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STAP Report to the 6th GEF Assembly

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This Report includes the following papers:

Integration: to solve complex environmental problems

Managing knowledge for a sustainable future

A future food system for healthy human beings and a healthy planet

Plastics and circular economy

Environmental security: dimensions and priorities

Integration: to solve complex environmental problems

A STAP document

June 2018

STAP SCIENTIFIC AND TECHNICAL ADVISORY PANEL

An independent group of scientists that advises the Global Environment Facility

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ABOUT STAP

The Scientific and Technical Advisory Panel (STAP) comprises seven expert advisors supported by a Secretariat, who are together responsible for connecting the Global Environment Facility to the most up to date, authoritative and globally representative science. http://www.stapgef.org

ABOUT GEF

The Global Environment Facility (GEF) was established on the eve of the 1992 Rio Earth Summit, to help tackle our planet's most pressing environmental problems. Since then, the GEF has provided $14.5 billion in grants and mobilized $75.4 billion in additional financing for almost 4,000 projects. The GEF has become an international partnership of 183 countries, international institutions, civil society organizations, and the private sector to address global environmental issues. http://www.thegef.org

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CONTENTS

SUMMARY

Science indicates that several planetary boundaries have already been breached, including genetic biodiversity, biochemical (nitrogen and phosphorus) flow, land-system change and climate change. Large scale, transformational change is needed to deal with these problems, and without a stable and healthy Earth system the Sustainable Development Goals will not be achieved.

In the World Economic Forum's Global Risks Report 2018, 6 of the 10 greatest risks, in terms of likelihood and impact, are environment-related. Food and water crises are both intertwined with the environment, and also in the top 10 risks. A deteriorating global environment poses significant threats to environmentally sustainable development.

Environmental challenges are complex and interlinked, not only in themselves but also with social and economic issues. Better human well-being, for example, poverty reduction, improved human health, energy access and economic growth, are linked to ecological factors. Solutions for one problem can lead to unintended negative consequences, or create new environmental or socio-economic problems. For example, increasing food production in ways that deplete soils, waste water, kill pollinators and increase desertification and deforestation, would eventually prove self-limiting.

Addressing these interconnected and interacting environmental and social challenges requires systems thinking; this is fundamental to better integration. Systems thinking examines the relationships between the different parts of a system, for example, the food supply system, or a commodity supply chain, especially cause and effect relationships, and positive or negative feedback mechanisms, between the biophysical and socio-economic features of the system. Systems thinking also considers the interactions between components of a system across different locations and organizational levels, as well as over time. Many of these relationships are non-linear. Understanding the connections between variables helps to identify points for effective intervention.

Since its inception in 1992, the GEF has recognized that environmental benefits and socio-economic development objectives can be achieved simultaneously. Integration was built into the design of the GEF: it is specifically tasked with integrating global environmental concerns with national objectives in the framework of national sustainable development strategies.

The GEF has made considerable progress in successfully designing and implementing integrated projects: in biodiversity, international waters, land degradation, and in multi-focal area projects. In 2014, the GEF further cemented its efforts on integration with the three Integrated Approach Pilot programs on food security, commodity supply chains, and sustainable cities, conceived in response to the GEF's 2020 Vision.

The Independent Evaluation Office's OPS6 report, "The GEF in the Changing Environmental Finance Landscape", recommended a continued focus on integration: "The GEF should continue pursuing an integrative principle in its programming based on scientific and technical merits. A strong, cogent rationale for designing integrated programs and multi-focal area projects – based on demonstrated additionality, GEF experience, GEF comparative advantage, innovative contributions, environmental need, and national relevance – must be the basis for such interventions."

Balancing complexity and efficiency as the GEF seeks transformational change and lasting outcomes remains a challenge. Nevertheless, STAP encourages the GEF to continue pursuing integrative projects based on systems thinking. These actions will lead to more efficient and effective approaches to planning, monitoring and implementing projects addressing complex human-environment interactions.

To improve integration further in the design of future GEF projects, STAP recommends:

1. **Apply systems thinking:** i.e. address inter-connected environmental, social, economic, and governance challenges across sectors with an eye towards resilience and transformational change.

2. Develop a **clear rationale and theory of change** to tackle the drivers of environmental degradation through assessing assumptions and outlining causal pathways – and have a 'Plan B', should desired outcomes not materialize.

3. Assess the potential **risks and vulnerabilities** of the key components of the system, to measure its resilience to expected and unexpected shocks and changes, and the need for incremental adaptation or more fundamental transformational change.

4. Devise a logical sequence of interventions, which is responsive to changing circumstances and new learning (**adaptive implementation pathways**). Develop clear indicators that will be monitored to determine progress and success in achieving lasting outcomes.

5. Develop explicit plans and funding for **good quality knowledge management** including: sustainable databases; simple, useful and usable common indicators; face-to-face consultations; and building stakeholder capacity. This is essential for 'lessons learned', and scaling up.

6. Apply **exemplary stakeholder engagement**, including with local communities, not just government officials, from inception and design, through to project completion. This is crucial for identifying diverse needs and managing trade-offs.

7. **Allow flexibility in project preparation** to accommodate the additional transactions costs and time required to tackle complex issues through multi-agency teams.

Transformational change necessarily entails risk. Risk and transformational change are intertwined, and lie at the core of building the GEF's capacity to respond to change and making it resilient. The GEF can strengthen its organizational capacity to deal with change, and to deal with uncertainty through experimentation and innovation. The GEF could also encourage a greater diversity in the risk profile of projects.

The GEF is uniquely placed to lead the way in applying and strengthening evidence on the science of integration and systems thinking to deliver global economic, social and environmental benefits.

1. WHAT IS THE ISSUE?

"When you are living in a globalized economy and a globalized world, you cannot live in isolation; all the problems and solutions are interconnected…" Kailash Satyarthi, Nobel Peace Prize winner

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe." John Muir

The ecosystems, biomes and processes that regulate the stability and resilience of the Earth system are under severe pressure[1]. Science indicates that several planetary boundaries have already been breached, including genetic biodiversity, biochemical (nitrogen and phosphorus) flow, land-system change and climate change[2,3]. At its quadrennial replenishment in 2018, it is timely for the GEF to reflect on how our understanding of tackling environmental problems has shifted, and what factors make for successful outcomes. Large scale, transformational change is needed to deal with these problems, and without a stable and healthy Earth system humanity will not achieve the Sustainable Development Goals (SDGs)[4].

In the World Economic Forum's *Global Risks Report 2018* [5], six of the ten greatest risks, in terms of likelihood and impact, are environment-related[6]. There is increasing recognition that a deteriorating global environment poses significant threats to future economic growth and development. Standard risk management approaches will not be sufficient to address the complex societal, environmental, and economic systems and their interactions, that characterize nations across the world[7].

The notion that environmental problems can be dealt with in individual silos is long gone. Reducing the loss of biodiversity simply by establishing protected areas will not succeed, when much biodiversity is found in areas under production, both in agriculture and in the seas. Furthermore, as the climate changes, habitat fragmentation restricts species to smaller spaces, reduces genetic variability and stresses or dramatically alters ecosystems[8]. Protected areas are important – but are only part of the answer. Innovative ways are needed to integrate development and biodiversity protection. There is a risk of inadvertently making things worse, for example, by expanding agriculture in ways that deplete soils, waste water, kill pollinators and increase desertification and deforestation. Otherwise, efforts to increase food production will eventually prove to be self-limiting.

Biodiversity loss, pollution of land and water resources, land degradation, and poverty are interrelated problems that result from multiple interacting causes, and are further exacerbated by climate change and its impact on the environment and livelihoods. Some factors are synergistic, while others are antagonistic, leading to trade-offs[9]. Food, energy, and water are closely interrelated and need to be considered simultaneously, along with maintaining the biophysical resource base – the land, soil, hydrological and biological resources – to ensure the sustainable delivery of ecosystem services.

There are many important interconnections at different scales, and levels: across different driving factors; across socio-economic and environmental objectives; across environmental issues; across spatial scales; across different parts of systems; and across stakeholder groups[10]. Greater understanding of these connections is required to address environmental and development objectives simultaneously, including the SDGs[11].

2. WHAT DOES THE SCIENCE SAY?

a. The need for integration

Environmental challenges are complex and interlinked, not only in themselves but also with social and economic issues. Solutions for one environmental problem, for example climate change, can, and often do, lead to unintended negative consequences, or create new environmental or socio-economic problems[12]. For example, establishing monoculture plantations to sequester carbon could diminish biological diversity and downstream water availability, and affect diets and nutrition[13]. On the other hand, it is possible to find synergistic solutions that can help solve two or more environmental challenges. For example, mitigating climate pollutants such as black carbon[14], methane, and tropospheric ozone will help mitigate climate change while also improving human health, increasing agricultural productivity (providing greater food security), and creating economic benefits[15]. Furthermore, all social-economic goals and targets aimed at improving human well-being, for example poverty reduction, improved human health, energy access and economic growth, are linked to ecological factors, and require a functioning planetary life support system[16]. Addressing these interconnected and interacting environmental and social challenges requires systems thinking[17]. See Box 1.

The Global Risks Report, 2018, argues that "…humans have become skilled at addressing conventional risks – risks that can be easily identified and managed through standard risk management approaches. As the world becomes increasingly integrated and is faced with a rapid evolving landscape, new challenges are arising when dealing with complex risks in systems. These risks are usually defined by feedback loops, tipping points and unclear cause-effect relationships[18]." Systems thinking encourages consideration of a system's capacity, its knock-on effects on other systems, and whether incremental or transformational change is needed to mitigate risks[19].

A lack of integration is a major detriment to achieving sustainability[20]. For example, a review[21] of progress in achieving global environmental goals, including those Multilateral Environmental Agreements (MEAs) supported by the GEF, underscored fragmentation as a major cause of slow progress. The review emphasized the need for integration: between types of problems and identified solutions; between the responsibilities and resources available to implementing institutions; and in governance and institutional structures. An earlier study on the success of global environmental governance attributes the lack of improvement in the overall state of the environment, despite significant efforts, partly to the lack of integration in global environmental objectives[22]. This assertion is supported by a UN Environment analysis[23] that highlights several factors responsible for failure to achieve the Millennium Development Goal on environmental sustainability, including:

- neglect of the interconnectedness between environmental objectives and their social and economic aspects;
- not targeting the root causes of problems; and
- lack of coordination between design, implementation and monitoring.

Furthermore, several analyses of natural resources management and biodiversity conservation also show that the non-integration of ecological, socio-economic and cultural aspects is a major reason for their failure[24].

Integrated approaches can deliver multiple benefits by bringing together the objectives of different Multilateral Environmental Agreements (MEAs) in a more comprehensive approach to planning and management. This can enhance synergies while managing trade-offs at the local, sub-national, and national level, and in sectors, for example, by increasing food production without degrading land, increasing greenhouse gas emissions, or polluting water resources. Integrated approaches can also untangle complexity, so that root causes can be identified and managed through focused interventions, while also anticipating feedbacks and building whole-system resilience[25].

BOX 1.
Global risks interconnections map 2018

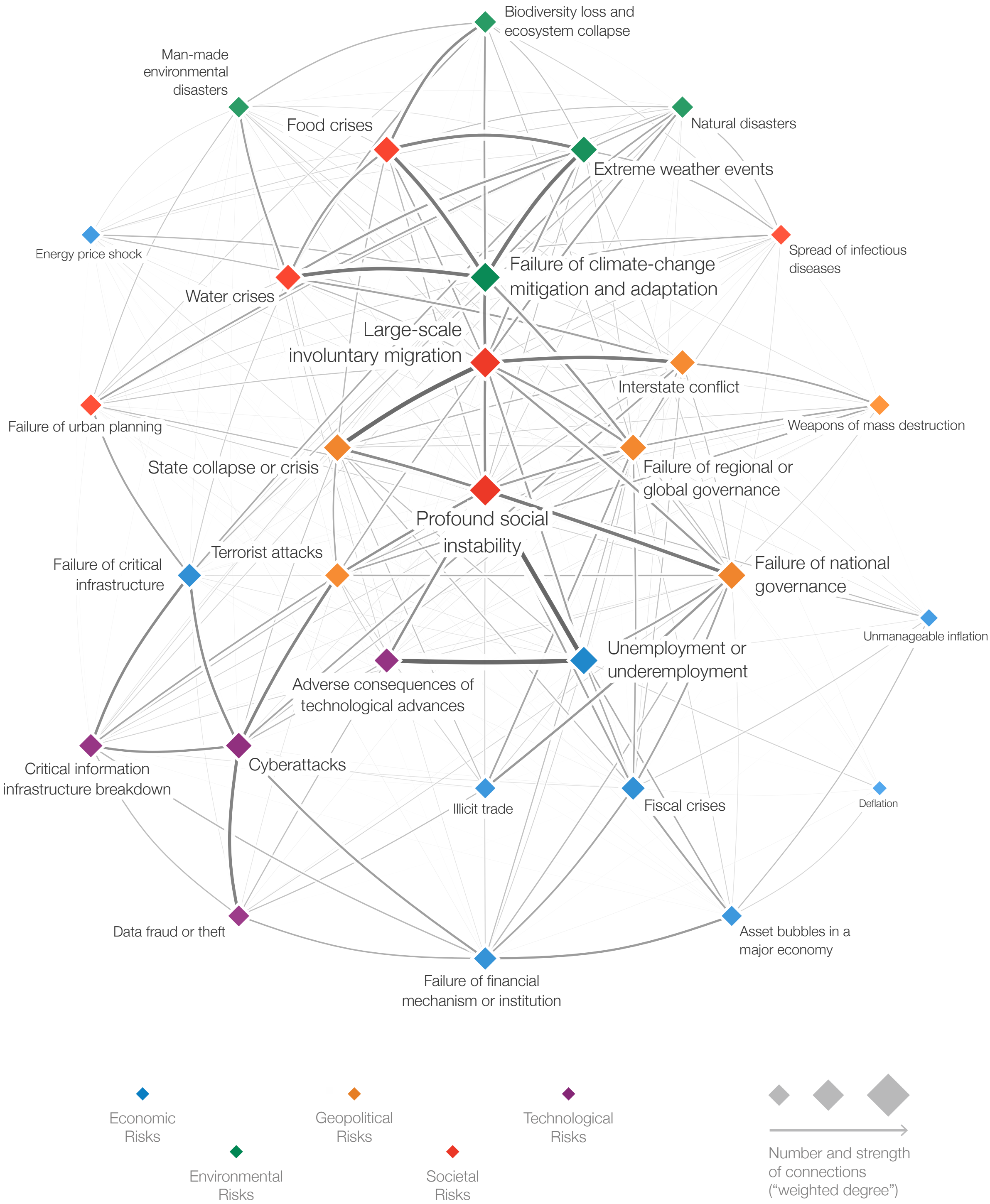


Figure 1. The Global Risks Interconnections Map shows the linkage and complexity of global challenges and associated risks. The top ten risks, in terms of their impact, feature several environmental risks: extreme weather events, natural disasters, failure of climate change mitigation and adaptation, biodiversity loss, and ecosystem collapse. Two further societal risks (food and water crises) are closely intertwined with the environment, and are also in the top ten. (Adapted from The Global Risks Report 2018, 13th Edition.)

Integrated approaches which use systems thinking have proved effective in solving problems with complex and varied interactions, for example[26]:

- problems that require stakeholders to grasp the "big picture", beyond their own role;
- problems that recur or have been exacerbated by previous interventions;
- problems where an action affects the surrounding environment; and
- problems without an obvious solution.

Table 1 provides further examples of benefits of system integration *(adapted from Liu et al., 2015)*

Benefits of system integration	Example
Understanding complexity	Agricultural intensification schemes are assumed to lead to the sparing of land for conservation. However, when other socio-economic factors (including the resulting improved yield, increased agricultural rents, greater consumption, as well as increased economic activities and diversification) were considered, intensification was shown to lead to further agricultural expansion and deforestation over the long term. This highlights how system integration can expose hidden interactions and complexities[27].
Understanding policymaking	Using an integrated assessment model, the cost of delayed climate change mitigation action was estimated, taking into account geophysical, technological, social, and political factors. Political choices were shown to have the largest effects, followed by geophysical and social factors. Availability of technological solutions had the least impact. This can help in thinking about the relative importance of each factor for informed policy-making[28].
Addressing multiple issues simultaneously	Systems integration can help in examining different technological and policy measures which yield multiple benefits simultaneously in the climate change-health-food security nexus, for example in climate change mitigation, reduced premature deaths, and improved agricultural productivity[29].
Assessing the feasibility of multiple and conflicting goals	Integrated coastal zone management allows for multi-organizational management for competing interests such as recreation, fisheries and biodiversity conservation[30].
Identifying complementary policies and management strategies	Analysis of the interaction between the global economy, energy security, health and the impacts of climate change (the air-climate-energy nexus), shows that integrating energy security policies with optimal climate and air pollution policies would decrease oil consumption compared to implementing energy policies alone[31].
Maximizing economic gains and minimizing environmental costs	Integrated soil-crop management systems can maximize grain yields, while minimizing applications of fertilizers and greenhouse gas emissions[32].

b. How to achieve integration

Systems thinking is fundamental to better integration. Systems thinking considers the relationship between the whole socio-ecological-economic system and its various components, as well as their interactions across space, time, and organizational levels. Many of these relationships are non-linear. Systems thinking applies understanding of connections between variables to identify effective intervention points[33].

The core concepts of systems thinking include[34, 35]:

- interconnectivity: the relationships between system elements across scales in social-ecological systems;

- feedback loops: the sequence of cause and effect that can amplify, or lessen, the effects of change;

- resilience: the ability of a system to absorb shocks and reorganize to retain the same functions, structure and feedbacks;

- adaptive capacity: the capacity of stakeholders to respond to shocks and stresses and manage resilience. Adaptive capacity involves continuous learning, adaptive management and use of knowledge to deal with change; and

- self-organization: is the ability of a system to self-organize after a shock and to transform to a new identity, based on learning, to deal with change.

STAP's work on the science of integration is informed, *inter alia*, by its work on "resilience thinking", presented in the Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) framework[36]. Resilience thinking refers to the inter-related concepts of resilience, adaptation and transformation (see Annex 1).

STAP commissioned a study, Integrated Approaches to Natural Resource Management[37], which: reviewed systems thinking literature; reviewed 28 completed projects[38], and 10 in-depth case studies of integrated programs and projects; and analyzed key aspects of integration and assessed their implementation in GEF natural resource management projects in biodiversity, international waters, and land degradation.

The study concluded that integrated approaches need to be flexible and not become a 'straitjacket' or simply a 'check-list'. Attempts at embedding learning and adaptive management were included in all the projects studied, but slightly less than half of the projects did this adequately. All the projects included stakeholder consultation but few projects practiced 'coproduction of knowledge' where local stakeholders are engaged from start to finish. All projects took knowledge management into consideration, but there was not a clear indication that learning and adaptive knowledge management was taking place during project implementation.

Overall the projects showed some benefits from integration, but there is room for improvement. The study identified factors for successful integration including: articulation of a clear theory of change; a clear description of the system boundaries to enable a strong focus on the root causes of environmental degradation; support of innovation at the local level; better equipping projects to address learning, innovation and adaptive management; enhanced stakeholder interactions, communication and partnerships.

A second study, Integrated Approaches to Climate Change Mitigation and Chemicals and Waste Projects[39] reviewed complex adaptive systems literature to understand how this influenced transformational change. The study analysed 32 GEF climate change mitigation and chemicals and waste management projects. The findings suggest that projects which incorporate complex systems thinking are more successful in achieving their long-term goals and more likely to deliver social and economic benefits, including benefits across focal areas – and are ultimately more transformational.

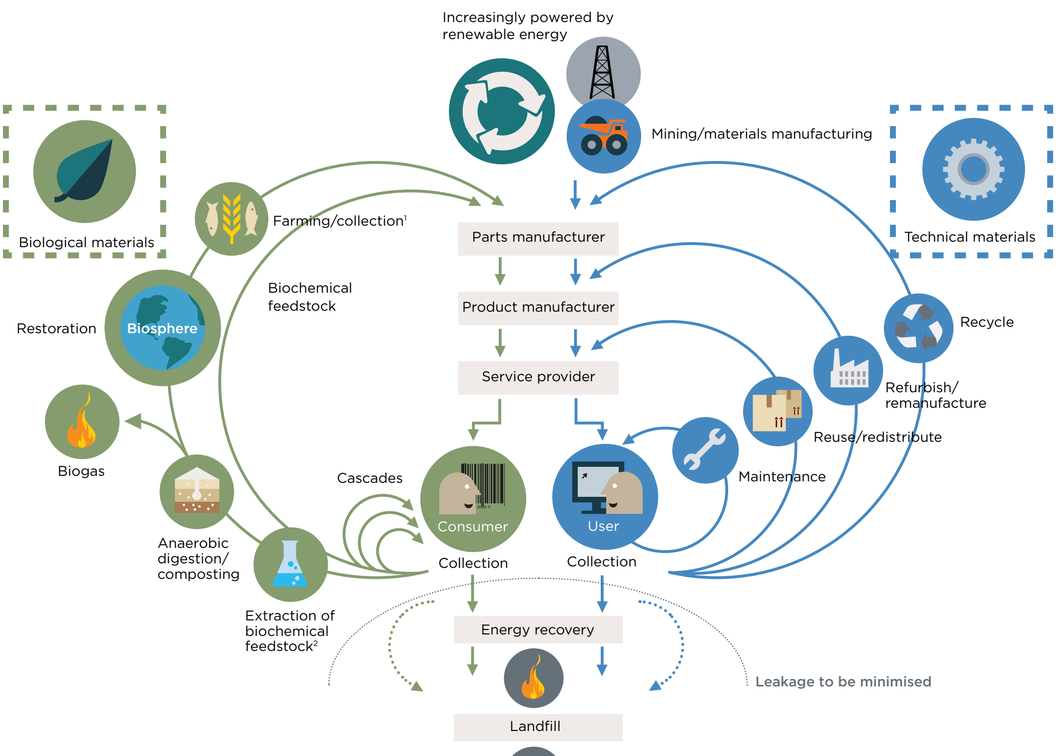
The paper identified some key elements of successful projects including: fostering conditions for behavioural change across domains and scales; demonstrating the comparative advantage of an innovation or new technology; ensuring sustainability by building on-going processes, and strengthening capacities to support the project's continuity after funding ends; and planning for further adoption by including mainstreaming, replication, and scaling-up in project design.

There are several frameworks that can be used to implement an integrated approach including, integrated landscape management, integrated natural resource management, integrated urban planning and management, integrated water resource management, integrated coastal zone management, life cycle assessment, the circular economy concept, and integrated supply chain analysis. Boxes 2, 3 and 4 provide examples of integrated frameworks.

BOX 2.
Integrated landscape management in China

A landscape approach addresses competing land uses by implementing policies and integrated management practices that ensure equitable and sustainable use of land[40]. It aims to integrate social and economic development with ecological issues including climate change, biodiversity conservation, and land restoration through coordination across various scales and spaces[41]. The approach can facilitate sustainable agriculture, contribute to climate change mitigation, promote afforestation and reforestation. This will reduce erosion and land degradation, protect water resources, reduce flood risks, provide potable water, and conserve biodiversity[42]. The achieved ecological improvements enhance livelihoods, health, security and resilience to climate variability and change[43]. The approach has been adopted in the implementation of several landscape restoration programs with reasonable successes. For example, the adoption of the landscape approach in the Loess Plateau of China led to perennial vegetation cover increasing from 17% to 34% across the plateau in 10 years. This diminished erosion and dust storms and reduced sediment flow into the Yellow River by 100 million tons a year. Adopting the landscape approach also increased employment, yielded a 62% growth in grain output, increased food security and nearly tripled household incomes[44, 45].

