Environment pointed out that many countries have difficulty constructing and producing indicators (Steinbach et al. 2016, p.3).

In a recent assessment of available statistics for following up progress on the 2030 Agenda (SCB 2017b), Statistics Sweden found that only two of the global indicators suggested by the Interagency and Expert Group on SDG Indicators (IAEG-SDGs 2016) for SDG 12 could be applied at the national level as formulated, and another one could be measured in part using the global indicators or with a national indicator. Additionally, the study found that five non-statistical indicators (e.g. policy assessments) could be used to measure SDG 12 progress in Sweden.

The study proposed two alternative indicators for national monitoring, one using domestic and international emissions due to Swedish, the other using the intensity of emissions per unit of GDP (SCB 2017b).

Steinbach et al. (2016) also argue that to avoid an unfeasible reporting burden, it is important that current international reporting systems converge. For example, they suggest using the existing System of Environmental-Economic Accounting (SEEA) for reporting on SCP-related targets (both under SDG 12 and throughout the SDGs).

The Swedish Environmental Protection Agency (EPA) has identified changes to patterns of consumption and the underlying production of goods and services as highly relevant to Sweden's Environmental Quality Objectives and the overarching goal of Swedish environmental policy, the Generational Goal.[2] However, in 2015 it reported that the experience and capacity to analyse consumption in the follow-up of the objectives remained limited (SEPA 2015). One research initiative addressing this need is the EPA-funded research programme PRINCE, which explored possible new indicators for the environmental impacts of Swedish consumption (see http://prince-project.se and Steinbach et al. 2018).

In the workshop, participants noted the importance of research that reveals the full impacts of consumption and production, along global supply chains. This includes taking into account less-measured impacts such as emissions from the airline industry. They highlighted both supply chain transparency (citing the Trase initiative – http://trase.earth – among others) and lifecycle analysis (LCA; citing the Global LCA Data Access Network https://www.globallcadataaccess.org/). Traceability was also mentioned as an area for research and one that could support more sustainable business models.

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[2] The Generational Goal is to hand over to the next generation a society in which the major environmental problems have been solved, without increasing health and environmental problems outside Sweden's borders. See https://www.miljomal.se/Environmental-Objectives-Portal/.

Universal access to this data was also mentioned as a priority, for example to support sustainable lifestyle choices and as a way to strengthen accountability among large companies with globally distributed supply chains.

4 Key theme 2: Natural resource management

4.1 Global material use and efficiency

As the 2030 Agenda makes clear, sustainable natural resource management is a prerequisite for sustainable development (Ludwig et al. 2015, p.3). Economic trends and natural resource use are closely related, with economic growth usually correlated with increasing resource use. According to the International Resource Panel, launched by UN Environment in 2007, environmental impacts are "disproportionately accelerated" by declines in global material efficiency (UNEP 2016, pp.15, 40). To reduce material use quickly and in a sustained way, the Panel argues that we must find ways to overcome inertia in global systems (UNEP 2016, p.14).

The International Resource Panel comprises eminent scientists in the field of natural resource management, offering scientific analysis and policy advice. Its 2018–2021 strategy proposes a focus on the following areas (UNEP 2017, p.2):

- Current trends and future prospects for global resource use and sustainable resource management
- Sustainable resource management within the global climate change agenda
- Socioeconomic implications of the transition to more resource efficient economies and societies
- Sustainable resource management links to conflict, security and migration

4.2 The role of consumption in natural resource management

According to the International Resource Panel report, in recent decades changing consumption patterns have been the main driver of increased material use, outstripping even population growth (UNEP 2016, p.5). A material footprint indicator in the report (measuring the quantity of natural resources required to meet consumption demand) indicates that wealthy countries have achieved their level of development largely through unsustainable, resource-intensive consumption and production patterns (UNEP 2016, p.5) and in many cases through large-scale imports of materials from other regions (UNEP 2016, pp.14–15).

This means that the interests of net raw materials importing countries and net exporting countries can differ. While net importers want to improve material efficiency in their production processes and keep raw materials prices low in order to keep down their costs, exporters benefit from higher export volumes and/or prices (UNEP 2016, p.15). Both of these can have negative implications for environmental and socio-economic sustainability.

Two of the cross-cutting issues discussed in the previous section – consumption patterns and consumer behaviour, and whole-system perspectives (and cooperation) – are relevant here.

4.3 Linking research with policy and practical needs

There is increasing recognition of the importance of framing research to reflect policy and practice needs. Involving stakeholders from various sectors and disciplines in setting research priorities has had demonstrated successes (see e.g. Petrokofsky et al. 2010, p.357). The International Resources Panel also names engaging the private sector as "a key transversal element" (UNEP 2017, p.2).

A multi-country comparative analysis of natural resource management programmes under the CGIAR partnership looked at how different kinds of "boundary work" (i.e. defined as engaging with "new science, other sources of knowledge, and the worlds of action and policymaking") contributed to success (Clark et al. 2016). They found that knowledge needed to be perceived by decision-makers as both scientifically credible and relevant to their needs in order to be used to support decision-making. They warn of the dangers of "insufficiently permeable" boundaries – where scientists simply guess at what is relevant, and decision-makers are unaware of relevant research – and "overly permeable" boundaries, where science becomes politicised or, conversely, politicians avoid responsibility for decisions with social equity or other implications by "repackaging" them as merely technical matters (Clark et al. 2016, p.4617).

5 Key theme 3: Food waste and loss

Each year, approximately 1.3 billion tonnes of food, or one-third of all food produced for human consumption, is never consumed (FAO 2015). This also means that about 24% of the caloric value of food intended for human consumption is wasted (Lipinski et al. 2013, p.1).