BOX 3.
The circular economy concept



1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input
SOURCE: Ellen MacArthur Foundation –
Adapted from the Cradle to Cradle Design Protocol by Braungart & McDonough

The circular economy concept aims to change the linear economic model which is based on 'take, make, use, and dispose,' to a more sustainable production and consumption model that is restorative and regenerative by design[46]. The concept ensures that the value of products, materials, and resources is maintained in the economy at their highest value and usefulness for as long as possible while minimizing waste[47]. This builds asset recovery (after use) and waste prevention pathways into product design, and underpins product and service delivery with energy and materials from renewable sources[48]. Applying circular economy principles (see above figure) through a systems approach could help to achieve objectives in:

- Climate, for example, recycling one tonne of plastic could avoid one tonne of CO_2 equivalent emissions, while also providing societal benefits worth more than USD 100 per tonne of recycled plastic[49];
- Chemicals, for example, alternatives to toxic chemicals and encouraging the redesign of products to increase their longevity, and to prevent wastage and pollution; and
- Land, water, and biodiversity, for example, redesigning the food system to be circular can save nutrients and water, help reduce land degradation, prevent marine pollution and improve biodiversity[50,51].

A circular approach will also yield socio-economic gains. The World Economic Forum reported that material cost savings of up to $1 trillion could be achieved per year by 2025 by implementing the circular economy concept[52]. Transitioning to the circular economy in five European countries by 2030, apart from reducing carbon emissions by two-thirds, would also lower business costs and increase the workforce by about 4%, creating more than 1.2 million jobs[53].

3. WHY IS THIS IMPORTANT TO THE GEF?

The GEF was established to support the implementation of the Rio Conventions on climate change, biodiversity and desertification, which emerged from the 1992 Rio Earth Summit; this Summit initiated global efforts to deliver environmentally sustainable development. Since its inception in 1992, the GEF has recognized that environmental benefits and socio-economic development objectives can be achieved simultaneously. Integration was built into the design of the GEF: it is specifically tasked with "integrating global environmental concerns with national ones in the framework of national sustainable development strategies"[54]. Sustainable development is central to the delivery of global environmental benefits. STAP has stated that "an integrated approach has to be followed from the outset, where the synergy between development and environment is pursued, and the generation of multiple benefits is promoted vigorously"[55].

In 2000, the GEF began to implement crosscutting initiatives with Operational Program 12 (OP12) on "Integrated Ecosystem Management." This program pre-dated the land degradation focal area and served as the entry point for land degradation projects, combined with integrated investments in biodiversity, international waters, and climate change. Socio-economic benefits were a key part of OP12 projects because they were expected to integrate ecological, economic, and social goals to achieve multiple benefits[56]. Following OP12, multiple focal area projects were specifically encouraged through the creation of the multifocal area portfolio in 2002. Cross-focal area integration has been promoted by the STAP[57], and has been increasingly adopted across the GEF; this is reflected in the increasing proportion of multi-focal area projects, which now comprise 52% of the GEF portfolio[58].

In 2014, the GEF introduced large-scale integrated programming with three Integrated Approach Pilot (IAP) programs, on food security, commodity supply chains and sustainable cities[59]. This integration modality was conceived in response to the GEF's 2020 Vision that focused on addressing drivers of environmental degradation and supporting broad partnerships to implement innovative programming[60]. From the inception of each of these IAPs, there has been a strong focus on understanding the scope of the full 'system' where change is to be effected and on stakeholder engagement, from local to regional.

In 2015, policy makers reaffirmed the need to make progress across economic, social and environmental dimensions of sustainable development through the adoption of the "2030 Agenda for Sustainable Development", articulated as the Sustainable Development Goals (SDGs). GEF interventions are expected to contribute to delivering the SDGs[61], and the GEF is seeking to help countries coordinate their planning to deliver on their MEA commitments and relevant SDGs. Applying integrated approaches will contribute to a science-based analysis of the trade-offs between actions targeting the various SDGs and MEA priorities, which is necessary to deliver a cohesive plan of action and achieve long-lasting, sustainable development outcomes[62].

In considering programming for 2018-2022, the GEF again recognized the need to apply "…integrated approaches for transformational change in economic systems"[63] to address drivers of environmental degradation, as it had in its 2020 Strategy.

Integration in the GEF portfolio

Recognizing the evolving science of integration, STAP has supported increased 'systems thinking' within GEF's portfolio – within Focal Areas (FAs), in Multi-Focal Area (MFAs) Projects, in Programs, and in the Integrated Approach Pilots (IAPs). While clearly relevant to the design and implementation of MFA projects and the IAP programs, lessons have also been learned from integration in FAs.

The Independent Evaluation Office (IEO) highlighted examples of FA integration, in its recent OPS-6 report, "The GEF in the Changing Environmental Finance Landscape"[64]. Their findings in three focal areas are summarized below:

Biodiversity: "Mainstreaming (biodiversity) activities are associated with better outcomes and sustainability"; and "review of the terminal evaluations suggests that PA projects receive more satisfactory ratings when they have mainstreaming components" (p42). (The GEF's mainstreaming strategy includes: developing policy and regulatory frameworks; spatial and land use planning; encouraging biodiversity-friendly production practices; and piloting financial mechanisms to incentivize the encouragement of biodiversity.)

International Waters: "The international waters focal area was the first to shift toward a program modality, and demonstrated successes in that regard". The IEO notes that IW serves as a catalyst for integration with other focal areas and places significant emphasis on learning and knowledge sharing (pp 55, 56, 57).

Land Degradation: The IEO notes that the land degradation focal area "has been gradually moving toward integrated approaches aimed at delivering global environmental benefits in multiple focal areas while generating local environmental and development benefits". It "has an opportunity to address complex interrelated drivers and generate local socioeconomic benefits", and "the potential to increase food production, mitigate GHG emissions, and increase climate resilience through adaptation" (pp 58, 62, 63).

In support of integration and systems thinking, STAP has offered the GEF guidance on improved MFA design and incorporating resilience into project design and implementation.

Multi-focal Area: STAP evaluates each full-size project proposal to be sure it has a sound "Theory of Change" (TOC) and that there is a sound basis for the proposed actions leading to identified outputs and durable outcomes. In the last few years, STAP has encouraged improved TOCs so that the actions chosen are clearly thought through to possible endpoints. Better quality TOCs were needed especially in MFAs because some of the early MFAs did not discuss synergies or trade-offs across focal areas. To that end, STAP provided MFA guidance in 2016[65].

STAP identified the following essential characteristics of good MFA projects:

- the project objective would not be achievable by addressing a single focal area;
- there are linkages and drivers of environmental degradation common to several focal areas;

- integration of the different focal areas contributes to maximizing environmentally sustainable development and minimizing trade-offs in relation to the project's objective; and

- the project has a realistic theory of change which will allow for robust monitoring and assessment of each of the focal area outputs and specific indicators contributing to the project's objective.

Progress is being made. At the June 2017 Council meeting, the STAP chair reported that the recent MFA projects reviewed had better TOCs and scientific justification for proposed actions, that integration is improving at the site or country level, there is an increased focus on governance, and that resilience thinking is being incorporated. In the August 2017 OPS-6 report, the IEO concluded[66], "The multi-focal area portfolio reflects global trends toward integration across sectors and between environmental and socioeconomic goals as stated in the three Rio Conventions and the SDGs." "The great majority of multi-focal area projects respond to convention guidance, as well as to both global trends and national priorities" (p69). "Multi-focal area projects have the potential for producing synergies and mitigating trade-offs" (p71).

Resilience: Recognizing that there could be synergies in achieving goals of more than one MEA, the UNCCD asked STAP to develop a common indicator for agro-ecosystem resilience. This was supported by the CBD, and was also relevant to the UNFCCC[67]. In response to this, STAP commissioned and produced a number of reports on "resilience thinking" including the RAPTA framework[68]. An adaptive management and learning component can be critical to successful GEF projects, as many conditions (including climate, demographics, and policies) may change over the course of a project. STAP guidance on embedding resilience thinking into projects was developed at GEF's request in 2016[69]. The RAPTA framework applies adaptive management during implementation, uses results from monitoring and assessment to revise strategies, and tests hypotheses underlying the project design. Agencies have been asked by the GEF to consider this guidance in future project designs.

At the May 2017 Council meeting, the STAP chair noted that the IAPs had demonstrated good progress on elements key to the science of integration[70]. In particular advances in knowledge management have been made by including a coordinating budget and dedicated management team, by having many face-to-face consultations, building databases, developing common indicators and exchanging learning. There has also been broad stakeholder engagement and consultation – including at the local level, and coordination across contributing projects.

The IEO OPS-6 report concludes that the IAP programs: "are broadly coherent in terms of their objectives"; "emphasize knowledge exchange through dedicated platforms for collaborative learning"; have emphasized "broader adoption" in their design, and there are "innovative features beginning with the Theory of Change", but that "considerable efforts will need to be made to realize their potential" (p89).

The GEF has made considerable progress in designing and implementing integrated projects and programs. Applying the evolving science of complex systems will help the GEF achieve even more in the coming years.

4. HOW CAN THE GEF RESPOND?

The next generation of integrated projects in GEF-7 should build on the lessons learned from its own experience, as well as that of the practitioner and scientific worlds. STAP strongly encourages a continued focus on integration within FAs, across MFAs, in Programs, in IAPS, and in future IPs. This should include strong elements of a theory of change, adaptive management, integration of resilience thinking, indicators of progress, and KM.

The IEO, in OPS6, recommended a continued focus on integration: "The GEF should continue pursuing an integrative principle in its programming based on scientific and technical merits. A strong, cogent rationale for designing integrated programs and multi-focal area projects—based on demonstrated additionality, GEF experience, GEF comparative advantage, innovative contributions, environmental need, and national relevance — must be the basis for such interventions"[71]. However, the IEO also noted that ''with their emphasis on integration, programmatic approaches and multi-focal area projects are relevant in addressing drivers of environmental degradation; however, complex program designs have implications for outcomes, efficiency, and management" (Conclusion 3, p132).

STAP acknowledges that, as identified by the IEO, complex projects targeting multiple environmental issues, crossing focal areas, involving multiple agencies and countries tend to have higher management costs, and slower progress in project preparation (IEO, 2017). Nevertheless, STAP encourages the GEF to pursue integrative projects and to apply integration science, based on systems thinking, which will lead to more efficient and effective approaches to planning, monitoring and implementing complex projects.

Balancing complexity and efficiency as the GEF seeks transformational change and lasting outcomes remains a challenge. There are many elements of integration that can be improved across the temporal, spatial, institutional, and governance contexts. Building learning and adaptive management into project design, conducting serious mid-term evaluations and planning for long-term knowledge management will improve efficiency and integration while delivering global environmental benefits.

Drawing from the theory of integration and management of complex projects, and learning from GEF projects and programs that have applied integrated approaches[72], STAP recommends the following to improve integration in future GEF project design[73].

STAP makes the following recommendations:

1. Develop a good understanding of the social-ecological system in which the project will be implemented. Describing the system helps to identify the key environmental, social, economic and governance issues to be addressed, and how these are interconnected, with an eye towards resilience and transformational change (**system description, and systems thinking**).

2. Articulate a clear rationale for the project, its goals and what the proposed interventions are expected to achieve. The expected environmental, social and economic objectives of the project should be clearly identified and a pathway for achieving them presented. A realistic **theory of change** should be made explicit. This should tackle the drivers of environmental degradation by assessing assumptions, outlining causal pathways, as well as including a 'Plan B' should desired outcomes not materialize. It should be informed by previous efforts in the same geographical or disciplinary area.

3. Assess the potential **risks and vulnerabilities** of the key components of the system, to measure its **resilience** to expected and unexpected shocks and changes, and the need for incremental **adaptation** or more fundamental **transformational change**.

4. Devise a logical sequence of interventions, formulated as an implementation plan, which is responsive to changing circumstances and new learning (**adaptive implementation pathways**). Develop clear indicators that will be monitored to determine progress and success in achieving lasting outcomes.

5. Develop explicit plans and dedicate funding for **good quality knowledge management and learning** including: sustainable databases which endure beyond life of the project; simple, useful and usable common indicators; face-to-face consultations; and building the capacity of stakeholders. Good knowledge management is essential for adaptive management, developing 'lessons learned' to inform future investments, and for 'scaling up'.

6. **Engage stakeholders**, including local communities, civil society networks, industry associations or other key private sector actors as appropriate (not just government officials) from project inception and from design

through to completion. This is crucial to identifying diverse needs, achieving buy-in, and managing trade-offs. It should:

a. use a participatory process to refine the system description and devise the theory of change, so developing a common understanding of the problem and its most promising solutions;

b. form multi-disciplinary teams with wide expertise to assess proximity to thresholds and, consequently, whether the need is for adaptation or transformation;

c. involve stakeholders in characterizing and prioritizing actions to build, or maintain, resilience or achieve transformation;

d. establish multi-stakeholder platforms and institutional partnerships to facilitate knowledge sharing and data collection for monitoring progress; and

e. apply strategies starting at the local level to produce a shared vision for effective transformational change.

7. Acknowledging the additional effort involved in this approach, STAP suggests that GEF could improve integration by **allowing flexibility in project preparation** to accommodate the additional transactions costs and time required to tackle complex issues through multi-agency teams. (One approach would be to allow the detailed project plan to be further developed after approval, as the first stage of project implementation, to enable meaningful stakeholder engagement in devising the system description and assessment and the design of implementation pathways.)

Transformational change necessarily entails risk. Risk and transformational change are intertwined, and lie at the core of building the GEF's capacity to respond to change and making it resilient. The GEF can strengthen its organizational capacity to deal with change, and to deal with uncertainty through experimentation and innovation. The GEF could also encourage a greater diversity in the risk profile of projects.

The GEF is uniquely placed to lead the way in applying and strengthening evidence on the science of integration and systems thinking to deliver global economic, social and environmental benefits. The recommendations in this paper, developed from review of the GEF's own experience, commissioned research and published literature, provide guidance on applying integration to improve the management of complex systems.

Annex 1: Scientific approaches to achieving integration

Simple, narrow, linear approaches are not sufficient to address the complexities of the inter-connected environmental and social challenges that all countries face. Several concepts and theories related to management of complex social-ecological systems and sustainable development can be applied to enhance integration and assist the GEF in navigating complexity. This list draws from O'Connell et al. (2016)[74], Berbés-Blázquez et al. (2017)[75], Tengberg and Valencia (2017)[76], and Zazueta (2017)[77].

Systems thinking examines relationships between the different parts of the targeted system, especially cause and effect relationships and positive or negative feedback mechanisms, between the biophysical and socio-economic features of the system. The system is defined by boundaries that describe the spatial scale and biophysical and social components inside the system. The environment surrounding the system should also be considered, as it influences problem-solving within the system. It is important to manage the fundamental "slow variables" – e.g. soil organic matter content – that control the state of the system and respond gradually to change, and to be aware of non-linear responses.

Resilience thinking refers to the inter-related concepts of resilience, adaptation and transformation. It is the basis for building the capacity of systems to withstand expected and unexpected shocks and stresses, including climate change and also socio-economic stresses such as conflict. Resilience thinking examines the risks and vulnerability of key components of the system, including proximity to thresholds that could lead to regime shifts. It evaluates the need for adaptation (incremental change) or transformational change, to cope with anticipated shocks and meet desired goals. Resilience thinking supports intentional transition to desired systems and reduces the probability of unplanned transitions to undesired systems.

Theory of change describes the impact pathways through which a project expects to meet its goal (Weiss, 1995)[78]. The Theory of Change may be devised in a participatory process involving key stakeholders and includes these elements: "1. the context for the initiative, including social, political and environmental conditions, the current state of the problem the project is seeking to influence and other actors able to influence change; 2. the long-term change that the initiative seeks to support and the ultimate beneficiaries; 3. the sequence of events anticipated (or required) to lead to the desired long-term outcome; 4. the assumptions about how these changes might happen, and about contextual conditions that may affect whether the activities and outputs are appropriate for influencing the desired changes; 5. a diagram and narrative summary that represents the sequence and captures the discussion[79]."

Effective stakeholder engagement requires involving the right people, in the right way, at the right time, using ethical and transparent processes. It requires defining the roles, responsibilities and accountabilities of stakeholders involved in project design, implementation and governance. Stakeholders' participation ensures that local and contextual knowledge informs the system assessment, including local perspectives, needs and cultural values which enhance the relevance and acceptability of the outputs. Stakeholder engagement in project implementation enhances effectiveness and learning.

The ***system description*** is a record of the current understanding of the social-ecological system and the assumptions and evidence which underpin it. It is built from stakeholders' diverse perspectives. It is a dynamic description that details what is changing and why, the connections between the different elements, and the cross-scale interactions with higher, e.g. national and lower scales, e.g. household. It creates a fundamental base to assess the system's resilience, the need for adaptation or transformation and for devising interventions.

System assessment is a central component of resilience thinking. It identifies potential risks, points of no return and key influencing factors (controlling variables) associated with anticipated future shocks or changes, as well as opportunities for adaptation or transformation to meet project goals. System assessment considers whether the system is currently on a trajectory towards a desirable or undesirable future. It considers the factors that confer general resilience, enabling the system to cope with unexpected shocks, and it analyzes the risk of crossing thresholds associated with known risks, shocks or trends.

Adaptive implementation pathways provide a strategy for planning and sequencing interventions. They use the theory of change to identify options and develop an implementation plan that is adaptable, based on the circumstances, learnings from project implementation and the consideration of alternative pathways. Interventions should focus on root causes and vulnerable elements identified through the system assessment. The implementation plan should present a logical sequence of interventions to build resilience or achieve transformation. During the implementation phase, adaptive management should be used to respond to information gathered and new learning. Implementation plans should include review points, to assess the need for revising the plan. Monitoring and assessment enables project managers to track project progress and reflect on successes and failures during project implementation so the necessary adjustments can be made to achieve goals.

Adaptive management applies knowledge, including results from monitoring and assessment, iteratively to refine interventions over time, to improve their effectiveness as conditions continue to change, and to revise Theory of Change, to inform future projects.

Learning and innovation. A structured approach that utilizes systems thinking should guide learning (e.g., data collection and interpretation) and testing of the Theory of Change. The results of learning should be captured to inform future phases of the project and program, as well as future projects. The engagement of stakeholders, e.g. government policymakers, NGOs, community members, in learning is essential to enhance self-assessment, awareness of their roles and their capacity to influence future action. Leveraging knowledge from the design stage through to the implementation of projects, as well as from past experiences through successful knowledge management, spurs innovation. Engaging stakeholders in project design, implementation, and governance encourages innovation and transformative change at the local level where niches of innovation, experimentation and learning occur. Strengthening communication across stakeholder groups (local communities, practitioners, and policy-makers) involved in multiple sectors fosters learning, adaptive management and induces innovation related to integration. Learning through monitoring and assessment and adaptive management should be documented and systematized in the project to form the basis of the project's knowledge management strategy. This requires that the project cycle build learning and knowledge iteratively, based on the project's successes and failures.

Transformational change is required to tackle many deep-seated complex global problems. The need for transformation of a social-ecological system is identified through the system assessment. Different strategies may be required at different levels: transformation may be required for some components of the system to maintain resilience of the whole. Effective transformation requires a shared vision among stakeholders, and starts at the local level: niches of innovation, experimentation and learning are scaled up through regime shifts that lead to wider adoption at the landscape level.

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ABOUT GEF

The Global Environment Facility (GEF) was established on the eve of the 1992 Rio Earth Summit, to help tackle our planet's most pressing environmental problems. Since then, the GEF has provided $14.5 billion in grants and mobilized $75.4 billion in additional financing for almost 4,000 projects. The GEF has become an international partnership of 183 countries, international institutions, civil society organizations, and the private sector to address global environmental issues. http://www.thegef.org

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CONTENTS

SUMMARY

Maximizing global environmental benefits, and delivering transformational change at scale requires the GEF to ensure that it makes full and effective use of the knowledge and learning it has accumulated from its previous investments, and applying that to its current and future projects.

Knowledge Management (KM) is the systematic management of an organization's cumulative knowledge and experience, i.e., its knowledge assets. This is valuable for meeting an organization's operational and strategic objectives, by ensuring that what the organization already knows is applied to future actions. Done well, KM provides the right knowledge to the right person at the right time, so it can be usefully applied.

Knowledge management has been a key goal of the GEF since 2011. Improving KM will make the GEF a more powerful, effective and efficient institution in tackling complex environmental problems, and delivering global environmental benefits, and sustainable development. This requires:

- Embedding KM more systematically into the project cycle, as an essential part of project design. STAP offers two practical suggestions about how this could be done effectively at the Project Identification Form (PIF) and CEO endorsement stages. Adequate resources, training, and incentives of GEF and agency staff would also help to embed KM, and feed information into a KM system.

- More easily searchable PIFs, CEO-endorsed projects, mid-term evaluations, and terminal evaluations to compare strategies, compile 'lessons learned' from both successes and failures, and better link practitioner and academic research.

As the GEF moves further towards integrated approaches, multi-focal projects and impact programs, it is increasingly important to facilitate acquisition of formal and tacit knowledge, organize knowledge assets from complex situations and make them available to inform future investments. The Integrated Approach Pilot (IAP) programs and Impact Programs impose greater needs for connections between 'child' projects and program objectives. KM is the obvious means to tie these connections together, to collect evidence-based learning, and to achieve sustained impact that deliver benefits far into the future.

However, KM is often treated as an afterthought, and lacking relevance for operations. An under-exploited resource, whereas it should be a primary source of value for the GEF. KM remains a 'niche' topic – often accepted as useful, but regarded as optional. By contrast, the IAPs have embedded KM in their structure from the outset. The OPS6 report recognizes that further improvements are needed for a KM system to be functioning "…to enable the GEF to demonstrate its results, and serve the needs of the partnership for learning."

Further work is therefore needed to extend the scope and depth of KM in the GEF to exploit its full power to develop, manage, track, share and, above all, learn from its projects and programs.

STAP has long been a champion of KM in the GEF, and has frequently made the scientific case for KM to be an essential activity that should be included in all GEF investments. In 2015, STAP made recommendations on KM, and believes that these recommendations are still relevant. Some progress has been in implementing them, but more remains to be done.

1. WHAT IS THE ISSUE[1]?

Maximising global environmental benefits, and delivering transformational change at scale requires the GEF to ensure that it makes full and effective use of what it already knows and has learned from its previous investments. However, KM is often treated as an afterthought, and therefore is an under-exploited resource: it should be a primary source of value for the GEF.

2. WHAT DOES THE SCIENCE SAY?

What is KM? KM is the systematic management of an organization's cumulative knowledge and experience, i.e., its knowledge assets (see Box 1). This is valuable for meeting an organization's operational and strategic objectives, by ensuring that what the organization already knows is applied to future actions.

KM consists of the methods, processes, learning experiences, strategies and systems that support the storage, retrieval, assessment, analysis, refinement, scaling-up and creation of knowledge (Box 2).

KM provides the means to collect experiences, lessons and results from projects and programs in a structured and user-friendly format. KM involves the management of, and access to, knowledge to maximize impact from investments to provide guidance in scaling-up project experiences, and to support a culture of learning and leveraging beneficial change.

Done well, KM provides the right knowledge to the right person at the right time, so it can be usefully applied[2].

BOX 1.
Definitions

Knowledge Management (KM): the systematic processes, or range of practices, used by organizations to identify, capture, store, create, update, represent, and distribute knowledge for use, awareness and learning across and beyond the organization.

Knowledge Management Systems (KMS): any kind of IT system that stores and retrieves knowledge, improves collaboration, locates knowledge sources, mines repositories for hidden knowledge, captures and uses knowledge, or in some other way enhances the KM process.

Knowledge Products and Services: these refer to outputs such as databases, publications, visual material, maps (knowledge products) and outcomes such as awareness raising, information sharing, and capacity building (knowledge services).

Knowledge Assets: are the accumulated intellectual resources of an organization in the form of information, ideas, learning, understanding, memory, insights, cognitive and technical skills, and capabilities.

Source: *Knowledge management in the GEF: STAP Interim Report* 2015; Baldrige Glossary for Business, Public Sector and Other Nonprofit 2003.

KM is therefore a process that formalizes the management and use of the intellectual assets of an organization and its human resources. This is close to most formal definitions of science itself[3]. This makes KM a specialized applied science required to add order to intellectual assets and experiences, and is therefore essential in the codification, storage and access to knowledge and information. This is the primary scientific justification for KM: it is a pre-requisite science for all projects and programs that derive new information or insights that may have future utility.

STAP has long been a champion of KM in the GEF. Under this umbrella of KM as an applied science, STAP has already made the scientific case for KM to be an essential activity that should be included in all GEF investments[4]. Drawing on an assessment of 138 projects, STAP concluded that at the design stage, GEF project and programs typically provide relatively little evidence of systematic treatment of the need for KM. From this analysis STAP recommended:

1. knowledge-sharing and learning should be strengthened across the GEF partnership;

2. guided learning questions are an effective way to support knowledge management[5] (See Annex 2);

3. KM should be mainstreamed systematically into the GEF project cycle from the PIF stage onward[6];

4. knowledge management and knowledge management system functions should be included in project/program monitoring and evaluation activities[7];

5. the GEF should develop an Open Data Policy;

6. knowledge management progress indicators should be included in the GEF Results-Based Management system;

7. an enterprise-wide GEF Knowledge Management System should be adopted. The new GEF portal offers the chance to create an enterprise-wide system across all agencies with features that improve the functionality to extract, edit, and file information for the purposes of generating knowledge; and

8. incentives for successful dissemination of project outputs should be considered, for example, prizes, and pay awards.

STAP believes these recommendations still hold good. Annex 1 provides details of some tools and methods for supporting and implementing KM in projects and programs.

3. WHY IS THIS IMPORTANT TO THE GEF?

KM is an important conduit for translating evidence and learning into improved practices and policies. This has been proven in the implementation of evidence-based practices, commonly applied in the health sector, which also is relevant to the environmental discipline[8].

Over the last 15 years, the importance of good KM has increased as knowledge and experience of the global environment has accumulated, and more targeted efforts have been designed[9].

Better KM will make the GEF a more powerful, effective and efficient institution in tackling complex environmental problems, and delivering global environmental benefits, and sustainable development.

BOX 2.
Knowledge management plan for the Caspian Sea project – KM in successful practice

The GEF Caspian Sea project considered countries' sensitivity to sharing data. Through a KM component, the project supported countries' efforts on information gathering, accessing knowledge, and implementing a protocol for using the knowledge. Because governments understood the data, and agreed to the KM protocol, the countries requested continuously data and information.

Having a strong KM and data plan increased cooperation between the countries, which led to policy harmonization in the Caspian. The project's lessons emphasized that project design should:

1. Include a detailed KM and data plan for the project with the tools necessary to manage the project monitoring; and,

2. Appoint a KM proponent in each country to manage the data, liaise with the government, and develop data management and KM protocols to support the countries.

Details of the Caspian Sea Project can be found at: http://www.iwlearn.net/iw-projects/basins/lakes/1

KM is essential to order, deploy and disseminate the GEF's intellectual assets and experiences. It plays a critical role in codification, storage, access and deployment of knowledge and information.

KM is integral to how the GEF achieves results and transformational change. It is the way that outputs (immediate project deliverables) are connected to outcomes (longer-term achievement of environmental benefits and sustainable development) and impacts (the desired transformative change).

KM is also essential for scaling-up project results to larger areas and wider landscapes and seascapes (horizontal scaling), to more agencies and organizations (vertical scaling-up) and to additional related situations (replication and extrapolation).

The IAPs and IPs impose greater needs for connections between 'child' projects and program objectives. KM is the obvious means to tie these connections together to collect evidence-based learning and achieve sustained impact that deliver benefits far into the future.

It is true that KM has more prominence in the GEF than hitherto, but only in the IAPs is KM a core component.

The GEF 2020 Strategy[10] emphasized the need to generate knowledge as a priority. The GEF has co-published, with the World Bank, guidance on how to share knowledge across different stakeholders, and in multiple settings[11] ("The Art of Knowledge Exchange Guide: A Results–Based Planning Guide for the GEF Partnership").

The GEF also set-up the knowledge management advisory group to discuss activities, to elicit feedback across the agencies and with STAP, and to strengthen the implementation of knowledge management in the partnership. The sixth evaluation of the GEF (Sixth Overall Performance Study, OPS6)[12] recognizes these and other accomplishments on KM led by the GEF Secretariat.

BOX 3.
Generating knowledge from the IAPs

In the Food Security IAP, knowledge management is used for the monitoring and assessment of integrated approaches to natural resource management, and will be helpful in scaling-up the program.

In the Cities IAP, a global knowledge platform was created, which enables 23 cities to harness state of the art thinking, and methods for integrated urban planning, and to share those experiences globally.

The Commodities IAP has adopted a specific component on adaptive management and learning, which will focus on program-level monitoring and evaluation, and knowledge management; this will include a global community of practice to convene practitioners to share best practices and learning.

Source: GEF2020 Strategy for the GEF, 2014.

But KM remains a 'niche' topic – accepted as useful but often regarded as optional. The OPS6 report recognizes that further improvements are needed for a KM system to be functioning "…to enable the GEF to demonstrate its results, and serve the needs of the partnership for learning[13]." The evaluation also acknowledges that "…the GEF has placed less emphasis on: improving knowledge management at the program/project level; developing technical solutions to manage knowledge; implementing a systematic approach to its knowledge management products; or linking creators of knowledge with users through facilitating access, transfer, and sharing[14]."

Part of the reason for the lack of progress appears to be a perception that KM will add to operational costs and create further barriers to project completion, and partly to KM's lack of profile in the GEF project cycle[15].

The project proposal templates[16] require a description of the knowledge management approach that will be used, but KM needs to be applied more systematically in the project cycle. This includes encouraging adaptive management and identifying project level indicators to monitor and assess how KM is used to address the changes that result from learning.

Further work is therefore needed to extend the scope and depth of KM in the GEF to exploit its full power to develop, manage, track, share and, above all, learn from its projects and programs. A shift in mind-set is also required so that the GEF considers itself as part of the system and responds to feedbacks which enable change on the ground.

4. HOW CAN THE GEF RESPOND?

STAP makes the following recommendations:

a. Foster a culture of learning by bringing KM in to the mainstream of the GEF

The importance of fostering an organization-wide culture of learning has long been recognized in industry[17], but equally applies to public bodies. There are many advantages including: increased efficiency and productivity; a

greater sense of ownership and responsibility; better employee satisfaction; and an improved ability to adapt to change.

Creating a culture of learning requires leadership and advocacy. An African Proverb: "If you want to go quickly, go alone. If you want to go far, go together[18]." Leaders need to set the example of valuing learning and KM. This may simply be through showing active interest in KM activities, through to applying KM in their day-to-day management and decision-making.

Building an organizational culture of learning would benefit stakeholders at all levels[19]. Creating and maintaining a learning culture would encourage an intellectual and intelligent environment that actively seeks development opportunities.

The single biggest change required is to put KM in the mainstream, as a core element in the way the GEF does business. This means bringing KM out of its current niche, as cross-cutting issue, where it is often overlooked, or regarded as optional, and lacking relevance to operations.

b. STAP reiterates its 2015 recommendations on KM

These are still relevant – see page 5. Some progress has been in implementing them, but more remains to be done.

c. KM needs to be embedded more systematically into the project cycle, as an essential part of project design

STAP offers two practical suggestions about how this could be done effectively at the PIF and CEO endorsement stages.

At both stages, project proponents are asked to outline the "Knowledge Management Approach" for the project and how it will contribute to the project's overall impact, including plans to learn from relevant projects and initiatives; processes to capture, assess and document, in a user-friendly manner, information, lessons, best practice and expertise generated during implementation; and knowledge outputs to be produced and shared with stakeholders.

i. PIF stage

A STAP study[20] found that a simple response was provided on how to address KM in the project. Several of these responses indicated that a KM approach would be developed later. Promisingly, however, the study indicated that GEF-6 projects contained significantly more information than their equivalents in GEF-5.

It may be helpful therefore for project proponents to know that when STAP screens for KM, it is looking for the following:

- What overall approach will be taken, and which knowledge management results indicators will be used?
- What knowledge can be captured from stakeholders, past projects and relevant initiatives at local, country or global levels? How will this be done?
- How will assessment and documentation of results be achieved?
- What plans are proposed for sharing, disseminating and scaling-up results, lessons and experience?
- How will sharing and related outcomes be measured?

ii. CEO endorsement stage

Responses at this stage were generally more elaborate than PIF templates, but highly inconsistent. Many projects focused on knowledge outputs, rather than knowledge management, and very few projects explicitly referred to learning designed to be targeted at the GEF.

Annex 2 provides additional guidance on the three principal topics expected to be elaborated within an overall KM strategy, i.e., baseline learning; results assessed and documented; and sharing with stakeholders.

d. Adequate resources

KM delivers cost-efficiencies and savings, for example, reduced failure of projects, and it needs up-front resourcing to cover for additional time, specific tools and database needs. The GEF needs more consistent portfolio-level and program resourcing for KM. It is equally important to strengthen KM expertise in the GEF. KM professionals are essential in applying the discipline, including creating tools and products that help establish KM as a standard practice throughout the organization. Resources also for training to gain experience in the use of KM tools and analytical techniques. It may be as simple as hands-on experience of databases and KM platforms.

e. Incentives

There need to be advantages and rewards for using KM and providing information to a KMS; this is widely accepted, for example, by the business sector and health sector[21]. (Similarly, there could be penalties for not employing KM.) Rewards range from pay awards to prizes. There needs to be better recognition for KM inputs, achievements and publicity. Rewarding projects at mid-term, for example, for demonstrating the use of knowledge to improve and/or adapt the project to meet project objectives may be an effective incentive. The GEF could simply award time to the project team to undertake KM and the creation of new knowledge.

Annex 1: KM tools and methods

KM tools are many and varied. Not all will be applicable to all situations. Examples of tools relevant to GEF projects include:

- Databases. The GEF's new portal will serve as the corporate database for projects, reports, and documentation. The portal will improve the capture of information and knowledge from projects. This includes more efficient methods to enter data, and track results. The portal will be user-friendly, comprehensive and accessible. The GEF's IW:LEARN shows how a database can underpin a knowledge platform. This example of an open data tool hosts project results, lessons learned and access to communities of practice.

- Knowledge platforms. This includes databases but with better functionality to create, acquire, integrate, and apply knowledge. Spatial capabilities or links to facilities such as Google Maps can be useful. Platforms need to have effective search functions, filters (such as drop-down menus) and analytical capabilities (see below). Two examples. WOCAT (World Overview of Conservation Approaches and Technologies) platform organizes information thematically and spatially in country reporting, and makes it available on-line for use by others. The GEF's IW:LEARN shares best practices, lessons learned, and innovations for transboundary water management projects. The platform approach promotes learning across the GEF partnership.

- Groupware systems, include communication, collaborative management tools, and conferencing (see below). Groupware systems facilitate the sharing of explicit knowledge, identify sources of tacit knowledge and support the creation of new knowledge through a "meeting of minds". 'Enterprise' and KM 2.0 are recent examples of groupware.[22]

- Analytical tools, include statistical packages and software that can analyze text and non-numerical data. For example, cost-benefit analysis is a useful tool to determine the scale-up potential of project investments.

- Video and/or virtual conferencing. Conferencing enables communication, the discussion of shared experiences, and the promotion of learning and encouragement for the creation of new knowledge.

Further tools include: organizational intranet to integrate multimedia communication and act as a platform for groupware applications and publishing; decision-support systems that employ data-mining techniques; content management systems to provide templates for storing information through to providing tracking tools for changes. Non-IT based tools may include storytelling, one of the most effective ways of sharing norms and values, generating trust and commitment. The best narratives have 'champions' and 'heroes' and describe how challenges were overcome.

Annex 2: Guidance to GEF agencies to improve KM in CEO endorsement requests

This guidance is intended to assist Agencies in providing the GEF with adequate information about the knowledge management approach being proposed in CEO Endorsement Requests, following GEF Council approval of their PIF or PFD submissions.

The KM approach outlined in PIF (or Program Framework Document (PFD)) submissions may need to be elaborated in the CEO Endorsement Request in order for the GEF to fully understand which uptake pathway the Agency intends to follow and what barriers to learning and knowledge exchange are to be overcome. To achieve this aim, Agencies first need to review what they originally wrote in the PIF (or PFD) KM section and then synthesize their KM approach information from across the project brief, including from any components detailing KM, and structure their response accordingly.

Table 1: Questions on KM to consider when developing projects

KM topic	Key questions to consider with some example responses
Overall KM strategy	What overall approach will be taken? Which KM results indicators will be used? Example responses: Context of the KM approach in the agency's own frameworks (refer to agency's published KM strategy, if available); Approach to be taken at project, country and international levels to measure results of KM activities (e.g. results framework, M&E approach); Overview of embedding of KM in project structure, e.g. components.
Baseline learning	What knowledge can be captured from stakeholders, past projects and relevant initiatives at local, country or global levels? How will this be done? Example responses: State how and which stakeholders have been identified, including plans for consultation and learning from; Index or summarize knowledge from specific projects and initiatives (GEF and non-GEF) informing design; Explain how the design of proposed interventions reflects the knowledge, lessons, and insights of similar situations.
Results assessed and documented	How will assessment and documentation of results be achieved? Example responses: Who has responsibility for the capture of results and transferable lessons and experience? Products to be generated and plans for their review and maintenance.
Sharing with stakeholders	What plans are proposed for sharing, disseminating and upscaling of results, lessons and experience? How will sharing and related outcomes be measured? Example responses: Role of stakeholders and how the project enables their participation; Specify dissemination methods, e.g., community meetings, internet, community of practice, peer review, and support for post-project actions; Refer to activities outlined in results framework with associated indicators; Specify how the GEF's knowledge base will be built, contributed to and maintained.

Endnotes

1 This paper continues STAP's on-going advice to the GEF on Knowledge Management including its nine recommendations on improving the GEF's performance in KM – see Supporting documents and STAP website. http://www.stapgef.org/knowledge-management-gef Last accessed March 21, 2018.
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A future food system for healthy human beings and a healthy planet

A STAP document

June 2018

STAP
SCIENTIFIC AND TECHNICAL ADVISORY PANEL
An independent group of scientists that advises the Global Environment Facility

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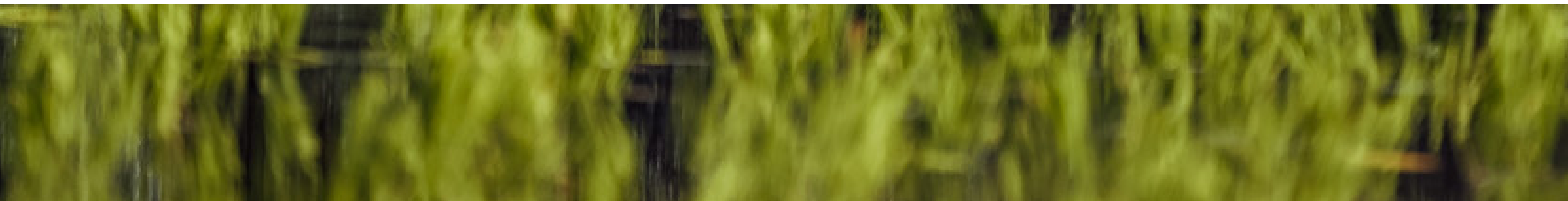

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The Scientific and Technical Advisory Panel (STAP) comprises seven expert advisors supported by a Secretariat, who are together responsible for connecting the Global Environment Facility to the most up to date, authoritative and globally representative science. http://www.stapgef.org

ABOUT GEF
The Global Environment Facility was established on the eve of the 1992 Rio Earth Summit to help tackle our planet's most pressing environmental problems. Since then, the GEF has provided over $17.9 billion in grants and mobilized an additional $93.2 billion in co-financing for more than 4500 projects in 170 countries. The GEF has become an international partnership of 183 countries, international institutions, civil society organizations, and the private sector to address global environmental issues.
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A future food system for healthy human beings and a healthy planet

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June 2018

STAP SCIENTIFIC AND TECHNICAL ADVISORY PANEL
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CONTENTS

SUMMARY

Food production will need to increase by more than 50% to feed a global population of more than 9 billion people by 2050, and to meet the increased demand for protein, driven by rising incomes. The challenge is to achieve this in a sustainable way without compromising the natural capital and ecosystem services which support food production.

The current food production and consumption model is a "take-make-waste" linear system with significant deleterious effects on the environment. The agri-food sector, from the farm to the plate, contributes nearly one-quarter of total global greenhouse gas (GHG) emissions. A further 10 to 15% of total GHGs come from converting forests and peatlands to farmland. The sector also causes around two-thirds of biodiversity loss and extensive land and water degradation. Over 70% of freshwater withdrawals are used for agriculture, mostly for irrigation. The science confirms that significant changes to the present food supply system are urgently required.

Many scientific studies offer potential solutions to improving sustainability in the agri-food sector in both the short and long-terms. Making the transition to a more sustainable food supply system would be assisted by reducing food losses and wastes and implementing a "circular economy" approach. This aims to recycle nutrients and water, adopt conservation farming systems, improve resource use efficiency, displace fossil fuels with renewable energy, and maintain materials and resources in the economy at their highest utility and value for as long as possible. As a result, food production systems would become more resilient to climate change impacts, and other global goals of the GEF would be advanced, such as clean water, sustainable forest management, climate change mitigation, biodiversity conservation and avoiding land degradation.

In the short term, in addition to reducing food losses and wastes, improved sustainability of the food supply system could be achieved by the more efficient use of resources. Reducing inputs per unit of food production whilst increasing productivity would help avoid negative impacts on biodiversity, soil quality, freshwater supplies, and the atmosphere. Practical examples include conservation tillage; efficient food processing operations and transport logistics; sustainable land management practices; precision farming to apply fertiliser, water, and chemical inputs judiciously; improved post-harvest storage; reducing consumption of animal protein; and better access to markets to reduce food losses. STAP recommends that the GEF encourage one or more of these strategies be incorporated in food-related projects in GEF-7. This experience will provide useful information to inform complex projects attempting to achieve a full circular economy.

In the longer-term, more ambitious action will be required to improve sustainability and avoid further degradation of land, water and nutritional quality of food. Adopting the circular economy approach for the agri-food sector will involve the development of agro-ecological systems and instigating innovative energy-smart and climate-smart production systems to reduce competition for productive land and freshwater and avoid further loss of soil fertility.

The GEF is already attempting to reconcile increased food production with fostering long-term sustainability and resilience through the Food Security and the Commodities Integrated Approach Pilots (IAPs). These integrate management of land, water, soil, and genetic resources with maintaining ecosystem services and should yield important 'lessons learned' to build upon.

The planned GEF Impact Program (IP) on Food Systems, Land Use, and Restoration will focus on promoting sustainable food systems to tackle negative externalities; deforestation-free agricultural commodity supply chains; and large-scale restoration of degraded landscapes for sustainable production and ecosystem services. This IP will provide an opportunity for researchers, businesses, and practitioners to better understand the complexities and principles involved when working towards a circular economy for agri-food. STAP recommends that child projects under this IP should include involvement of both key stakeholders and circular economy specialists at an early stage of project preparation. Together they would help assess the practicalities of achieving key outputs and outcomes for the project and help develop the project proposal accordingly.

Overall, the GEF is well positioned to support the essential transition needed to feed everyone on the planet adequately whilst avoiding negative externalities and sustaining biodiversity as well as the health of human beings, ecosystems, and the planet.

"As well as energy, climate change discussions should focus more on food production and cutting food waste, but a lack of knowledge is fuelling public resistance. All these things can help us ensure that, in producing the food that we need to feed the billions of people on this planet, we're not destroying the planet in the process."

Barack Obama, May 2017[1]

1. WHAT IS THE ISSUE?

Global food production continues to grow to meet the demand from rising populations and incomes. Food insecurity today is mainly due to conflicts, droughts, and floods rather than from systemic production shortfalls[2]. Today's food supply system[3] produces around 2.8 billion tonnes of cereals and 330 million tonnes of meat annually[4], largely thanks to the "Green Revolution" of the mid-20th Century that involved new crop varieties, fertilisers, agri-chemicals, mechanisation and improved farm management. Land use change from forests and peatlands to provide more agricultural land has also contributed to growth in the food supply.

However, food production needs to increase by a further 50% by 2050 to meet the projected demand[5]. This needs to be achieved sustainably in order to produce nutritious food without compromising natural capital and ecosystem services that support food production. This target could possibly be achieved by changing consumption patterns[6]; increasing the productivity of crops and animals (e.g. tonnes per hectare, milk solids per cow); adopting the circular economy approach; reducing food losses; and minimising negative externalities in the food supply value-chain. Innovative technologies can also contribute to this goal.

From subsistence farming to medium and large, vertically-integrated corporations, a range of adverse environmental impacts are frequently observed. The modern industrial food supply system consumes resources and energy inputs on-farm and in pre-processing, storage, transport, food processing, retailing and cooking. A significant proportion of these resources are wasted due to the failure to consume around one-third of the food produced as a result of losses in storage and wastes at the retail and consumption stages.

The agri-food sector consumes over 30% of total global end-use energy, mostly from fossil fuels, and emits around 22% of total global anthropogenic greenhouse gases (GHG)[7, 8], including methane (from livestock and paddy rice) and nitrous oxide (from fertiliser and animal urine). Land use change from converting forests and peatlands to agricultural use contributes a further 10 to 15% of total emissions.

The sector also causes almost two-thirds of biodiversity loss, causes extensive land and water degradation[9], depletes fishing stocks, and over-exploits the world's aquifers. The sector needs to be transformed so it can produce enough nutritious food for everyone while minimising its negative impacts on the planet's resource base, climate, and ecosystems[10].

The modern food supply system is mainly linear with respect to inputs of nutrients, energy, water and increasing distance to markets (Fig. 1a). Transition to a more circular economy (Fig. 1b) would improve resource use efficiency, substitute renewable or recyclable resources for finite ones, and enhance ecosystem services from pasture, crop, and forest lands[11]. In addition, agro-ecosystems could be designed to provide environmental health, watershed functions, disaster risk mitigation and healthy human habitats; biodiversity could be sustained and landscapes in production regions re-wilded; food losses and wastes could be minimised and consumption patterns changed; and sound human nutrition levels could be provided universally[12].