According to Lipinski et al. (2013, p.1), "economically [food loss and waste] represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide."

It has been argued that more agricultural and food system research – including on how to scale up existing good practices – is essential to achieve food, water and energy security for the future. This research must look not just at increasing food production, but also at how to steer systems towards better social and environmental outcomes. Reducing unnecessary food waste in the food system is one way to improve these outcomes, and consequently to put less pressure on the environment (Swedish Government 2017, pp.73–74).

The workshop participants highlighted three specific areas for research: (i) knowledge and structures for reducing food waste, in particular reusing leftover foods; (ii) the specific case of the airline industry: reduction of food waste (and related plastic waste); and (iii) a lifecycle analysis perspective on the food industry.

5.1 Food loss

While wealthier countries tend to see more food "leaving" the system as food waste at the consumption stage, in developing countries it tends to happen in the form of food losses during production, handling and storage (Lipinski et al. 2013, p.8). This reduces the food available to eat or sell, reducing farmers' control over their incomes and ability to hold back crops until market prices are favourable (Kibaara 2015).

Sweden has identified the importance of taking or supporting action in production countries as part of its sustainable consumption strategy, for example through helping to build scientific and technological capacity (Swedish Government 2017, p.73). This could include capacity to harvest, process and store food crops more efficiently.

CGIAR has identified food system losses as one of five "major research challenges with potential for very high payback" in terms of improving the lives of the poorest in low- and middle-income countries (Kyte 2016, p.33). It notes the need to consider the whole value chain, and to put residues and by-products to more productive use – as soil conditioner, fertiliser, or feedstock for energy generation, for example. It also stresses the potential of big data and the need to keep pace with the impacts of climate change, water shortages and other shocks.

A 2013 working paper by the World Resources Institute recommended doubling global investment in reducing post-harvest losses in developing countries in order to spur action to cut food loss and waste (Lipinski et al. 2013). It said that in developing regions, post-harvest losses (which happen during handling and storage) account for between one-fifth and one-third of all food loss and waste, and more than 40% of fruits and vegetables spoil before they are consumed (Lipinski et al. 2013, p.33). Reducing post-harvest losses attracts only 5% of agricultural research investment, compared to 95% on increasing crop production despite its cost-effectiveness (Lipinski et al. 2013, p.29) – as illustrated by a government programme in Rwanda (Kibaara 2015).

Better post-harvest storage could not only cut food loss but also reduce economic losses, improve food safety, reduce market gluts (and associated price dips), and allow a greater share of the harvest to meet food safety stands for export. Godfray and Jahn (2014, pp.13–14) call for more research on applying "modern technologies, breeding approaches and improved logistics and infrastructure in food supply networks" to reduce food loss. Potential areas for research include more resistant crop varieties; better packing and transport; reducing pests

and diseases in stored food; and low-cost, efficient cooling and refrigeration facilities suited to developing country contexts; and productive reuse of nutrients or energy in food that spoils.

Some research areas that relate to both boosting crop yields and reducing post-harvest loss are: the variety, risks and opportunities in different smallholder production systems; farm size dynamics; and governance models for shared resources (Godfray and Jahn 2014, p.10).

5.2 Consumer food waste

There is a need for more research and innovation on strategies for tackling consumer food waste (Lipinski et al. 2013, p.33). There is also a need to scale up consumer awareness campaigns and increase the number of countries doing them (Lipinski et al. 2013, p.25), which implies a possible need for research into the best ways to convince consumers to reduce their waste.

One practical example of a strategy to reduce food waste is food redistribution – giving away food that would otherwise be lost or wasted. This can be done at the production, manufacturing and distribution stages of the food supply chain, but there are important questions regarding, for example, the logistics of transporting the food in time, legal consequences if the food is no longer safe to eat, and the question of who pays for the redistribution (Lipinski et al. 2013, p.12).

On a related note, while it is typically developed countries who see food waste on the consumption side, developing countries, similar food waste patterns can also emerge in developing countries as diets change and incomes rise (Lipinski et al. 2013, p.33). Thus, this area of research should also be considered in developing countries.

5.3 Better data on food systems

In general, estimates of food wastage are poor and better data is needed to guide policy (Godfray and Jahn 2014, pp.13–14). In a progress report on Target 12.3, it has been noted that baseline food loss and waste levels need to be established, with regular follow-up monitoring (Lipinski et al. 2017, p.17).

Lipinski et al. also recommended the development of a food loss and waste measurement protocol, which "should be globally applicable to enable consistency, comparability, and transparency across users. It should cover both food loss and waste, and be relevant for both countries and private-sector entities" (Lipinski et al. 2013, p.28). This has now been done in the first iteration of the Food Loss and Waste Accounting and Reporting Standard (Hanson et al. 2016). The global uptake of this standard as well as accompanying analyses should be encouraged to improve the consistency of data.

5.4 Research on an integrated supply chain approach

Technical solutions often depend on other parts of the food supply chain to function well; for example, if farmers cannot access a market to sell their harvest surplus, improving storage facilities will not reduce food loss. This highlights the need for an integrated whole-supply-chain approach to substantially reduce food loss and waste (Lipinski et al. 2013, p.11).

Individual supply chain actors would not necessarily be willing to invest in research on, and collaboration with, other parts of the supply chain; thus investment in collaborative efforts will probably have to come governments, foundations, development agencies and multilateral institutions

6 Conclusions

The results presented here demonstrate the value of the novel approach to assessing research needs in relation to SDG goals and targets applied here. Exploratory expert workshops complemented the findings of the literature review, adding knowledge of ongoing research and debate, as well as practical needs. Although the methodology is limited to the "known unknowns" in terms of research needs, it does provide rich information.

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