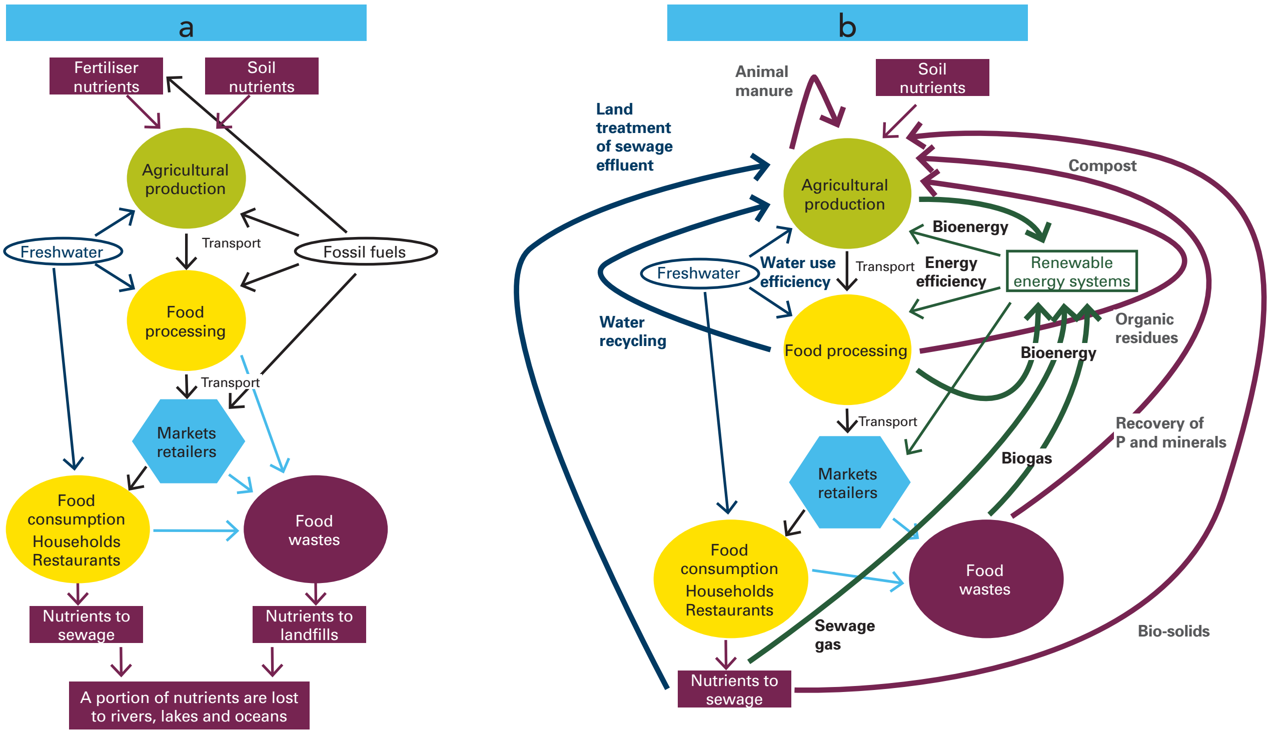

Figure 1. a) The conventional food supply system is mainly linear, relying on the extraction of non-renewable resources and the subsequent loss and waste of nutrients causing pollution[13]. A few circular elements are already common practices, such as applying animal manure to land, but these are limited.

b) A circular food economy uses renewable energy systems linked with improved energy efficiency, can recover and recycle nutrients to farmland (red); reduce food losses and re-use wastes for animal feed, compost and bioenergy (green); and recycle water and increase use efficiency (blue) to reduce demand for freshwater and avoid pollution of waterways.

2. WHAT DOES THE SCIENCE SAY?

The present world food system is not sustainable in the long term due to many factors. Present scientific analysis confirms that significant changes are urgently required, and many scientific studies offer potential solutions to improve sustainability in both the short and long terms. For example, implementing the individual components that contribute to a circular economy approach (Fig. 1b) would aid the transition to a more sustainable food supply system.

A range of potential technical and behavioural solutions, as identified in the scientific and practitioner literature, are summarised in strategic terms below. Food systems exacerbate climate change and are not resilient to it. This is covered by the first three strategies listed. Protecting sustainable land and water use are critical for food production and are covered by the next three. For these six general categories, as well as for improving resource use efficiency, some recommendations are made by STAP in Section 4. These advise the GEF on how its programs and investments can help make the global food supply system become more sustainable in the near and longer term future.

• Reducing GHG emissions in the value-chain

Keeping the global temperature rise below 1.5°C above pre-industrial levels would mean achieving net zero emissions across all sectors of the global economy well before the end of this century. However, the current agricultural development pathway projections show sector emissions would not be cut sufficiently[14]. So either other sectors will need to achieve negative emissions (at an acceptable marginal cost per tonne of CO_2-equivalent avoided) to offset future agri-food sector emissions or, more likely, the agri-food sector will need to transform from its present state. Options to reduce methane emissions from rice paddy fields and ruminant livestock, and to reduce nitrous oxide from animal urine and the application of nitrogenous fertilisers, appear limited[15]. Transformative technical and policy options and investments are therefore urgently needed.

Increasing productivity at the global scale[16], avoiding food losses, and giving special attention to the role of carbon stocks in soils and biomass have good potential to reduce emissions intensity in the short term. Improving the efficiency and productivity of agricultural production could potentially reduce emissions by up to 1.1 billion tonnes of CO_2-equivalent by 2030[17]. This would be consistent with global emission pathways that limit warming to below 2°C. In addition, sequestering carbon is possible in many soils by incorporating organic matter and/or adding biochar[18], as well as through re-vegetation and agricultural land-use mosaics[19].

• Transition to a renewable and efficient energy supply

A vast amount of energy is needed to bring the world's food to the table[20]. This includes energy for on-farm production and harvesting, fertiliser manufacture, food processing, transport, storage, and cooking. Except for the traditional use of biomass to provide heat (mainly from combustion of fuelwood and dung) most of this energy comes from fossil fuels. Future price shocks in the energy market would, therefore, affect the price of food for all.

The environmental and economic impacts of the global food system can be reduced by the rapid and wide deployment of renewable energy systems, as well as greater energy efficiency throughout the value-chain.

• Climate-proofing future food production

Agricultural production systems are highly vulnerable to the impacts of climate change. In warm regions, higher temperatures will stress crops and livestock, thereby reducing productivity and product quality. Elsewhere, increased incidence of droughts, floods, and spread of pests and diseases will cause further losses. Conversely, in temperate to high latitudes, climate change could possibly increase crop yields, thus widening existing disparities[21]. However, 'protected agriculture', urban agriculture, hydroponics, biocultures, algae, and aquaculture all offer more climate-resilient means of food production.

Stakeholders throughout the agri-food sector will need to become more resilient[22] in the face of a changing climate. New and innovative climate-proof food production systems, such as drought-resistant crop species, conservation tillage methods to reduce soil erosion under high rainfall events, and protected vertical horticulture systems, will need to be further developed and widely deployed.

• Higher productivity to reduce land clearing

Measures to increase productivity that are well understood (for example, system of crop intensification – Box 1) can help address food security as well as reduce GHG emissions. Novel mitigation options to address non-CO2 emissions, such as methane inhibitors for ruminant livestock, are being developed. To be successfully taken up by farmers, they need to increase, or at least maintain animal productivity[23]. Such technologies may achieve a reduction in GHG emissions intensity per unit of food produced but, if not well-designed, could result in an increase in absolute GHG emissions.

Expansion of grains, soybeans, palm oil, sugar, beef and other commodities has caused worldwide losses of carbon stocks, forests, grasslands, and biodiversity[24]. Agricultural practices and inputs can seriously interfere with wildlife habitat; agri-chemicals can affect non-pest species (such as bees, birds, and fish), disrupt reproduction, and contaminate water and food sources; tillage can destroy soil structure, microbiota, and birds' nests; and water diversion can disrupt natural water supplies. At the same time, large areas of land are being farmed at levels well below their potential optimal productivity[25].

Improving the productivity per hectare on existing land will reduce the need for further land clearing and hence also reduce biodiversity loss.

BOX 1.
System of crop intensification (SCI)

Originally introduced for rice crops[26, 27] SCI is claimed to give higher productivity, use less water and land, reduce production costs and generate higher income for farmers. It is part of a family of agro-ecological methods and strategies aiming to give good economic returns, especially for smallholders with limited resources, together with environmental benefits. These methods include conservation agriculture, pest management, nutrient management, agroforestry, holistic rangeland management, aquaculture, and water harvesting all integrated into the farming system. The methods determined for rice crop intensification have also been extrapolated to wheat, sugarcane, potatoes and other crops[28, 29].

• **Conservation farming to avoid land degradation**

Around one-third of the agricultural land is "moderately to highly degraded due to erosion, salinisation, compaction, acidification, and chemical pollution"[30]. Severe cases result in 2 to 5 million hectares of cropland being abandoned each year[31]. This is the result of unsustainable farming practices such as cultivation of slopes, over-grazing, inefficient irrigation resulting in soil salinisation, and excessive use of nitrogenous fertilisers leading to soil acidification[32]. Soil organic matter has declined in many croplands through stubble burning or removal of crop residues for animal feed, bedding or bioenergy use and ecosystems have also been affected.

Conservation farming systems, including organic farming, the addition of biochar to the soil, and improved farm management systems, can help slow the current rate of land degradation in some regions.

• **Better water management to improve water quality and watershed functions**

Over 70% of the world's total freshwater withdrawals are for agriculture[33] with irrigated land producing about 45% of the world's food. Extraction of surface water affects lake, stream and river ecology and flow rates[34]. Major aquifers have been depleted and water tables lowered where extraction has been greater than the recharge rate, particularly in the USA, China, and South Asia. In addition, glacial retreat is threatening future freshwater supplies, for example, in East Africa and the Andean countries of Latin America. Local waterways, aquifers, and estuaries are often adversely affected by agricultural pollution and sediment, with increasing impacts on wildlife biodiversity. Freshwater sources have also been extensively polluted by agri-chemicals, fertiliser run-off, livestock wastes, food processing effluents, and nitrate infiltration.

Contaminated watersheds can be restored to acceptable ecological quantity and quality by improving local farm management and food processing systems, monitoring water availability and managing extraction rates.

- **Improving resource use efficiency**

Over the past 50 years, crop production has tripled due to increased land clearing, a doubling of the total area irrigated, a five-fold increase in fertiliser application, and a 30-fold increase in the use of agri-chemicals[35]. Continuing along this pathway is not sustainable.

More efficient use of resources can improve the sustainability of food supply systems by reducing inputs per unit of food production whilst increasing productivity and avoiding negative impacts on biodiversity and water quality[36].

Examples of how the GEF might incentivise improving resource efficiency in both the short and long terms are discussed in Section 4.

3. WHY IS THIS IMPORTANT TO THE GEF?

The challenge is to feed over 9 billion people by 2050 whilst significantly reducing the negative externalities. Food production will need to increase by more than 50% by 2050 and also meet the increasing demand for protein as rising incomes expand the middle classes, especially in Asia.

Currently, the sector causes almost two-thirds of biodiversity loss, extensive land and water degradation[37], depleted fish stocks, and over-exploitation of the world's aquifers. Therefore the sector needs to be transformed so it can produce enough nutritious food for everyone while minimising its negative impacts on the Planet's resource base, climate, and ecosystems[38]. Supporting sustainable intensification to reduce environmental degradation and negative externalities from food supply systems and value-chains[39] can be achieved by promoting well-understood best practices and innovative tools. To provide a secure supply of quality food for all without increasing the environmental impacts, many of the possible solutions will need integrated systems thinking.

Meeting the growing food demand[40] while reducing the negative impacts would be made easier if the wastage of around one-third of the food produced globally was reduced. This stems from both post-harvest handling and storage losses mainly in developing countries, and food wastage by the food-processing industries and consumers mainly in developed countries. In addition, better nutrition can curb the unhealthy diets responsible for the current pandemic in non-communicable diseases which claim 70% of human lives[41].

The global goals of the GEF around land degradation, clean water, sustainable forest management, climate change mitigation and adaptation, and biodiversity conservation cannot be met unless the agri-food sector is better aligned with these objectives.

The GEF is already addressing this through two of the IAPs.

- The Food Security IAP program focuses on fostering long-term sustainability and resilience through integrated management of natural capital (land, water, soil and genetic resources) in Africa. Efforts focus on shifting agricultural productivity to a low-emission and resilient pathway. This entails adopting techniques and approaches that sequester carbon in soils while improving soil quality; improving the accuracy of fertiliser application to minimise agro-chemical residues in water; and carefully managing the production system so that interactions between land, water and energy are considered in land management decisions.

Because the agri-food sector encompasses many disciplines, it has wide-ranging impacts on several of the Sustainable Development Goals (SDGs). The Food Security IAP responds directly to SDG 2 (zero hunger) and SDG 15 (life on land). The child projects under this program also have strong links to SDG 1 (no poverty), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production) and SDG 13 (climate action).

- The Commodities IAP program takes an integrated approach to tackling the underlying root causes of deforestation that results from agriculture commodities through value-chain management. Beef, palm oil, and soy production together account for nearly 70% of deforestation globally. The pathways of agricultural production, consumption, and potentially food waste are followed for each of these commodities. Through this approach, the program avoids the risk of improving some activities in the value-chain but then shifting the problem to other activities in the value-chain. Embedding sustainability measures (such as those described in this paper), throughout the food pathways is critical.

In addition, the Impact Program on Food Systems, Land Use, and Restoration planned for GEF-7 will focus on three interrelated priorities:

- promoting sustainable food systems to tackle negative externalities in entire value-chains;
- promoting deforestation-free agricultural commodity supply chains; and
- promoting large-scale restoration of degraded landscapes for sustainable production and ecosystem services.

4. HOW CAN THE GEF RESPOND?

In order to deliver the objectives of the relevant multilateral environmental agreements, the GEF should assess how best to support projects that will change present food consumption patterns and lead to more secure and sustainable food supply systems. This is challenging because major environmental impacts are associated with the conventional agri-food sector, innovative technological developments are evolving rapidly with several close to commercial viability, and a wide range of institutional models directly link agri-business development opportunities with environmental management at both the value-chain and large landscape scales.

Rather than supporting projects which achieve only incremental improvement to conventional, mainly linear, food systems, the GEF should invest in projects that:

- integrate a long-term vision and theory of change for improving productivity;
- promote the circular economy (Fig. 1b) and zero waste concepts;
- value co-products that arise from sustainable production and consumption systems;
- support innovative protein production systems; and
- engage consumers in designing future sustainable food supply systems.

Models of more resource-efficient and less environmentally-damaging systems are available. In addition to using well-understood practices to increase productivity and efficiency, the GEF can play a role by promoting various initiatives that are just starting to reform the global food system in order to "feed a growing global population with healthy food from a healthy planet"[42]. These would have positive net benefits on watershed functions, on the generation of ecosystem services from agricultural landscapes for biodiversity and natural habitats, and on climate change mitigation and adaptation. Overall, this will create a more synergistic relationship between economic, ecological and social systems (including human health and well-being).

Integrating such initiatives synergistically into larger-scale strategies and incorporating them into more ambitious transformation efforts to reduce GHG emissions and restore planetary health would generate integrated models that could guide investment in sustainable food supply systems by governments, civil society, and the private sector.

The GEF should consider incorporating the following elements into its integrated initiatives relating to food supply and consumption:

a. Short term actions

Sustainability of the food supply system can be improved in the short term through supporting more efficient use of resources leading to reduced inputs per unit of food production whilst increasing productivity and avoiding negative impacts on biodiversity and water quality. Many of these are well understood and already supported in past GEF projects and programs

In its current programmes and forthcoming projects relevant to food supply systems, where appropriate, the GEF should continue to support the following initiatives:

- careful management of on-farm production systems, crop residues, stubble and grazing lands to minimise soil erosion and enhance soil fertility[43];
- sustainable land management practices and conservation tillage techniques;
- urban agriculture, bio-cultures and other climate-proof systems, especially those that enable nutrient and water recycling and conservation;
- if technologies and practices used by the leading 10% of practitioners to reduce their emission intensities were adopted by all, this could reduce GHG emissions in the food process by 30%[44];
- improving the efficiency of water and energy use along the food supply chain;
- increasing the installation of renewable energy heat and electricity generation systems to displace fossil fuels and provide greater energy access;
- precision farming, including more accurate fertiliser, irrigation, and agri-chemical applications;
- judicious use of chemical inputs to minimise food, water, and wildlife contamination[45];
- remote sensing, use of drones for pest monitoring, and smartphones for disease diagnosis;
- more efficient food processing operations and transport logistics;
- improved post-harvest storage and better access to markets to reduce food losses; and


Source: Adobe Stock

- creating better consumer education and awareness of food retailing, preparation, cooking and nutrition to help minimise consumer food wastes. Any remaining food wastes can also be converted into feed for animals or for insects that can then be processed to supply protein for consumption by humans, fish or poultry[46].

Exactly "how" the GEF can support these and other specific strategies in the short term will depend on the proponents of food-related projects being aware of the complex issues that involve making the food supply system more sustainable. Providing an understanding of the enormity of the problem and the need to make progress in starting to resolve it should encourage project proponents to consider incorporating at least some of the initiatives listed above into their projects wherever appropriate to do so.

Making the transition of the current linear food supply sector to more of a circular economy concept (Section 1) will require gaining more knowledge and experience of each of the components. This could be achieved by initially undertaking demonstrations of one or more of the technical and behavioural components involved in a circular economy as part of relatively small projects rather than aiming for full integration from the onset. Thus, GEF-7 multi-focal area projects could include, for example, composting of food wastes, recycling of food processing effluents, or conversion of crop by-products to bioenergy. This would help provide a greater understanding of the challenges of achieving a true circular economy from real-world experiences, leading to developing a fully integrated sustainable food supply system in the longer-term.

STAP recommends that proponents of any GEF-7 projects relating to the agri-food sector be encouraged to include one or more additional components linked to the circular economy wherever practical to do so.

b. Longer term actions

In the longer term, additional concerns will need to be addressed if sustainability of the food supply system is to be improved, sectoral GHG emissions reduced, and further degradation of land, water and nutritional quality of food avoided. The GEF could encourage the integration of a number of innovative solutions, as outlined below, into its current and future programs.

This begs the question: "How can the GEF encourage the integration of land, water, energy and climate strategies into agri-food related projects that would lead to incorporating systems thinking around the circular economy?"

Given the magnitude of making the transition from the current linear global food system towards a more complex circular one (Fig. 1), and knowing that the 1.5°C target, or even the 2°C target, of the Paris Climate Agreement, cannot be met without significant GHG emission reductions coming from the agri-food sector (since it is responsible for around 22% of total GHG emissions[47]), the answer will require careful deliberation.

The planned Impact Program (IP) on Food Systems, Land Use, and Restoration currently under development offers an opportunity. Researchers, businesses, and practitioners working towards a circular economy for agri-food are presently having to move up a steep learning curve in order to better understand the complexities involved. Therefore STAP recommends that when a child project under this IP involves one or more of the eleven strategies listed below, that the project proponent is encouraged to organise a meeting of key stakeholders at an early stage of project preparation. The aims would be to deliberate on the practicalities of achieving a realistic outcome for the project, report back to the GEF and partner agencies on the lessons learned, and develop the project proposal accordingly. The group of stakeholders to be consulted for a project should include:

- representatives of research organisations specialising in the circular economy concept;
- private sector enterprises with direct investment in commercialising the technologies or systems in question;
- farmer, food processor, food retailer or waste management associations as appropriate;
- a social scientist if behavioural changes by consumers are involved in the project;
- financial organisations if a price on carbon, green bonds, quotas, or other economic instruments are involved in the project; and
- specialists in land use, water, energy, climate mitigation or adaptation as required.

For each of the following strategies, some general recommendations from STAP are also provided.

(i) Closing the nutrient cycle

The export of nutrients from farmlands in raw food products and co-products reduces the fertility of soils which threatens future productivity and food quality. Maintaining soil nutrient levels by applying mineral fertilisers is common practice but can result in negative consequences for the environment. The amounts of nitrogen and phosphorus released have already breached planetary boundaries[48]. For example, more than 400 dead zones have been formed in the oceans, such as in the Gulf of Mexico as created by fertiliser run-off from the Mississippi River's watershed[49].

Manufacturing mineral fertilisers usually involves high fossil fuel inputs. Novel methods are under evaluation which have lower GHG emissions, such as using renewable electricity to produce hydrogen that is then used to produce ammonia[50].

Returning nutrients to soils from animal manures, compost, or recovered elements (Fig. 1b)[51] reduces the requirement for chemical fertilisers, minimises sewage treatment, and reduces pollution. Compost made using food wastes from supermarkets, restaurants and households, and organic matter from crop residues, food processing by-products, sewage sludge and effluent outputs can be incorporated into the soil.

Growing leguminous crops that fix atmospheric nitrogen for plant uptake and use, and encouraging free-living nitrogen fixers in the soil, can reduce the demand for artificial nitrogenous fertilisers whilst maintaining crop productivity. Beneficial microbes can provide other positive impacts on soil systems.

Wherever appropriate, relevant programs of the GEF could encourage the recycling of nitrogen, phosphorus, potassium, other minerals and micronutrients currently lost in urban landfills and sewage treatment plants. Farming systems would be managed so as not to 'leak' nutrients and any food processing or consumer wastes remaining after efforts are made to avoid them could be re-processed.

(ii) Reducing competition for productive land

It has been estimated that the world's present productive land of 1540 million hectares (Mha) will need to increase by between 21 to 55% (320 to 850 Mha) by 2050 to satisfy growth in demand for food. The land area available would also need to accommodate competition for the production of fibre, biofuels, and bio-materials, and compensate for land lost to urban development and soil degradation[52]. However, this would then exceed the total area farmed of 1,640 Mha estimated by UNEP to be within the "safe operating space".

Improving productivity in the agri-food sector offers global environmental benefits but also some unique challenges. Past decades have seen a steady increase in crop and livestock productivity as a result of better management, improved seed genotype quality, and animal breeding. However, the annual rate of increase is beginning to slow in many regions, and the land resource base is also declining due to soil degradation.

Project evaluation criteria used by the GEF may need to recognise the potential problems from increased intensification. However, employing circular economy principles can reduce competition for land, for example, through the hydroponic culture of vegetable crops. By-products from food and fibre crops could be used to produce bioplastics or biofuels. Restoring or rehabilitating degraded land can provide additional productive land area for growing food crops. In addition, cutting the volumes of food losses and wastes will reduce the pressure for agricultural expansion, as well as lower the demand for inputs of energy, fertiliser, and water.

The increasing demand for agricultural land can be reduced by further intensifying farming systems to improve productivity (in terms of kg protein per animal or t/ha of crop) but without increasing environmental impacts. The system of crop intensification (SCI) is an example (Box 1)[53]. However, further intensification of some crop and livestock enterprises could also exacerbate local and global environmental impacts unless subjected to careful management.

(iii) Reducing freshwater use by constraining demand

Withdrawal of freshwater from lakes, rivers, and aquifers is now around 4,500 billion m^3 per year, with agriculture consuming nearly three-quarters of that (excluding direct rainfall on non-irrigated land). Globally, demand for freshwater is projected to increase by more than 50% by 2050, with agricultural demand increasing by 20%[54] or more. Freshwater shortages are already occurring due to adverse climate impacts, depletion of aquifers and rivers, and contamination of water sources especially in Africa, the Middle East and South-East Asia (Fig. 2). Many countries have shifted from being designated as 'water-abundant' to 'water-scarce' because of the increased demand for water, as a result of climate change and population growth.

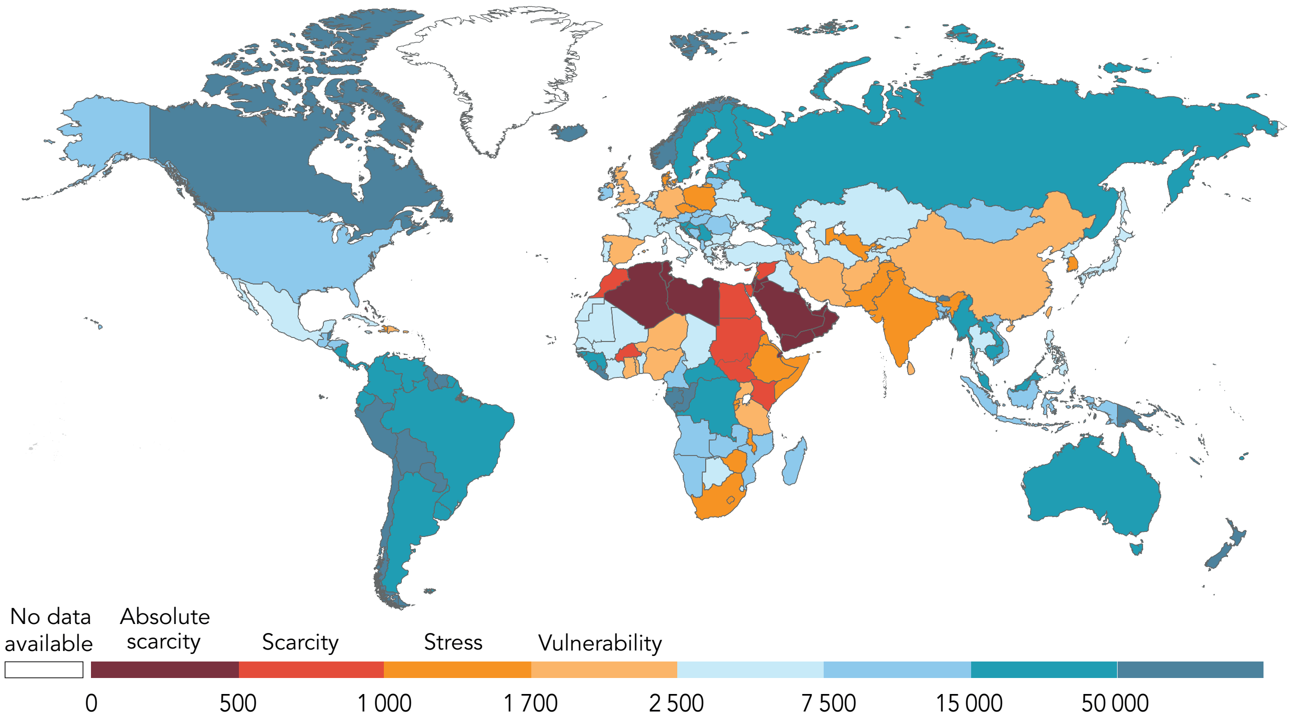

Figure 2. Total freshwater resource availability per capita by country in 2013[55].
Note: scale is non-linear.

Implementing "smart irrigation" schemes, conserving water[56], improving water catchment systems, recharging aquifers, and avoiding pollution of waterways will benefit many farmers and food processors. In countries where water supply and use are subsidised, efforts to conserve water are less likely to succeed. Conversely, the market pricing of water has resulted in more efficient use in Australia and elsewhere, and this model could be followed by others. Alternative sources of freshwater from desalination plants and crop fogging systems, and recycled grey water from buildings, food processing plants, wastewater treatment, urban stormwater etc. could all be used for intensive horticulture, livestock drinking water, and urban agriculture, where economically viable.

Improving the efficient use of water through precision irrigation, water harvesting and storage, water recycling (including urban and food processing wastewater), and imposing strict controls to avoid water pollution can all help restrict the growing demand for freshwater by the agri-food sector and avoid the need for costly desalination or removal of contaminants.

(iv) Safeguarding agro-ecological systems and soil carbon

Under many conditions, agro-ecological practices can compete with conventional farming practices on crop yields but in addition can deliver ecosystem benefits such as healthier soils, rainfall retention, aquifer recharge, removal of contaminants, and reduced run-off[57].

Improving crop productivity, and reducing GHG emissions without substantial investment being required, may be possible by using an agro-ecological approach that encourages low-input organic production of crops and animals, conservation tillage, crop rotations, and integrated crop/livestock systems. Where crop residues and animal wastes can be recycled to the land, soil losses from wind and water erosion are reduced, (but not always eliminated), and the soil carbon content increased.

Farm management systems based on conservation farming can increase agro-eco diversity, improve crop and animal health and provide greater resilience. In addition, a "landscape approach" to managing productive agricultural land can achieve social and economic objectives whilst meeting environmental and biodiversity goals[58].

Soil carbon sequestration at scale is feasible using a variety of measures including:

- rotational grazing and agro-forestry systems;
- replacing annual crops, particularly for animal feed, with perennial alternatives that store carbon longer-term in root systems;
- application and soil incorporation of biochar produced from sustainable sources; and
- a variety of land and vegetation restoration practices, including re-wilding.

There are good opportunities to make agro-ecological systems, and the services they provide, more sustainable in the long term by enhancing their resilience to climate change and hence reducing the negative impacts of modern intensive food production. Any practices known to increase soil carbon contents would be worthy of support by the GEF.

(v) Promoting diversity through agro-ecological practices in agricultural systems

The diversity of genes, species, communities, and landscapes is a critical factor in enhancing the value of agricultural food production systems as are landscapes for ecosystem services, wildlife habitat, climate resilience, and disaster risk reduction. Agro-ecological practices can benefit farm households and rural communities, as well as ecosystem services and biodiversity. They can complement natural habitat management, achieve increased productivity goals, and help promote healthier and more sustainable food and fibre products at local markets.

The GEF should encourage diversification of agro-ecosystems by facilitating access to new seed varieties and supporting innovations that facilitate the marketing of a wide range of food products from local farms and communities.

(vi) Deploying low-carbon, climate-smart technologies

Energy-smart food production systems have been assessed at all scales in both developing and developed countries[59]. Access to renewable electricity and heat allows farmers and food processors to adopt new technologies and so increase productivity, food quality and hence add value to their products.

Other climate-smart mitigation technologies have potential to reduce GHG emissions in agri-food systems. These include solar water pumping, conservation tillage, efficient solar-powered cold storage systems, and drip irrigation. A methodology has been developed[60] to enable decision-makers to make informed decisions when prioritising investment in the many climate mitigation technologies and practices available for deployment along the food supply chain. The technical parameters, financial and economic feasibility, local community benefits, and sustainability of these and other technologies and practices are accounted for when considering the mitigation potential under local conditions. Barriers which may hinder the adoption of specific climate-friendly technologies have been identified and policies have been proposed[61] to remove them and stimulate market penetration.

The UN Food and Agricultural Organisation (FAO) has also undertaken a broad analysis of applying renewable energy technologies in the agri-food sector, using milk, rice and vegetable value-chains as examples[62]. The costs and non-economic benefits have also been evaluated[63]. These include improved human health, saving of time, reduced drudgery, water saving, increased productivity, improved soil quality and fertility, biodiversity protection, improved livelihoods and quality of life, and gains in food security. Trade-offs need to be taken into account when developing policies to encourage the uptake of these technologies.

Many opportunities exist to improve energy efficiency throughout the food supply chain, including on-farm, transport, and processing. Deploying renewable energy systems is feasible along the entire food-chain. Proven climate-smart technologies that have a range of co-benefits should be promoted where appropriate.

(vii) Reducing the demand for animal protein

The global demand for animal protein is growing. Reducing animal protein intake per capita, especially in affluent and urbanised societies, by substituting vegetable protein would not only reduce GHG emissions and the demand for land and water, but could also improve human health. Consumer demand is the key driver of the food sector, so heightened awareness of these issues could be a key step to making behavioural changes. However, in some regions, for traditional communities where meat is a high-quality form of dietary protein and wild meat is traded, livestock production can have cultural and economic significance. Also in drylands and cold regions, there may be no viable alternative productive use of land.

To produce a unit of animal protein uses significantly more land, water, and energy than a unit of vegetable protein. Providing protein from other sources where feasible also uses fewer resources per unit than when producing animal protein. As a circular economy principle, protein demand could probably be met by low input alternatives including those derived from pulses, vegetables, insects, and biological and chemical synthesis. These alternatives also impact less on biodiversity and ecosystem services than when producing animal protein, although the differences are still to be quantified[64].

There is a growing trend towards producing synthetic protein biochemically and several companies are developing and retailing such products[65]. For example, this “meat” can be grown cleanly and efficiently under factory conditions by fermentation of vegetable proteins or from just a few stem cells. These synthetic food products are claimed to be able to supply all human nutritional needs, including vitamin B12 which is mainly found in animal products. If the energy inputs for such a process can be met from renewable sources, the carbon footprint is much lower than from farming animals[66] and demand for water and soil nutrients are also reduced.

Innovative techniques to produce food products from synthetic proteins are rapidly becoming commercialised. Such developments should be supported and promoted by the GEF to reduce demand for animal protein and offset the environmental impacts resulting from animal production for meat and milk products.

(viii) Producing food within the urban landscape

Rooftop gardens, community vegetable plots, and living building facades are becoming common in cities worldwide. They could provide significant volumes of local food for the citizens in the near term. Multi-storey “factory farms” (known as “vertical farming”) are more long term, although demonstration plants already operating in some cities are claimed to achieve about 70 times the food intensity per unit land area compared with field crop production[67].

Since urban citizens consume (or waste) more than half of total food nutrients and a quarter of total freshwater demand, cities could become a major enabler of the circular food economy by capturing and reusing these resources for urban food production.

Integrating the management of food production activities within urban locations can help meet the disaster risk management, biodiversity and climate goals of a city as well as reduce water demand and improve water quality[68].

Encouraging the development of urban food production should be supported, for example as a component of the GEF/World Bank's Sustainable Cities IAP.

(ix) Promoting advanced innovative technologies

Radical changes to global food production systems during the next decade could include the rapid development of novel practices and technologies[69] such as robotics, advances in biotechnology, genetic modification, artificial intelligence, virtual reality, and big data analysis.

New and near-commercial technologies include:

- monitoring soils and crops remotely;
- precision farming systems that apply fertiliser, agri-chemicals, and water only when and where needed;
- drones that apply agri-chemicals precisely and can also be used to check the health of crops and livestock;
- cows milked robotically whenever they choose to be without human intervention;
- smartphones used by farmers to help diagnose crop disease, receive expert advice, and check market prices;
- energy efficient storage facilities and refrigeration systems, including solar absorption technologies;
- crops grown in non-soil media under a controlled environment in urban locations using diverse, highly technical, indoor ecosystems; and
- renewable heat and electricity generated for use on-site by small and large-scale farms as well as food processors.

Many innovations not yet commercially viable but reaching the demonstration phase could prove beneficial for making the food supply system more sustainable in the long-term.

The GEF should assess the relevance, impact, and sustainability of these technologies for different types of food systems (e.g rice, milk, vegetables); support their adoption where needed; and monitor the environmental costs relative to the potential benefits for farmers, food processors, and consumers.

(x) Stimulating policy and institutional advances

Transforming agri-food production and consumption systems and mainstreaming the circular economy will require cross-sectoral collaboration, the inclusion of the private sector, leverage of private financing and capacity building. A number of organisations have recently developed a strong involvement in working towards a circular economy in the food sector. For example, the Ellen Macarthur Foundation in the UK has initiated a major analysis of the concept linking food supply with cities[70].

The GEF could play a catalytic role by supporting enabling activities to develop a better alignment between the agri-food sector and environmental management. It could provide incentives for cross-sectoral collaboration and develop partnerships with the private sector and other interested organisations. In addition, it could assist recipient countries to develop and adopt suitable policies and provide them with incentives to support demonstration projects of novel technologies, systems and institutional innovations suited to the prevailing circumstances of the agri-food sector.

(xi) Measuring success

The potential environmental benefits per unit of food product delivered to the consumer are complex but can be measured in terms of units of water or fossil fuel energy inputs consumed, amount of GHGs emitted, nutritional quality, and food losses and wastes avoided (in terms of total production per unit of product finally consumed). A full range of indicators to measure project success has been proposed by U.N. Environment's International Resource Panel[71]. In addition, the Food Sustainability Index[72] identified 58 indicators used to assess, compare, and rank how a country's food supply system, and its stakeholders, are moving towards greater sustainability. However, the present suite of indicators is relatively weak on ecosystem services, climate impacts, land health and biodiversity measures, as well as evaluation within complex landscapes.

The GEF could play a leadership role in strengthening and encouraging the use of metrics that not only address environmental impacts per unit of agricultural output, but also track the overall health of agricultural landscapes in terms of production, productivity and ecosystem services, biodiversity, food security and human well-being.

Conclusion

The global food supply system and the land/water/energy/climate nexus are complex. Currently, the global food supply system is not sustainable. The GEF's integrated programs that relate to the future sustainability of food supply should be monitored to ensure that potential solutions to reducing environmental impacts, including promoting the circular economy approach and any trade-offs, are well understood. Given the rapid rate of technological development and growing consumer awareness, any future interventions by the GEF should be supported by the latest scientific knowledge.

Endnotes

1 Thomson Reuters Foundation. Climate change talks should focus on food, despite resistance. http://news.trust.org/item/20170526132835-rjekn/

2 FAO. 2017a. The future of food and agriculture – trends and challenges, UN Food and Agricultural Organisation, Rome. http://www.fao.org/3/a-i6583e.pdf

3 The terms "food supply system" and "agri-food sector" are used interchangeably in this paper. They describe the wide range of activities and businesses involved in providing food and drink to consumers along food supply value-chains. "From plough-to-plate" includes production on farms and in fisheries, post-harvest storage and losses, food processing operations, transport, marketing, cooking, consumption and wastage. Where only on-farm activities are being considered, the term "agricultural production" is used.

4 FAO. 2016a. FAOSTAT, Statistics division of the UN Food and Agricultural Organisation, Rome. http://www.fao.org/faostat/en/#home. Up from about 741 billion tonnes of cereal and 71 million tonnes of meat in 1961.

5 Ibid – FAO. 2017a

6 For example, by reducing demand for meat and milk protein and by reducing excessive consumption and unhealthy diets that lead to obesity and associated poor health.

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Plastics and the circular economy

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Summary

The production of plastics increased by more than twenty-fold between 1964 and 2015, with an annual output of 322 million metric tonnes (Mt), and is expected to double by 2035, and almost quadruple by 2050. Plastics contribute to economic growth, but their current production and use pattern, on a linear model of 'take, make, use, and dispose', is a primary driver of natural resource depletion, waste, environmental degradation, climate change, and has adverse human health effects.

Conventional plastic production is highly dependent on virgin fossil feedstocks (mainly natural gas and oil) as well as other resources, including water - it takes about 185 litres of water to make a kilogram of plastic. Plastic production uses up to 6% of global oil production, and this is expected to increase to 20% by 2050, when plastic-related greenhouse gas emissions may represent 15% of the global annual carbon budget.

Some plastics contain toxic chemical additives, including persistent organic pollutants (POPs), which have been linked to health issues such as cancer, mental, reproductive, and developmental diseases. It is difficult to recycle some plastics without perpetuating these chemicals.

About 4900 Mt of the estimated 6300 Mt total of plastics ever produced have been discarded either in landfills or elsewhere in the environment. This is expected to increase to 12,000 Mt by 2050 unless action is taken. The ocean is estimated to already contain over 150 Mt of plastics; or more than 5 trillion micro (less than 5mm) and macroplastic particles. The amount of oceans plastic could triple by 2025 without further intervention. By 2050, there will be more plastics, by weight, in the oceans than fish, if the current 'take, make, use, and dispose' model continues.

Plastics stay in the environment for a long time; some take up to 500 years to break down; this causes damage, harms biodiversity, and depletes the ecosystem services needed to support life. In the marine environment, plastics are broken down into tiny pieces (microplastics) which threaten marine biodiversity. Furthermore, microplastics can end up in the food chain, with potentially damaging effects, because they may accumulate high concentrations of POPs and other toxic chemicals.

Microplastics are an emerging source of soil and freshwater pollution. The contamination of tap and bottled water by microplastics is already widespread, and the World Health Organization is assessing the possible effects on human health.

The continued rapid growth in the production and use of plastics will have a severe and deleterious effect on the GEF's ability to deliver its objectives in the following areas:

(i) Chemicals and waste: some POPs are used as chemical additives in some plastics, and dioxins and furans are byproducts of polyvinyl chloride (PVC) manufacture.

(ii) Climate change mitigation: producing plastics using fossil fuels is an important source of greenhouse gas emissions, as is the open burning and incineration of plastic wastes. Greenhouse gas emissions from plastics were estimated to be 390 million tonnes of CO_2 in 2012.

(iii) International waters***:*** plastics pollution is prevalent in all oceans globally.

(iv) Biodiversity: plastics pollution is the second most significant threat to the future of coral reefs, after climate change. The impact of plastic on marine species, including entanglement and ingestion by turtles, birds, fish and mammals, is well documented. Many of the chemicals additives used in plastics have proven adverse effects on fisheries and their habitats.

(v) Land degradation and food systems: the emerging threat from microplastics to terrestrial ecosystems, especially agricultural soils could lead to further land degradation affecting food production, including through microplastics contamination of food products.

The circular economy is an alternative to the current linear, make, use, dispose, economy model, which aims to keep resources in use for as long as possible, to extract the maximum value from them whilst in use, and to recover and regenerate products and materials at the end of their service life. It offers an opportunity to minimise the negative impacts of plastics while maximising the benefits from plastics and their products, and providing environmental, economic, and societal benefits. Circular economy solutions for plastics include: producing plastics from alternative non-fossil fuel feedstocks; using plastic wastes as a resource; redesigning plastic manufacturing processes and products to enhance longevity, reusability and waste prevention; collaboration between businesses and consumers to encourage recycling and increase the value of plastic products; encouraging sustainable business models which promote plastic products as services, and encourage sharing and leasing; developing robust information platforms to aid circular solutions; and adopting fiscal and regulatory measures to support the circular economy.

Circular economy solutions will help in 'closing the material loop', i.e. to minimise waste and to keep materials in the economy and out of landfills and incinerators, but the circular economy will not completely solve the global plastic problem. An all-encompassing solution should seek to 'slow the material loop', that is to reduce demand and produce only essential plastic products, including through discouraging non-essential production and use of plastics, and promoting the use of renewable and recyclable alternatives to plastics.

The GEF can play a significant role in promoting a transition to the circular economy in the plastics sector. In the short term, the GEF should mainstream circular economy concepts into its overall strategy, for example, as criteria for priority setting and decision making; invest in projects that promote circular concepts in the plastics sector to deliver global environmental benefits; help to create an enabling environment to overcome barriers and promote the adoption and implementation of the circular economy in the plastics sector; and incorporate plastic pollution mitigation into the Integrated Approach Pilot (IAP) for sustainable cities.

Looking into the future, the GEF should consider: supporting the development of circular economy indicators relevant to its work; collaborating with, and supporting partnerships and projects aimed at tackling the global plastic challenge, and facilitating and supporting innovation and applied research related to implementing the circular economy into the plastics sector.

1. What is the issue?

Plastics are one of the world's greatest industrial innovations, but the sheer scale of their production and poor disposal practices are resulting in growing effects on human health and the environment, including on climate change, marine pollution, biodiversity, and chemical contamination, which require urgent action. Plastics are used in many sectors such as packaging, construction, automotive manufacture, furniture, toys, shoes, household appliances, electrical and electronic goods, and agriculture. This wide demand has caused plastics production to explode globally, now outgrowing most man-made materials[1]. Plastic production increased by more than twenty-fold between 1964 and 2015, with annual output reaching 322 million metric tonnes (Mt)[2]. A second analysis indicates that annual global plastics production rose from 2 Mt to 380 Mt between 1950 and 2015[3]. Future plastics production is projected to double by 2035 and almost quadruple by 2050[4].

Historically, plastics were mostly produced in Europe and the United States. However, this has recently shifted to Asia. China is now the leading producer with 28% of global production in 2015, while the rest of Asia, including Japan, produces 21% (Figure 1)[5], i.e. nearly half the global production in 2015.

Plastics contribute to economic growth[6], but their current production and use pattern, on a linear model of 'take, make, use, and dispose', is a primary driver of natural resource depletion, waste, environmental degradation, climate change, and has adverse human health effects. Globally, it is estimated that only 9% of the 6300 Mt of plastic waste generated between 1950 and 2015 was recycled[7]. India has probably the highest plastic recycling rate with estimates ranging from 47 to 60%[8]. In the EU, only approximately 30% of 25 Mt of post-consumer plastic waste was recycled in 2014[9]; China had a recycling rate of 22% in 2013[10]; while only 9.5% of plastics entering the US municipal solid waste stream were recycled in 2014[11]. In Latin America and the Caribbean, recycling rates are also low[12].

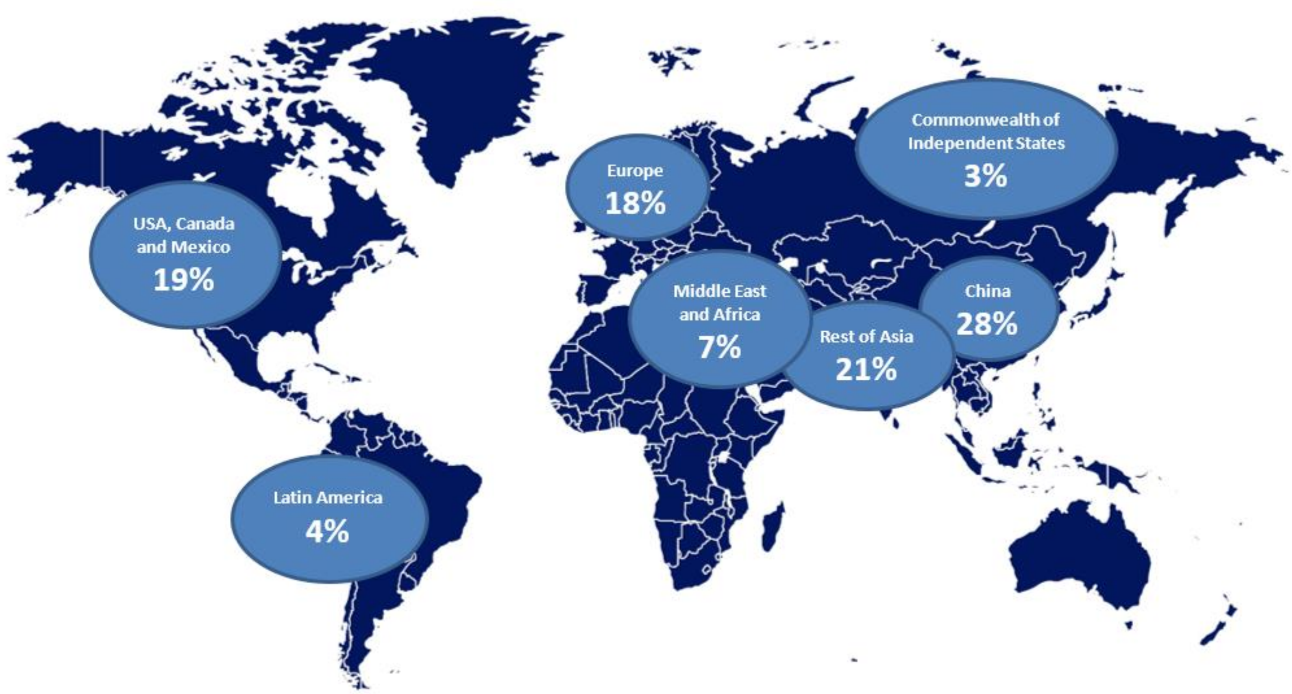

Figure 1. Global distribution of plastics production (based on estimates in endnote 5)

2. What does the science say?

2.1. Negative Impacts of Plastics

The production, use and disposal of plastics are associated with significant adverse externalities in the environment, economy and society, at different stages of their life cycle (Figure 2). These include:

Impacts of plastics production and use

- **Conventional plastic production is highly dependent on virgin fossil feedstocks (mainly natural gas and oil) as well as other resources, including water - it takes about 185 litres of water to make a kilogram of plastic[13].** Plastics production consumes up to 6% of global oil production and is projected to increase to 20% by 2050 if current consumption patterns persist[14]. Plastics are therefore a major contributor to greenhouse gas emissions: CO_2 emissions from the extraction and processing of fossil fuel as plastics feedstocks; and the combustion of waste plastics, emitting 390 million tonnes of CO_2 in 2012[15]. On current trends, emissions from the global plastics sector are projected to increase from 1% in 2014 to 15% of the global annual carbon budget by 2050 (Figure 2)[16].

- **Some plastics contain toxic chemical additives,** which are used as plasticisers, softeners or flame retardants. These chemicals include some **persistent organic pollutants (POPs)**[17] such as short-chain chlorinated paraffins (SCCP), polychlorinated biphenyls (PCBs), polybromodiphenyl (PBDEs including tetrabromodiphenyl ether (tetraBDE), pentabromodiphenyl ether (pentaDBE), octabromodiphenyl ether (octaBDE) and decabromodiphenyl ether (decaBDE)), as well as endocrine disruptors such as bisphenol A (BPA) and phthalate [18] . Chlorinated dioxins (polychlorinated dibenzo-p-dioxins), chlorinated furans (polychlorinated dibenzofurans), PCBs (polychlorinated biphenyls), and hexachlorobenzene (HCB) are also byproducts of the manufacture of polyvinyl chloride (PVC)[19]. These chemicals have been linked to health issues such as cancer, mental, reproductive, and developmental diseases[20].

Impacts from disposal and post-disposal

- **It is difficult to recycle some plastics without perpetuating the harmful chemicals they contain.** Furthermore, some plastics are very thin, for example, plastic bags and films, or multi-layered, for example, food packaging, making them difficult and expensive to recycle[21]. The lack of universally agreed standards and adequate information about the content and properties of some plastics also discourage recycling. It is estimated that between USD 80 and 120 billion worth of material value is lost to the global economy annually because of the low recycling rate of most plastic packaging[22].

- **Around 4900 Mt of the estimated 6300 Mt total of plastics ever produced have been discarded either in landfills or elsewhere in the environment**. **This is expected to increase to 12,000 Mt by 2050 unless action is taken[23]. The ocean is estimated to already contain over 150 Mt of plastics[24]; or more than 5 trillion micro (less than 5mm) and macroplastic particles**[25]. Much of this land-based discharge to the oceans originates in five Asian countries: China, Indonesia, the Philippines, Thailand, and Vietnam[26], with ten rivers across Asia and Africa (Indus, Ganges, Amur, Mekong, Pearl, Hai he, Yellow, Yangtze, Nile, and Niger) responsible for transporting 88 - 95% of the global load into the sea[27]. The top 20 polluting rivers, mainly in Asia, release 67% of all plastic waste into the oceans[28]. **The amount of oceans plastic could triple by 2025 without further intervention[29]. By 2050, there will be more plastics, by weight, in the oceans than fish, if the current 'take, make, use, and dispose' model continues[30].** Single-use plastics contribute significantly to this leakage. About 330 billion single-use plastic carrier bags are produced annually and often used for just a few hours before being discarded into the environment[31]. Single-use plastics make up about half of beach litters in all four European Regional Seas Areas – the Mediterranean, North Atlantic, Baltic, and the Black Sea[32] and they can now be found even in the deepest world's ocean trench[33].

- **Plastics stay in the environment for a long time; some take up to 500 years to break down;** this causes damage, harms biodiversity, and depletes the ecosystem services needed to support life. **After climate change, plastic is the biggest threat to the future of coral reefs:** it increases the likelihood of disease outbreaks by more than 20 times, threatening marine habitats that provide food, coastal protection, income, and cultural benefits to more than 275 million people[34].

- **In the marine environment, plastics are broken down into tiny pieces (microplastics[35]) which threaten marine biodiversity[36].** Furthermore, microplastics can end up in the food chain, with potentially damaging effects on human health, because they may also accumulate high concentrations of POPs and other toxic chemicals[37], and potentially serve as a pathway for their transfer to aquatic organisms[38], and consequently human beings[39]. There have been calls for microplastics to be considered as POPs[40] because of their pervasive and persistent nature[41]. There is, however, currently no scientific evidence that microplastics are directly harmful to human health.

- New knowledge suggests that **microplastics are an emerging source of soil pollution**[42]. The impacts of microplastics in soils, sediments and freshwater could have a long-term damaging effect on terrestrial ecosystems globally through adverse effects on organisms, such as soil-dwelling invertebrates and fungi, needed for important ecosystem services and functions[43]. Up to 895 microplastic particles per kilogram have been found in organic fertilisers used in agricultural soils[44]. Up to 730,000 tonnes of microplastics are transferred every year to agricultural lands in Europe and North America from urban sewage sludges used as farm manure, with potentially direct effects on soil ecosystems, crops and livestock or through the presence of toxic chemicals[45].

- **Microplastics are an emerging freshwater contaminant which may degrade water quality and consequently affect water availability and harm freshwater fauna[46].** The contamination of tap and bottled water by microplastics is already widespread[47], and the World Health Organization is assessing the possible effects on human health[48].

- **A significant proportion of disposed plastic ends up in municipal solid waste (MSW)**[49]. In many developing countries[50], inadequate or informal waste management systems mean that waste is usually burned in open dumps or household backyards, including in cities linked to the top ten rivers which transport plastic waste to the sea. In other places, MSW is incinerated. **The open burning or incineration of plastics has three negative effects:** it releases CO_2 and black carbon – two very potent climate-changing substances[51]; burning plastics, especially containing chlorinated and brominated additives, is a significant source of air pollution, including the emission of unintended POPs (uPOPs) such as chlorinated and brominated dioxins, furans, and PCBs[52]; and burning plastic poses severe threats to plant, animal and human health, because toxic particulates can easily settle on crops or in waterways, degrading water quality and entering the food chain[53].

- In 2014, UN Environment estimated **the natural capital cost of plastics, from environmental degradation, climate change and health, to be about USD 75 billion annually** with 75% of these environmental costs occurring at the manufacturing stage[54]. A more recent analysis[55] indicates the environmental cost could be up to USD 139 billion[56].

	Recent Estimates	Business as Usual Projections
Production and Use		
Tonnes of plastic produced	**311-380 Mt in 2015[a]**	**1244-1520 Mt by 2050[b]**
Plastics share of global oil and gas consumption[c]	**6% in 2014**	**20% by 2050**
Plastics share of global carbon budget[c]	**1% in 2014**	**15% by 2050**
Disposal and Post-disposal		
Amount of plastic waste generated[d]	**Approx. 5,800 Mt from primary plastics or 6,300 Mt when waste from secondary (recycled) plastics are included. Cumulative from 1950 to 2015**	**Approx. 26,000 Mt from primary plastics or 33,000 Mt when waste from secondary (recycled) plastics are included. By 2050**
Plastics in landfill or in the environment[d]	**4900 Mt in 2015**	**12,000Mt by 2050**
Plastics in oceans[e]	**Over 150 Mt in 2015**	**Over 450 Mt by 2025**
Ratio of plastics to fish in the oceans (by weight)[c]	**1:5 in 2014**	**1:1 by 2050**

a = this is a range of estimates in Plastic Europe, 2016; WEF, EMF, McKinsey & Company, 2016; and Geyer et al. 2017
b = estimated by applying the 2050 projection in WEF, EMF, McKinsey & Company, 2016 to the range of 2015 estimates in Plastic Europe, 2016; WEF, EMF, McKinsey & Company, 2016; and Geyer et al. 2017
c = see WEF, EMF, McKinsey & Company, 2016
d = see Geyer et al. 2017
e = based on estimates in Ocean Conservancy, 2015 and extrapolation of this estimate using 2025 projection by Jambeck et al. 2015.

Figure 2: A summary of current and future impacts of continuing linear production and use of plastics

2.2. The Circular Economy

The circular economy is an alternative to the current linear, make, use, dispose, economy model, which aims to keep resources in use for as long as possible, to extract the maximum value from them whilst in use, and to recover and regenerate products and materials at the end of their service life[57]. The circular economy[58] promotes a production and consumption model that is restorative and regenerative by design[59]. It is designed to ensure that the value of products, materials, and resources is maintained in the economy at the highest utility and value, for as long as possible, while minimising waste generation, by designing out[60] waste and hazardous materials. The circular economy applies both to biological and technical[61] materials. It embraces systems thinking and innovation, to ensure the continuous flow of materials through a 'value circle'[62], with manufacturers, consumers, businesses and government each playing a significant role[63].

The World Economic Forum reported that material (technical and biological) cost savings of up to $1 trillion per year could be achieved by 2025 by implementing the circular economy worldwide[64]. And the World Business Council for Sustainable Development (WBCSD) "CEO Guide to the Circular Economy" indicates that the circular economy could help unlock USD 4.5 trillion of business opportunities while helping to fulfil the Paris Agreement[65]. Implementing the circular economy across the energy, built environment, transport, and food sectors in Europe could reduce carbon emissions by 83% by 2050 compared to 2012 levels[66]. A study by the Club of Rome also indicates that transitioning to a circular economy across various economic sectors in five European countries (Finland, France, the Netherlands, Spain and Sweden) by 2030 could lead to a two-thirds reduction in carbon emissions, lower business costs, and create up to 1.2 million jobs[67]. While studies on developing countries are scarce, UNDP reported that circular economy strategies could help the Lao DPR achieve its climate mitigation targets, while also developing local industries, reducing dependency on resource rents, imported materials and products, thus helping to eradicate poverty[68].

2.3. Circular Economy Solutions for the Plastic Sector

The Ellen MacArthur Foundation summarised the goals for a circular economy in the plastics sector (Figure 3) as follows: improve the economic viability of recycling and reuse of plastics; halt the leakage of plastics into the environment, especially waterways and oceans; and decouple plastics production from fossil-fuel feedstocks, while embracing renewable feedstocks[69].

Recent science and innovation highlights examples of how these goals might be achieved:

(i) Produce plastics from alternative feedstocks.

Examples of alternative feedstocks include greenhouse gas such as CO_2 and methane[70], bio-based sources such as oils, starch, and cellulose[71], as well as naturally occurring biopolymers, sewage sludge and food products[72]. Some plastics can be produced using benign and biodegradable materials[73]. And eco-friendly alternative flame retardants have been developed which could eliminate the use of some hazardous chemicals in plastics manufacture[74].

Figure 3: Circular economy solutions in the plastics sector

To mitigate the adverse effects of the current mainly linear plastics production and use model, plastics production from renewable sources needs to increase to reduce dependence on fossil fuels significantly. Production processes and products should be redesigned to improve longevity, reusability, recyclability, as well as to prevent waste and chemical pollution prevention. Sustainable business models that promote products as services, facilitate sharing and leasing of plastic products, and increase reuse should also be encouraged. Plastics at the end of life should increasingly be recycled into new products to significantly reduce the volume of plastics leaking into the environment.

(ii) Use plastic waste as a resource

The capture and recovery of plastic waste for remanufacturing into new products has been widely demonstrated, for example, for making bricks and composites[75], in road construction[76], for furniture, as well as for making clothes and footwear[77]. Plastic waste has also been converted to liquid fuel[78] and has been burned as fuel in a waste-to-energy cycle[79], though there are downsides to the latter[80]. Through chemical recycling[81], the petrochemical components of plastic polymers can also be recovered for use in producing new plastics, or for the production of other chemicals, or as an alternative fuel[82]. For example, a recent study successfully developed plastics that can be chemically recycled and reused infinitely[83].

Studies[84] also suggest that polyethylene plastic, a significant proportion of manufactured plastics globally, can be broken down by bacteria and caterpillars, highlighting opportunities for biobased recycling of waste plastics[85].

(iii) Redesign plastics manufacturing processes and products to improve longevity, reusability and waste prevention, by incorporating after-use, asset recovery, and waste and pollution prevention into the design from the outset[86].

This means adopting a life-cycle approach[87] including: cleaner production; discouraging single- and other avoidable plastics use; as well as designing products for appropriate lifetimes, extended use, and for ease of separation, repair, upgrade and recycling[88]; eliminating toxic substances; and preventing the release of microplastics into the environment by redesigning products. For example, designing clothes and tires to reduce wear and tear, and eliminating, or using alternatives to, microplastics in personal care products such as toothpaste and shampoo. A further example, of redesign is the bulk delivery of cleaning and personal care products supplied with refillable plastic containers, thereby eliminating single-use bottles[89]. Existing applications of this model include Replenish bottles, Petainer packaging, and Splosh[90]. Another example is reusable beverage bottles as an alternative to single-use bottles, for example, a returnable bottle system and refillable bottles, which can lower material costs and reduce greenhouse gas emissions[91].

(iv) Increase collaboration between businesses and consumers to increase awareness of the need for, and benefits of, a shift from non-essential plastic use and a throw-away culture, to encourage recycling, and to increase the value of plastic products, for example, by using by-products from one industry as a raw material for another[92] (industrial symbiosis). Several analyses[93] have highlighted the climate and environmental benefits from plastic waste recycling through industrial symbiosis. Households can be included in the symbiosis process[94], by strengthening waste collection systems and by creating innovative and effective take-back programs[95]. Analysis of urban-industrial symbiosis (exchanging resources between residential and industrial areas) in a Chinese city[96] indicated that producing energy from plastic waste[97] led to an annual reduction in CO_2 emissions of 78,000 tonnes while avoiding the discharge of 25,000 tonnes of waste plastics[98] a year into the environment[99].

(v) Embrace sustainable business models which promote products as services and encourage the sharing and leasing of plastic products.

This would optimise product utilisation and increase revenue while decreasing the volume of manufactured goods. An example of this is the leasing of water dispensers and refillable plastic bottles to households and offices. Another example is the Lego's Pley system where consumers rent and return Lego sets rather than buy them[100].

(vi) ***Develop robust information platforms*** which provide data on the composition of plastic products, track the movement of plastic resources within the economy, support cross-value chain dialogue and the exchange of knowledge, and build on experiences gained through existing global institutional networks. An example of a global network is the RECPnet (Resource Efficient and Cleaner Production Network) that promotes resource-efficient cleaner production and facilitates collaboration including through the transfer of relevant knowledge, experiences and technologies [101].

(vii) Policy instruments including fiscal and regulatory measures to deal with the negative effects of the unsustainable production and use of plastics.

Without these measures, markets would continue to favour fossil feedstocks, especially when oil prices are low[102], and the barriers to achieving the circular economy (Box 1) would be more difficult to overcome.

Ensuring that the costs of unsustainable production and use are taken into account would encourage production from alternative less harmful sources, as well as prevent waste, and stimulate reuse and recycling. Fiscal policy measures, for example, direct surcharges, levies, carbon or resource taxes and taxes on specific types of plastic such as plastic bags, disposable cutlery and other one-use items, may be needed to discourage non-essential plastic use, and other unsustainable practices, while helping to improve the uptake, financial viability and quality of plastic recycling[103]. Other regulatory and policy measures are needed, including recycling targets, extended producer responsibility, container deposit legislation, mandatory requirements and standards for circular/eco-design, public procurement policies, bans on landfilling and incineration, and outright bans on some plastic products, for example, single-use plastic bags[104].

Figure 4 presents an overview of circular economy solutions to the plastics challenge.

Box 1: Barriers to the Circular Economy

Barriers to achieving a circular economy in the plastic, as well as, other economic sectors include:

- being locked into a linear plastics production infrastructure makes it costly to change;
- high up-front investment costs and risks when changing to the circular model;
- complex international production and consumption supply chains;
- lack of support for scaling up circular models, especially for small and medium-sized enterprises;
- difficulties in business-to-business cooperation, including transactions costs;
- resistance to change among product manufacturers, which could be due to a lack of knowledges;
- uncompetitive circular products because subsidies encourage the linear production and use model;
- inadequate knowledge and capacity for implementation;
- limited consideration of plastics in key legislation;
- unfavourable regulations and lack of standards;
- inadequate monitoring and reporting on plastics data, especially in developing countries; and
- lack of consumer awareness or enthusiasm and reluctance to accept recycled products.

Overcoming these barriers will require significant policy and regulatory support to foster innovation, increase the competitiveness of the circular model and create a demand-pull for circular plastic products. It will also require working with the private sector to catalyse change, as well as with the public to encourage changes in societal behaviour and create consumer demand for circular products.

Based on Preston, F. 2012. A Global Redesign? Shaping the Circular Economy. Chatham House Briefing Paper, UK; Bourguignon, D. 2017. Plastics in a circular economy: opportunities and challenges. European Parliament Think Tank Briefing, May 2017; Steensgaard, I.M. et al., 2017. From macro- to microplastics - analysis of EU regulation along the life cycle of plastic bags, Environmental Pollution, 224, https://doi.org/10.1016/j.envpol.2017.02.007; EC. 2018. A European strategy for plastics in a circular economy. European Commission.

Circular Economy Solutions	Description	Some Examples
 Plastic from alternative feedstocks	Producing plastics from alternative feedstocks including bio-based sources such as sugarcane, oils and cellulose, as well as from greenhouse gas, sewage sludge, food waste and natural occurring biopolymers.	• AirCarbon technology transforms methane/CO_2 to plastics: https://www.newlight.com/ • Covestro technology converts CO_2 into plastics: /www.co2-dreams.covestro.com/en • Plastics have been produced from sugarcane: http://sugarcane.org/sugarcane-products/bioplastics

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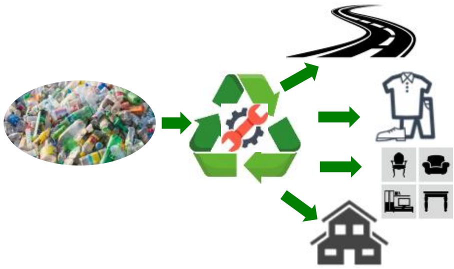
<tr><td>
Plastic waste as a resource</td><td>Using plastic waste for the remanufacturing of new plastics or conversion into other valuable products.</td><td>• Bricks and composites. See references in Section 2.3.
• Roads have been built from plastic waste: http://www.dykespaving.com/blog/texas-roads-made-from-plastic/; https://www.plasticroad.eu/en/; http://www.macrebur.com/; https://www.curbed.com/2017/4/26/15428382/road-potholes-repair-plastic-recycled-macrebur
• Clothing and footwear: http://www.repreve.com/; http://www.adidas.com/us/parley; https://plugin-magazine.com/living/rothys-the-environmentally-friendly-shoes-made-of-recycled-plastic/</td></tr>
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Redesign and innovation</td><td>Design plastic products to enhance longevity, reusability, recycling and waste prevention, by incorporating after-use, asset recovery, and waste and pollution prevention from the onset</td><td>• Bulk delivery of cleaning and personal care products with refillable plastic containers, thereby eliminating single-use bottles. For example, http://www.myreplenish.com/; http://www.petainer.com/; and https://www.splosh.com/#3.</td></tr>
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Business and Consumer Cooperation</td><td>Cooperation between businesses and with consumers, whereby by-products or waste from one industry or consumers become raw material for producing new products</td><td>• Examples of urban-industrial symbiosis exist in China and Japan highlighting environmental and climate benefits from the recycling of plastics. See references in Section 2.3</td></tr>
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Sustainable Business Models</td><td>Implementing business models that promote products as services and encourage sharing and leasing of products thereby optimising product utilisation and decreasing volume of manufactured goods</td><td>• Leasing of water dispensers and refillable plastic bottles to households and offices and the Lego's Pley system where consumers rent and return Lego sets rather than buy them</td></tr>
<tr><td>
Robust information platforms</td><td>Robust information platforms linking industries as well as consumers to ensure the flow of data and information on plastics</td><td>• For example, the RECPnet that promotes resource-efficient cleaner production and facilitate collaboration including through the transfer of relevant knowledge, experiences and technologies (http://www.recpnet.org/)</td></tr>
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Policy instruments</td><td>Implementing economic, policy and regulatory measures such as direct surcharges, taxes, extended producer responsibility, mandatory requirements and standards for circular/eco-design, and a ban on certain plastic types.</td><td>• Bangladesh phased out the use of lightweight plastic bags in 2002: http://news.bbc.co.uk/2/hi/7268960.stm
• Rwanda has banned single-use plastic bags: https://www.globalcitizen.org/en/content/how-eliminating-plastic-bags-in-rwanda-saves-liv-2/
• Italy banned plastic shopping bags in 2011: https://www.reuters.com/article/us-italy-retail-plasticbags/italy-to-ban-plastic-shopping-bags-on-january-1-idUSTRE6BS1ZJ20101229
• Kenya has recently implemented a regulatory ban on single-use plastic bags: https://www.reuters.com/article/us-kenya-plastic/kenya-imposes-worlds-toughest-law-against-plastic-bags-idUSKCN1B80NW</td></tr>
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Figure 4. An overview of circular economy solutions to the plastics challenge, and examples of their implementation

2.4. Beyond the Circular Economy in Plastics

The circular economy is a necessary part of the solution to the global plastics problem but not the complete solution. Producing all plastic from alternative feedstocks is desirable, but may not be possible because it might adversely affect human food supplies, or have unintended consequences on the environment or human health[105]. Detailed life cycle assessments are needed to understand, for example, the environmental and socio-economic impacts of using land resources for bioplastics production instead of food. And there is no universally agreed definition of plastic biodegradability: using biodegradable plastics would not decrease the leakage of plastics into the environment or reduce their associated chemical impacts[106]. "Closing the materials loop" through the redesign and increased recycling of plastic products would also not be sufficient.

The first priority is, therefore, to discourage non-essential production and unnecessary consumption or use of plastics[107]. There are many ways to do this: eradicating excessive plastic packaging on products such as food[108]; eliminating the non-essential use of micro-sized plastics in personal care products[109]; and promoting the use of renewable and recyclable alternatives to plastics, for example, wooden cutlery as an alternative to disposable plastic utensils, and cellulose-based materials as a replacement for plastic packaging and bags[110].

3. Why is this important to the GEF?

The continued rapid growth in the production and use of plastics will have a severe and deleterious effect on the GEF's ability to deliver its objectives[111] in the following areas:

- ***Chemicals and waste***: POPs, such as SCCP, PCBs, and PBDEs including tetraBDE, pentaBDE, octaBDE and decaBDE, are used as chemical additives in some plastics, particularly in the electrical and electronic, automotive, furniture and toy manufacturing sectors. Dioxins and furans are also byproducts of PVC manufacture used in building and construction. The use of these chemicals has been banned under the Stockholm Convention, but legacies of their historical use remain in old products. The burning of plastics, especially those containing chlorinated and brominated additives, releases POPs unintentionally, including dioxins. It has been proposed that the Stockholm Convention could use existing measures to regulate the production, use, as well as import and export of POPs destined for use in plastics and plastic waste containing or contaminated with POPs[112].

- ***Climate change mitigation:*** producing plastics using fossil fuels is an important source of greenhouse gas emissions, as is the open burning and incineration of plastic wastes. Recycling all global plastic waste could provide an annual energy saving equivalent to 3.5 billion barrels of oil per year[113]. Another estimate indicates that recycling half of the projected 15 million tons of waste plastics per year by 2030 would reduce CO_2 emissions equivalent to taking 15 million cars off the road[114].

- ***International waters:*** the oceans contain over 150 Mt of plastics or 5 trillion micro (less than 5mm) and macroplastic particles, with an estimated 4.8 to 12.7 Mt, being added every year[115]. Plastics pollution is prevalent in all oceans globally[116], with a significant proportion of discharge originating from a few countries and rivers. Microplastics are an emerging threat to freshwater, affecting water quality, security and safety in freshwater ecosystems.

- ***Biodiversity:*** plastics pollution is the second most significant threat to the future of coral reefs, after climate change[117]. The impact of plastic on marine species, including entanglement and ingestion by turtles, birds, fish and mammals, is well documented[118], with 17% of species affected listed as threatened or near threatened in the International Union for Conservation of Nature (IUCN) Red

List[119]. Many of the chemicals additives used in plastics have proven adverse effects on fisheries and their habitats[120].

- ***Land degradation and food systems:*** the emerging threat from microplastics to terrestrial ecosystem, especially agricultural soils could lead to further land degradation affecting food production, including through plant uptake of microplastics from contaminated soils. The use of plastics in agriculture, for example as mulches, in greenhouses and various agricultural coverings, is causing contamination of agricultural soils[121].

- ***Sustainable Cities:*** households in urban areas and cities are major consumers of plastics, and also major generators of plastic waste. Cities are responsible for a significant portion of the land-based release of plastics into the environment, especially in places where waste management systems are poorly developed. The Sustainable Cities IAP offers good opportunities to implement the circular economy, by reducing consumption, for example, using alternatives to PVC in construction, and by tackling plastic pollution.

The circular economy approach can help to deliver the Sustainable Development Goals (SDGs)[122,123]:

Goal 12 on ensuring sustainable consumption and production patterns includes targets on achieving sustainable management and efficient use of natural resources, sound management of chemicals and wastes, and improving waste prevention, reduction, recycling and reuse. Goal 8 on inclusive and sustainable economic growth includes a target to improve global resource efficiency in consumption and production and decoupling economic growth from environmental degradation. (A shift to a reuse model for plastics used in homes and personal care products via bulk delivery, as well as for carrier bags, could lead to material savings of 6 Mt while creating economic opportunities of more than USD 9 billion[124].)

The circular economy will also contribute to achieving Goal 14 on the use of oceans, seas, and marine resources and has a target on preventing marine pollution, from land-based activities, including marine debris, of which plastics make up between 60-80%[125].

Adopting a circular economy approach would also encourage innovation, create entrepreneurial opportunities and employment contributing to Goal 8 on decent work and economic growth. The benefit to society of recycling of plastic packaging[126] is estimated to be more than USD 100 per tonne. The circular economy offers an opportunity for developing countries to leapfrog the linear 'take, make, use, and dispose' economic and development model followed by developed countries, to a more sustainable development pathway that avoids locking in resource-intensive practices and infrastructure[127].

4. How can the GEF respond?

STAP recommends the following:

In the near-term, the GEF should consider the following actions:

A. ***Mainstream circular economy principles into GEF's overall strategy,*** *by including circular principles as a tool and criteria for priority setting and decision making* in chemicals and waste, climate change, international waters, biodiversity, land degradation, as well as in the Sustainable Cities and Food Security IAPs.

B. ***Invest in projects that promote circular principles in the plastic sector to deliver global environmental benefits***

- ***Plastic reuse and recycling investments:*** *Invest in projects that:*
  - Develop best-practice integrated waste management systems and infrastructure for the safe collection, sorting, separation, handling and processing of MSW.
  - Promote and scale-up high-quality recycling and use of plastic waste as a resource.
  - Bring private sector actors together, including small and medium scale enterprises, producers and users of plastics, as well as the informal waste management sector, to promote the adoption of the circular economy in the plastics sector.
  - Facilitate collaboration between businesses and consumers, to increase the value of plastic products and encourage recycling and reuse; for example, through urban-industrial symbiosis.

- ***Plastic waste prevention and minimisation investments:*** *Invest in projects that:*
  - Facilitate innovation and redesign of plastics to eliminate the use of POPs and other hazardous substances and improve the longevity, reusability and recyclability of plastic products.
  - Develop sustainable business and finance models to promote plastic products as services, encourage the sharing and leasing of products and facilitate new product delivery systems. (This would optimise product utilisation and reduce the quantity of plastics produced, thereby saving resources and preventing waste.)
  - Encourage the production of plastics from alternative feedstocks especially renewable and biodegradable non-fossil feedstocks, sources, for example, sugarcane, oils and cellulose, sewage sludge, food waste, naturally occurring biopolymers as well as greenhouse gases, to mitigate climate change, without compromising the environment, food supply or human health.
  - Develop and implement business cases for converting fossil fuel-based plastics manufacturing facilities to use sustainable alternative feedstocks, and recycled plastics.

C. ***Help create an enabling environment to overcome barriers and promote the adoption and implementation of the circular economy in the plastics sector.*** *The GEF could support projects and activities that help:*

- ***Develop supportive policies and regulations for a circular economy***, including economic incentives.
- ***Facilitate technical assistance and capacity building,*** especially in waste management.
- ***Create awareness-raising activities to encourage changes***[128], for example, through educational materials that encourage less consumption, discourage the throwaway culture, facilitate the acceptance of recycled plastic products, disseminate successful case studies and incorporate plastics recycling concepts into school curricula.
- ***Promote public-private cooperation and investment*** in sustainable plastic manufacturing, reuse, recycling and waste management.
- ***Prepare national circular economy strategies and implementation plans***.

D. ***Incorporate plastic pollution mitigation into GEF's Sustainable Cities IAP.*** Cities are a primary source of plastic consumption and pollution, and the sustainable cities IAP could be used to implement some of the proposed solutions, which could serve as case studies or pilots, to demonstrate opportunities, catalyse innovation, and leverage technical expertise, as well as investors.

Looking further ahead, the GEF should consider the following actions:

E. ***Support the development of circular economy indicators relevant to the GEF:*** there are several studies underway on suitable indicators for measuring the transition to a circular economy[129], but no consensus. GEF could develop indicators relevant to its business.

F. ***Collaborate with, and support partnerships and projects.*** This could be with governments, civil societies or private sector-led partnerships, for example, the Commonwealth Clean Oceans Alliance[130], the Clean Seas Campaign[131], and plastic clean-up efforts[132], for example, in partnership with the private sector. A partnership between Adidas and Parley has resulted in the sales of one million shoes made from recycled ocean plastics[133]. Such partnerships could also focus on improving standardisation and transparency of the chemical content of plastic, and on agreeing on the labelling of plastic products to aid decision-making on reuse, remanufacturing and recycling.

G. ***Facilitate and support innovation and applied research*****:** research and innovation are essential tools for realising the transition to a circular economy in the plastics and other sectors[134]. GEF could help set the research agenda and spur innovation in the various aspects of circular economy relevant to its work by engaging with the research and innovation communities and bringing relevant issues to the table. Areas of research interest include redesigning plastics manufacturing processes and products to enhance longevity; scaling up recently discovered opportunities for bio-based recycling of waste plastics; and developing novel business models for delivering plastics products as services, especially in developing countries.

Focusing the GEF's actions

The global production of plastic has shifted to Asia, where there are plenty of opportunities for GEF's investment to support a shift from unsustainable fossil-based production to renewable feedstocks-based production. The GEF could also target sectors where POPs are used as additives in plastics such as PVC processing, electrical and electronic, automotive, furniture, building materials, and toy manufacturing.

Up to 75% of the land-based release of plastics into the oceans is from uncollected waste, with the remainder due to leakage from waste management systems[135]. Investment in waste management could focus on the 20 rivers leaking the most plastics into the oceans (Section 2.1). Developing effective waste management systems would, however, require substantial investment, and may, therefore, involve public-private partnerships and support from Multilateral Development Banks.

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Primary microplastics are directly released into the environment as small-sized particulates; for example, from the use of consumer goods including laundering of synthetic textiles and abrasion of vehicle tires. Other sources include tooth paste, shampoo and other cosmetic products where micro-sized plastic particles are used as abrasive materials or binding agents. Secondary microplastics result from the degradation of large-sized plastics when exposed to photodegradation and other weathering processes in the environment (Boucher, J. and Friot, D. 2017. Primary microplastics in the oceans: a global evaluation of sources. International Union for Conservation of Nature. https://portals.iucn.org/library/node/46622; Blair, R.M et al. 2017. Micro- and nanoplastic pollution of freshwater and wastewater treatment systems. Springer Science Reviews. https://doi.org/10.1007/s40362-017-0044-7; ten Brink, P. et al. 2016. Plastics marine litter and the circular economy. A briefing by IEEP for the MAVA Foundation. https://ieep.eu/uploads/articles/attachments/15301621-5286-43e3-88bd-bd9a3f4b849a/IEEP_ACES_Plastics_Marine_Litter_Circular_Economy_briefing_final_April_2017.pdf?v=63664509972).

[36] Browne et al., 2013. Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity. Current Biology 23, http://dx.doi.org/10.1016/j.cub.2013.10.012; GESAMP. 2015. Sources, fate and effects of microplastics in the marine environment: a global assessment. Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study.pdf

[37] EC, 2011. Plastic waste: ecological and human health impact. European Commission, Science for Environment Policy In-depth Reports. http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR1_en.pdf; Lohmann, R. 2017. Microplastics are not important for the cycling and bioaccumulation of organic pollutants in the oceans—but should microplastics be considered POPs themselves? Integrated Environmental Assessment and Management, 13, DOI: 10.1002/ieam.1914

[38] Note however that, microplastics could potentially act as a sink for contaminants in some conditions thereby making them less available to organisms especially when buried on the seafloor (EC, 2011).

[39] ibid – EC.2011; Rochman, C.M. et al. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports 3, 3263, doi:10.1038/srep03263

[40] ibid - Browne et al. 2013; Ibid- Lohmann, R. 2017; Worm et al. 2017. Plastic as a Persistent Marine Pollutant. Annual Review of Environment and Resources, 42, https://doi.org/10.1146/annurev-environ-102016-060700

[41] Hurley et al. 2018. Microplastic contamination of river beds significantly reduced by catchment-wide flooding. Nature Geoscience, 11, 251–257. doi:10.1038/s41561-018-0080-1

[42] For example, Rillig, M.C. 2012. Microplastic in Terrestrial Ecosystems and the Soil? Environ. Sci. Technol. 46, dx.doi.org/10.1021/es302011r; Duis K and Coors, A. 2016 Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. Environ Sci Eur, 28, DOI 10.1186/s12302-015-0069-y; Horton, A.A. et al., 2017. Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. Science of the Total Environment, 586, http://dx.doi.org/10.1016/j.scitotenv.2017.01.190; Rillig M.C et al. 2017. Microplastic incorporation into soil in agroecosystems. Front. Plant Sci., https://doi.org/10.3389/fpls.2017.01805

[43] Machado A.A et al. 2018. Microplastics as an emerging threat to terrestrial ecosystems. Global Change Biology, 24, doi: 10.1111/gcb.14020

[44] Weithmann et al. 2018. Organic fertilizer as a vehicle for the entry of microplastic into the environment. Science Advances, 4, DOI: 10.1126/sciadv.aap8060

[45] Nizzetto, L. et al. 2016. Are agricultural soils dumps for microplastics of urban origin? Environ. Sci. Technol., 50, DOI: 10.1021/acs.est.6b04140

[46] Wagner, M et al., 2014; Microplastics in freshwater ecosystems: what we know and what we need to know. Environmental Sciences Europe, 26, http://www.enveurope.com/content/26/1/12; Eerkes-Medrano, D et al. 2015. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. Water Research, 75, http://dx.doi.org/10.1016/j.watres.2015.02.012; Rehse, S et al., 2016. Short-term exposure with high concentrations of pristine microplastic particles leads to immobilisation of Daphnia magna. Chemosphere, 153. https://doi.org/10.1016/j.chemosphere.2016.02.133

[47] See https://orbmedia.org/stories/Invisibles_plastics and https://orbmedia.org/sites/default/files/FinalBottledWaterReport.pdf

[48] https://www.theguardian.com/environment/2018/mar/15/microplastics-found-in-more-than-90-of-bottled-water-study-says

[49] Ibid - Jambeck, J.R et al. 2015.

[50] See for example, http://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management; https://www.climate-policy-watcher.org/waste-management/garbage-challenges-in-developing-countries.html; and Wilson, D.C et al., 2006. Role of informal sector recycling in waste management in developing countries. Habitat International 30, https://doi.org/10.1016/j.habitatint.2005.09.005

[51] See for example, Wiedinmyer, C et al., 2014. Global Emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste. Environmental Science and Technology. 48, DOI: 10.1021/es502250z; Reyna-Bensusan, N et al. 2018. Uncontrolled burning of solid waste by household in Mexico is a significant contributor to climate change in the country. Environmental Research, 163, doi: 10.1016/j.envres.2018.01.042.

[52] Valavanidid, A et al. 2008. Persistent free radicals, heavy metals and PAHs generated in particulate soot emissions and residual ash from controlled combustion of common type of plastics. Journal of Hazardous Materials, 156, doi: 10.1016/j.jhazmat.2007.12.019; Verma, R et al., 2016. Toxic pollutants from plastic waste- a review. Procedia Environmental Sciences, 35, https://doi.org/10.1016/j.proenv.2016.07.069

[53] For example, WECF factsheet on dangerous health effects of home burning of plastics and waste. http://www.wecf.eu/cms/download/2004-2005/homeburning_plastics.pdf, and ibid – Verma, R et al., 2016.

[54] UNEP. 2014. Valuing plastics: the business case for measuring, managing and disclosing plastic use in the consumer goods industry. United Nations Environment Programme. https://wedocs.unep.org/rest/bitstreams/16290/retrieve

[55] Lord, R. 2016. Plastics and sustainability: a valuation of environmental benefits, costs and opportunities for continuous improvement. Trucost and American Chemistry Council. https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf

[56] It should be noted however that the same report shows that the environmental cost of alternative materials to plastic such as glass, tin, aluminium and paper is about four times greater than that of plastics estimated as USD 533 billion

[57] WRAP and the circular economy - http://www.wrap.org.uk/about-us/about/wrap-and-circular-economy

[58] A detailed description of the circular economy can be found in EMF, 2013. Towards a circular economy – opportunities for the consumer goods sector. Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Report-2013.pdf

[59] EMF 2013. Towards the Circular Economy. Economic and Business Rationale for an Accelerated Transition. Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf; Smol, M et al. 2017. Circular economy indicators in relation to eco-innovation in European regions. Clean Tech Environ Policy, 19, DOI 10.1007/s10098-016-1323-8

[60] EC. 2015. Closing the loop - An EU action plan for the circular economy. European Commission. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614; Stahel, W.R. 2016. Circular Economy. Nature 531, doi:10.1038/531435a

[61] Biological materials are biodegradable materials and can be returned safely to the environment after use, for example, water and food; while refers to durable materials that can be reprocessed and returned to use via a closed-loop system, for example, some plastics, concrete, and metals.
[62] Ibid - Stahel, W.R. 2016; EEA 2017. Circular by design - Products in the circular economy. European Environment Agency. https://www.eea.europa.eu/publications/circular-by-design
[63] Ibid – EEA, 2017; Miao, X and Tang, Y. 2016. China: Industry parks limit circular economy. Nature 534, doi:10.1038/534037d
[64] WEF. 2014. Towards the circular economy: Accelerating the scale-up across global supply chains. World Economic Forum. http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf
[65] WBCSD. 2017. CEO Guide to the Circular Economy. World Business Council for Sustainable Development. http://docs.wbcsd.org/2017/06/CEO_Guide_to_CE.pdf
[66] EMF, SUN, McKinsey & Company. 2015. Growth within: a circular economy vision for a competitive Europe. Ellen MacArthur Foundation, Stiftungsfonds für Umweltökonomie und Nachhaltigkeit (SUN) and McKinsey Centre for Business and Environment. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf
[67] Wijkman, A and Skånberg, K. 2015. The circular economy and benefits for society. Club of Rome. https://www.clubofrome.org/wp-content/uploads/2016/03/The-Circular-Economy-and-Benefits-for-Society.pdf.
[68] UNDP. 2017. Circular economy strategies for Lao PDR. United Nations Development Programme. http://www.undp.org/content/undp/en/home/librarypage/climate-and-disaster-resilience-/circular-economy-strategies-for-lao-pdr.html
[69] Ibid - WEF, EMF, McKinsey & Company. 2016
[70] The AirCarbon technology developed by Newlight is able to transform methane gas or CO_2 to some plastics types (https://www.newlight.com/). Similarly, Covestro developed a technology that turns CO_2 into plastic: https://www.co2-dreams.covestro.com/en
[71] Bioplastics including polylactic acid (PLA) and Polyhydroxyalkanoates (PHAs) have been produced from palm tree, castor oil plant, sugar cane, corn, sugar beet, switch grass and eucalyptus (CE Delft. 2017. Biobased plastics in a circular economy: policy suggestions for biobased and biobased biodegradable plastics. http://www.cedelft.eu/publicatie/biobased_plastics_in_a_circular_economy/2022). See more examples at http://sugarcane.org/sugarcane-products/bioplastics; https://www.technologyreview'/.com/s/424790/cheap-plastic-made-from-sugarcane/ and http://www.braskem.com/site.aspx/Im-greenTM-Polyethylene
[72] For example, Solaiman, D.K.Y. 2006. Conversion of agricultural feedstock and coproducts into poly(hydroxyalkanoates). Appl Microbiol Biotechnol, 71, DOI 10.1007/s00253-006-0451-1; Rostkowski K.H et al. 2012. Cradle-to-gate life cycle assessment for a cradle-to-cradle cycle: biogas-to-bioplastic (and back). Environ Sci Technol, 46, DOI: 10.1021/es204541w; Bluemink, E. D et al. 2016. Bio-plastic (poly-hydroxy-alkanoate) production from municipal sewage sludge in the Netherlands: a technology push or a demand driven process? Water Science and Technology, 74, DOI: 10.2166/wst.2016.191; Revelles, O et al. 2016. Carbon roadmap from syngas to polyhydroxyalkanoates in Rhodospirillum rubrum. Environ Microbiol, 18, DOI: 10.1111/1462-2920.13087; Myung, J. et al. 2017. Expanding the range of polyhydroxyalkanoates synthesized by methanotrophic bacteria through the utilization of omega-hydroxyalkanoate co-substrates. AMB Express, 7, 118, DOI 10.1186/s13568-017-0417-y
[73] For example, Mülhaupt, R. 2013. Green polymer chemistry and bio-based plastics: dreams and reality. Macromolecular Chemistry and Physics, 214, DOI: 10.1002/macp.201200439; Sheldon, R.A. 2014. Green and sustainable manufacture of chemicals from biomass: state of the art. Green Chem., 2014, 16, DOI: 10.1039/c3gc41935e; Pellis, A et al. 2016. Fully renewable polyesters via polycondensation catalyzed by Thermobifida cellulosilytica cutinase 1: an integrated approach. Green Chemistry, DOI: 10.1039/C6GC02142E
[74] Papaspyrides, C.D and Kiliaris, P (Eds). 2014. Polymer Green Flame Retardants. Elsevier Science Limited, Amsterdam, Netherlands.
[75] For example, Ahmetli, G et al. 2013. Epoxy composites based on inexpensive char filler obtained from plastic waste and natural resources. Polymer Composite, 34, DOI: 10.1002/pc.22452; Guzman, A.D.M. and Munno, M.G.T. 2015. Design of a brick with sound absorption properties based on plastic waste and sawdust. IEEE Access, 3, 1260-1271. DOI: 10.1109/ACCESS.2015.2461536
[76] This has been studied (for example, Khan, I.M. et al. 2016. Asphalt design using recycled plastic and crumb-rubber waste for sustainable pavement construction. Procedia Engineering, 145, doi: 10.1016/j.proeng.2016.04.196; Appiah, J.A. et al. 2017. Use of waste plastic materials for road construction in Ghana. Case Studies in Construction Materials, 6, http://dx.doi.org/10.1016/j.cscm.2016.11.001) and also demonstrated in the United States (http://www.dykespaving.com/blog/texas-roads-made-from-plastic/); EU (https://www.plasticroad.eu/en/; http://www.macrebur.com/) and in the UK (https://www.curbed.com/2017/4/26/15428382/road-potholes-repair-plastic-recycled-macrebur)
[77] The companies, REPREVE - http://www.repreve.com/ and GRN Sportwear - http://www.grnsportswear.com/ are recycling waste plastic bottles into clothing products. Similarly, another company, ROTHY'S - https://rothys.com/, uses recycled plastics to make footwear (https://plugin-magazine.com/living/rothys-the-environmentally-friendly-shoes-made-of-recycled-plastic/). Recently, Adidas started selling shoes made from plastic debris from the ocean - http://www.adidas.com/us/parley
[78] For example, Panda, A.K. et al. 2010. Thermolysis of waste plastics to liquid fuel: A suitable method for plastic waste management and manufacture of value added products-A world prospective. Renewable and Sustainable Energy Reviews, 14, https://doi.org/10.1016/j.rser.2009.07.005; Sharma, B.K. et al. 2014. Production, characterization and fuel properties of alternative diesel fuel from pyrolysis of waste plastic grocery bags. Fuel Processing Technology, 122, https://doi.org/10.1016/j.fuproc.2014.01.019; and Wong, S.L. et al. 2015. Current state and future prospects of plastic waste as source of fuel: A review. Renewable and Sustainable Energy Reviews, 50, https://doi.org/10.1016/j.rser.2015.04.063.
[79] Sun, L. et al. 2016. Eco-benefits assessment on urban industrial symbiosis based on material flows analysis and energy evaluation approach: A case of Liuzhou city, China. Resources, Conservation and Recycling, 119, https://doi.org/10.1016/j.resconrec.2016.06.007
[80] As previously mentioned (section 2.1), burning plastic as fuel leads to air pollution and greenhouse gas emissions, and consequently human health impacts. Plastic burning is also least desirable in a circular economy because this does not ensure that the worth of plastics is maintained in the economy at their highest utility and value for as long as possible (see description of circular economy in Section 2.2). However, this might be the most economical and ecological feasible option for some plastic types that are difficult to recycle. Ultimately, the goal of a circular economy is for all plastics to be recyclable; hence, a need for redesign of plastics and their products (Section 2. 3).
[81]Chemical or feedstock recycling involves chemically degrading plastics waste into basic chemicals (http://www.plasticsrecyclers.eu/chemical-recycling).
[82] for example, ibid – Hopewell, J. et al. 2009; ibid – EC. 2011; Liu, T. et al. 2017. Mild chemical recycling of aerospace fiber/epoxy composite wastes and utilization of the decomposed resin. Polymer Degradation and Stability, 139, DOI: 10.1016/j.polymdegradstab.2017.03.017; Khoonkari, M. et al. 2015. Chemical recycling of PET wastes with different catalysts. International Journal of Polymer Science, 2015, 124524,

http://dx.doi.org/10.1155/2015/124524; Rahimi, A and García, J.M. 2017. Chemical recycling of waste plastics for new materials production, Nat. Chem. Rev. 1, doi:10.1038/s41570-017-0046.

[83] Zhu, J. et al. 2018. A synthetic polymer system with repeatable chemical recyclability. Science, 360, 398–403. DOI: 10.1126/science.aar5498

[84] Yoshida, S. et al. 2016. A bacterium that degrades and assimilates poly(ethylene terephthalate). Science, 351, DOI: 10.1126/science.aad6359; Bombelli, P et al. 2017. Polyethylene bio-degradation by caterpillars of the wax moth Galleria mellonella. Current Biology, 27, DOI: 10.1016/j.cub.2017.02.060;
Austin et al. 2018. Characterization and engineering of a plastic-degrading aromatic polyesterase. PNAS, https://doi.org/10.1073/pnas.1718804115

[85] All studies were carried out in laboratory conditions. More work is still needed to move their findings from laboratory to field or commercial scale.

[86] Ibid – EMF. 2017; ibid – EEA. 2017; den Hollander, M.C. et al. 2017. Product design in a circular economy: development of a typology of key concepts and terms. Journal of Industrial Ecology, 21, DOI: 10.1111/jiec.12610; Kaur, G. et al. 2018. Recent trends in green and sustainable chemistry & waste valorisation: rethinking plastics in a circular economy. Current Opinion in Green and Sustainable Chemistry, 9, https://doi.org/10.1016/j.cogsc.2017.11.003
den Hollander and colleagues highlighted the concept of circular product design where products are designed both for integrity (high physical and emotional durability that resist obsolescence and are easy to maintain and/or upgrade, thus enabling extended use) and designed for recycling (ensuring that product's materials can be efficiently and effectively looped back into the economic system) – ibid - den Hollander, M.C. et al. 2017.

[87] A life cycle approach involves a holistic review of product or service system in order to identify and quantify the energy and material inputs, evaluate the related environmental outputs, and further appraise the corresponding impacts on the environment – see https://www.springer.com/cda/content/document/cda_downloaddocument/9783319262222-c2.pdf?SGWID=0-0-45-1532480-p177780592

[88] For example, adopting modular design for products containing plastics could increase the ease of separation, reuse and recycling of plastic parts and may also reduce the amount of material resource needed for the product (Ishii, K. 2001. Modular design for recyclability. Implementation and knowledge dissemination. In Richards et al. (Eds). Information Systems and the Environment. National Academy Press, Washington DC; Lienig J., and Bruemmer, H. 2017. Recycling requirements and design for environmental compliance. In: Fundamentals of Electronic Systems Design. Springer, Cham, 193-218. DOI: https://doi.org/10.1007/978-3-319-55840-0_7 and http://sites.tufts.edu/eeseniordesignhandbook/2013/design-for-the-environment/)

[89] Ibid - EMF, 2017.

[90] See: http://www.myreplenish.com/; http://www.petainer.com/; and Splosh https://www.splosh.com/#3

[91] Ibid – EMF. 2013; ibid – EMF. 2017

[92] for example, ibid – Sun, L. et al. 2016; van Berkel, R et al. 2009. Quantitative assessment of urban and industrial symbiosis in Kawasaki, Japan. Environ. Sci. Technol. 2009, 43, 1271–1281; ibid – EMF. 2017; Ibid – EMF. 2017 highlights examples of possible business-to-business cooperation on plastic waste use include for large rigid packaging such as pallets, crates, foldable boxes, pails and drums; and single-use pallet wrap.

[93] For example, Geng, Y. et al. 2010. Evaluation of innovative municipal solid waste management through urban symbiosis: a case study of Kawasaki. Journal of Cleaner Production, 18, https://doi.org/10.1016/j.jclepro.2010.03.003; Chen, X. et al. 2011. The potential environmental gains from recycling waste plastics: Simulation of transferring recycling and recovery technologies to Shenyang, China. Waste Management, 31, https://doi.org/10.1016/j.wasman.2010.08.010; Dong et al., 2016. Promoting low-carbon city through industrial symbiosis: A case in China by applying HPIMO model. Energy Policy, 61, https://doi.org/10.1016/j.enpol.2013.06.084; Fuji et al., 2016. Possibility of developing low-carbon industries through urban symbiosis in Asian cities. Journal of Cleaner Production, 114, https://doi.org/10.1016/j.jclepro.2015.04.027

[94] Ibid - Miao, X and Tang, Y. 2016.

[95] For example, the city of Holbæk in Denmark has created a system to collect plastic waste from household for industrial use (https://stateofgreen.com/en/profiles/holbaek-forsyning-a-s/solutions/recycling-plastic-through-industrial-symbiosis). Similarly, the city of Beijing installed reverse vending machines in subway where people can insert empty plastic bottle and get rewarded with transportation credit or mobile phone minutes (https://www.forumforthefuture.org/sites/default/files/Card%20deck.pdf). Also, there is a Norwegian depositing and recycling scheme for non-refillable plastic bottles and beverage cans: https://infinitum.no/english/about-us.

[96] This analysis was conducted in Liuzhou, an industrial city located in the the Guangxi Zhuang Autonomous Region, with a total area of 18,707 km^2, and population of 3.76 million in 2009.

[97] As previously noted in Section 2.3, the burning of plastic wastes as fuel is least desirable in a circular economy as it does not ensure that the worth of plastics is maintained in the economy at their highest utility and value for as long as possible and could impact air pollution and climate change.

[98] It was noted that only a small fraction of total plastic waste (about 100 thousand tonnes per year) was used due to difficulty of plastics collection (highlighting the importance of effective waste collection systems), and technical requirement of furnace.

[99] Ibid – Sun, L. et al. 2016.

[100] https://www.forumforthefuture.org/sites/default/files/Card%20deck.pdf

[101] See: www.recpnet.org

[102] ten Brink, P. et al. 2017. T20 Task Force Circular Economy: Circular economy measures to keep plastics and their value in the economy, avoid waste and reduce marine litter. G20 Insights. http://www.g20-insights.org/wp-content/uploads/2017/05/Circular-Economy_The-circular-economy-plastic-and-marine-litter.pdf

[103] Ibid – EMF. 2017; ibid - ten Brink, P. et al. 2016.

[104] For example, Kenya and Rwanda has banned single-use plastic bags. See https://www.reuters.com/article/us-kenya-plastic/kenya-imposes-worlds-toughest-law-against-plastic-bags-idUSKCN1B80NW and https://www.globalcitizen.org/en/content/how-eliminating-plastic-bags-in-rwanda-saves-liv-2/

[105] Álvarez-Cháveza, C.R. et al. 2012. Sustainability of bio-based plastics: general comparative analysis and recommendations for improvement. Journal of Cleaner Production, 23, https://doi.org/10.1016/j.jclepro.2011.10.003

[106] UNEP. 2015. Biodegradable plastics and marine litter. Misconceptions, concerns and impacts on marine environments. United Nations Environment Programme. https://wedocs.unep.org/handle/20.500.11822/7468

[107] The waste management hierarchy ranks waste management options in order of preference for achieving environmental sustainability as follows: prevention, minimization, reuse, recycling, energy recovery and disposal. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf

[108] This has been demonstrated in Netherland where the world's first plastic-free aisle supermarket was recently opened. https://www.theguardian.com/environment/2018/feb/28/worlds-first-plastic-free-aisle-opens-in-netherlands-supermarket
[109] The UK government in January 2018 banned the use of microbeads in cosmetics and personal care product. https://www.gov.uk/government/news/world-leading-microbeads-ban-takes-effect
[110] https://www.sitra.fi/en/cases/renewable-durable-recyclable-material-replace-paper-plastic/
[111] The GEF aims to support transformational change and deliver integrated Global Environmental Benefits (GEBs) in the biodiversity, climate change, chemicals and waste, international waters, land, and forest work areas as well as in integrated areas including food security, sustainable cities, and fisheries.
[112] Raubenheimer, K and McIlgorm, A. 2018. Can the Basel and Stockholm Conventions provide a global framework to reduce the impact of marine plastic litter? Marine Policy, https://doi.org/10.1016/j.marpol.2018.01.013
[113] Ibid - Rahimi, A and García, J.M. 2017.
[114] Ibid – EC. 2018.

[116] STAP. 2011. Marine Debris as a Global Environmental Problem. Introducing a solutions-based framework focused on plastic. Scientific and Technical Advisory Panel for the Global Environment Facility. http://www.stapgef.org/sites/default/files/stap/wp-content/uploads/2013/05/Marine-Debris.pdf; ibid – Eriksen, M. et al., 2014; ibid - Ocean Conservancy. 2015.
[117] https://coral.org/coral-reefs-101/coral-reef-ecology/coral-reef-biodiversity/
[118] See for example, Derraik, J.G.B. 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin, 44, https://doi.org/10.1016/S0025-326X(02)00220-5; Gregory, M.R. 2009. Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. Phil. Trans. R. Soc. B. 364, doi:10.1098/rstb.2008.0265; Gall, S.C and Thompson, R.C. 2015. The impact of debris on marine life. Marine Pollution Bulletin, 92, http://dx.doi.org/10.1016/j.marpolbul.2014.12.041
[119] ibid - Gall, S.C and Thompson, R.C. 2015.
[120] Aoki, K.A. et al. 2011. Evidence suggesting that di-n-butyl phthalate has antiandrogenic effects in fish. Environ Toxicol Chem. 30, doi: 10.1002/etc.502; Zhao, X. et al. 2014. Toxicity of phthalate esters exposure to carp (Cyprinus carpio) and antioxidant response by biomarker. Ecotoxicology, 23, doi: 10.1007/s10646-014-1194-x; ibid - Lamb et al., 2018.
[121] Liu, E.K et al. 2014. White revolution' to 'white pollution'—agricultural plastic film mulch in China. Environmental Research Letters, 9, doi:10.1088/1748-9326/9/9/091001; Wang, J et al. 2013. Soil contamination by phthalate esters in Chinese intensive vegetable production systems with different modes of use of plastic film. Environmental Pollution, 180, https://doi.org/10.1016/j.envpol.2013.05.036; Scarascia-Mugnozza et al. 2011. Plastic materials in European agriculture: actual use and perspectives. Journal of Agricultural Engineering, 3, 15-28; Vox, G et al. 2016. Mapping of Agriculture Plastic Waste. Agriculture and Agricultural Science Procedia, 8, https://doi.org/10.1016/j.aaspro.2016.02.080
[122] For the description of the SDGs and their related targets, please see https://sustainabledevelopment.un.org/?menu=1300. A detailed mapping of the SDGs against the circular economy approach is presented in Preston F and Lehne J. 2017. A wider circle? The circular economy in developing countries. Chatham House Briefing. https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-12-05-circular-economy-preston-lehne-final.pdf
[123] Ibid – Circle Economy 2018; ibid - Preston F and Lehne J. 2017.
[124] Ibid – EMF. 2017.
[125] Ibid - Ocean Conservancy. 2015; Bourguignon, D. 2017. Plastics in a circular economy: opportunities and challenges. European Parliament Think Tank Briefing, May 2017. http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI%282017%29603940.
[126] This estimate considered societal benefits related to avoidance of greenhouse gas emissions. The social benefits are expected to be greater if the value of averted direct and indirect negative effects of plastics on human health, biodiversity, and ecosystem services is included.
[127] Ibid - Preston F and Lehne J. 2017.
[128] Moreau, V. et al. 2017. Coming full circle: why social and institutional dimensions matter for the circular economy. Journal of Industrial Ecology, 21, 497–506, DOI: 10.1111/jiec.12598
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[131] This is a campaign launched by UN Environment aimed at engaging governments, the general public, civil society and the private sector in the fight against marine plastic litter. http://www.cleanseas.org/
[132] There are several ongoing efforts to clean up plastics from the environment including in GEF-recipient countries which the GEF can key into (see examples in this links: https://www.theoceancleanup.com/; http://www.unep.org/stories/story/one-year-worlds-largest-beach-clean-still-fighting-plastic-tide; https://www.cnbc.com/2017/05/18/a-billionaire-is-giving-his-fortune-away-to-clean-up-oceans.html
[133] See http://www.adidas.com/us/parley and http://www.climateactionprogramme.org/news/adidas-has-sold-one-million-shoes-made-from-recycled-ocean-plastic for more details.
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Environmental security: dimensions and priorities

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Environmental security: dimensions and priorities

Summary

In its report to the 5th GEF Assembly (2014), the Scientific and Technical Advisory Panel (STAP) noted the importance of action to “enable improved human well-being, health, security, livelihoods and social equity at the same time as environmental benefits” and recommended increased attention to environmental security.

Environmental security has been described as a bundle of issues which involves the role that the environment and natural resources can play in peace and security, including environmental causes and drivers of conflict, environmental impacts of conflict, environmental recovery, and post-conflict peacebuilding. The scope of security and insecurity is by no means limited to violent conflict or its absence but includes the roots of sustainable livelihoods, health, and well-being.

Environmental security underpins the rationale for investment in global environmental benefits, and is essential to maintain the earth's life-supporting ecosystems generating water, food, and clean air. Reducing environmental security risks also depends fundamentally on improving resource governance and social resilience to natural resource shocks and stresses. The environment is better protected in the absence of conflict and in the presence of stable, effective governance. GEF investment to achieve global environmental benefits depends on effective management of environmental security risks as an element of human security.

The GEF is already engaged through its programmatic and project investments. But, to date, the GEF does not appear to have addressed environmental security in an integrated manner across its program areas. One reason may be the lack of a common framework or language to differentiate the various dimensions of environmental security and, thus, evaluate the case for different strategies of engagement.

There are four dimensions of environmental security which are of particular relevance to the GEF.

First, ecosystem goods and services fundamentally underpin human well-being and human security. Human beings depend on the earth’s ecosystems and the services they provide. The degradation of these services often causes significant harm to human well-being which, in the framework of the Millennium Ecosystem Assessment, explicitly includes human security.

Second, conflict, irrespective of its source, affects the viability or sustainability of investments in environmental protection and their outcomes. Violent conflict often results in direct and indirect environmental damage, with associated risks for human health, livelihoods and ecosystem services. Even where natural resources play no role as a source of tension in spurring conflict, the threat of violence or insecurity can undermine project implementation.

Third, ecosystem degradation, resource competition, or inequitable distribution of benefits increase vulnerability and conflict risk. Environmental degradation is a cause of human insecurity and can aggravate other sources of social division based on ethnicity, class, religion, or economic position. While rarely the simple or sole cause of conflict and insecurity, environmental change (including climate change) is increasingly characterized as a “risk multiplier.” Even where violent conflict does not occur,

longer-term environmental trends often act as stressors on rural livelihoods and increase the vulnerability of natural resource-dependent communities to social, economic, or environmental shocks.

Fourth, environmental cooperation can increase capacity for conflict management, prevention, and recovery. Managing shared natural resources sustainably and equitably can motivate greater cooperation, and can also help build institutions that moderate and reduce the disruptive impacts of conflict, or aid post-conflict reconciliation and rebuilding.

Environmental security is relevant to all of the GEF's focal areas. The international waters portfolio has given most explicit attention to investment in institutions for transboundary cooperation, in international river basins as well as large marine ecosystems. The biodiversity portfolio addresses direct threats to food security and well-being, often in sensitive environments: there is significant overlap between biodiversity hotspots and areas of civil strife. Investments addressing land degradation, including deforestation and desertification, offer direct routes to support the food and livelihood security of populations living in marginal environments. Approximately 3 billion people reside in areas with land degradation hotspots, with serious implications for food and water security, aggravated by climate change. Projects in the GEF portfolio are increasingly addressing these links.

Many GEF operations are also exposed to conflict risk. Half of GEF recipients (77 countries) experienced armed conflict since the GEF's inception in 1991, and over one-third of GEF recipients (61 countries) proposed and implemented GEF projects while armed conflict was ongoing somewhere in the country. Nearly one-third of all GEF funding has been invested in projects during years when recipient countries experienced conflict.

For all of these reasons, addressing environmental security in an explicit, consistent and integrated manner is essential to delivering global environmental benefits, including the long-term sustainability of project investments. Based on this rationale, STAP recommends the GEF should:

1. Explicitly address environmental security in project and program design. Expressing the benefits of GEF investment in terms of environmental security, as a component of broader human security, can link global environment benefits to the more immediate concerns of employment and livelihoods, equity, social stability and effective governance.

2. Assess conflict risk routinely among investment risks beyond the scope of GEF intervention. GEF agencies, including UNDP, UN Environment, and the World Bank, routinely carry out such analyses in their non-GEF financed portfolios. The GEF should consider how to make best use of these protocols when designing relevant projects.

3. Evaluate the relationships between environmental change and vulnerability within GEF interventions through the use of tools such as Resilience, Adaptation Pathways and Transformation Assessment (RAPTA). The aim should be to mainstream project-level analysis on how environmental change affects the vulnerabilities of different stakeholder groups, and how project interventions might mitigate or reverse these trends.

4. Contribute to conflict prevention through environmental cooperation. In all projects where conflict risk is salient, even if not immediate, there are opportunities for the GEF to contribute actively to conflict prevention, not only by mitigating the vulnerabilities affecting particular stakeholder groups but also by strengthening institutions of environmental cooperation and equitable resource governance.

Environmental security: dimensions and priorities

1. <u>What is the issue?</u>

Environmental security views ecological processes and natural resources as sources or catalysts for conflict and as barriers or limits to human well-being, and conversely as a means to mitigate or resolve insecurity.[1] Environmental security is understood as a foundation of human security more broadly, essential to sustainable livelihoods, health, and well-being among households and communities, and therefore central to achieving the mandate of the Global Environment Facility (GEF). However, lack of clarity over the many dimensions of the challenge, appropriate entry points for GEF engagement and metrics for assessing effectiveness have hindered progress. This paper distinguishes four dimensions of environmental security and recommends those where the GEF might respond to analysis provided by others, as distinct from those where the GEF can itself play a leading role.

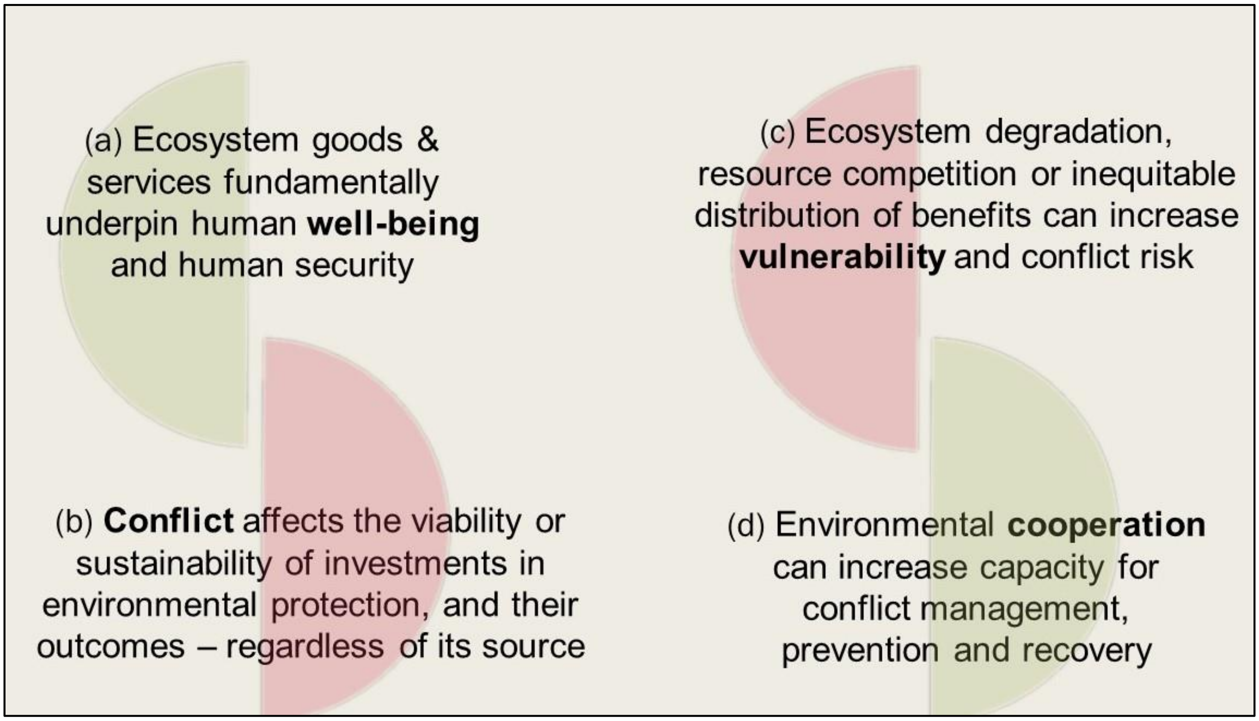
The latest annual Risk Report of the World Economic Forum cites the highest risks, by impact and probability, as extreme weather events, natural disasters and failure of climate-change mitigation and adaptation. Large-scale involuntary migration, water crises, and biodiversity loss and ecosystem collapse follow closely behind. "Profound social instability" was identified as the risk factor most highly connected to the range of global trends.[2]

In its report to the 5th GEF Assembly (2014), the Scientific and Technical Advisory Panel (STAP) noted the importance of action to "enable improved human well-being, health, security, livelihoods and social equity at the same time as environmental benefits" and recommended increased attention to environmental security.[3]

UN Environment describes environmental security as a "conceptual envelope" including a variety of issues involving the role that the environment and natural resources can play across the peace and security continuum, including environmental causes and drivers of conflict, environmental impacts of conflict, environmental recovery and post-conflict peacebuilding.[4] In this paper, the scope of security and insecurity is by no means limited to violent conflict or its absence, but includes as well the roots of sustainable livelihoods, health, and well-being among households and communities—the environmental dimension of what the UNDP and others have termed "human security."[5]

Seen in these terms, the importance of environmental security to the GEF mandate is very clear, and in many domains the GEF is already deeply engaged through its programmatic and project investments. To date, however, the GEF does not appear to have addressed environmental security in an integrated manner across its program areas.[6] One reason may be the lack of a common framework or language to differentiate the various dimensions of environmental security and, thus, evaluate the case for different strategies of engagement. To address this gap, four dimensions of particular salience for the GEF are used to structure the analysis in this paper. These four dimensions cover both positive benefits, linking the environment and human security, and negative impacts or risks (see Figure 1).

Figure 1. Four dimensions of environmental security from the perspective of the GEF



2. What does the science say?

a) Ecosystem goods and services fundamentally underpin human well-being and human security.

Human beings depend on the earth's ecosystems and the services they provide. These include *provisioning services* such as food and clean water, *regulating services* such as disease and climate regulation, *cultural services* such as spiritual fulfillment and aesthetic enjoyment, and *supporting services* such as primary production and soil formation. The degradation of these services often causes significant harm to human well-being which, in the framework of the Millennium Ecosystem Assessment, explicitly includes human security.[7]

Global trade networks have made the links between environmental resources and livelihoods less visible for many. Despite this, the risks of environmental degradation to human well-being and security have become globalized due to the dramatic growth of the human enterprise since the Industrial Revolution, threatening the "safe operating space for humanity."[8] This notion, first codified in the Planetary Boundaries framework, has since been adapted to incorporate dimensions of social equity and justice, described as the "safe and just operating space for humanity."[9] Others have incorporated dimensions such as nutrition and health, income, and access to education embedded in the Sustainable Development Goals.[10]

These frameworks are important not only for understanding the general linkages between ecosystems and human well-being and security, but also for identifying policy priorities to reduce vulnerabilities and build capacity for adaptation and system transformation at finer scales.[11] For example, researchers applied the "safe and just" inclusive sustainable development framework to South Africa, combining 20 indicators and boundaries for environmental stress and social deprivation. Results indicate that the country exceeds its environmental boundaries for biodiversity loss, marine harvesting, freshwater use, and climate change, and that social deprivation was most severe in the areas of safety, income, and employment,[12] which are significant factors in conflict risk. Further downscaling can be done to analyze and communicate socio-economic and ecological boundaries from a city's perspective.[13]

b) *Conflict affects the viability or sustainability of investments in environmental protection and their outcomes, regardless of its source.*

Violent conflict often results in direct and indirect environmental damage, with associated risks for human health, livelihoods and ecosystem services.[14] There are also examples where war hinders resource extraction because it makes certain areas inaccessible to commerce, with the unintended effect of protecting the resource base such as forest cover or marine fish stocks – though this effect is often reversed once commercial exploitation resumes.[15] In other cases, once conflict is underway, high-value resources such as gems, oil, and timber become a source of finance for combatant forces. Indeed, at least 18 civil wars since 1990 have been financed by the illegal exploitation of such resources.[16] Wildlife is the fourth largest illegal trade after the trafficking of drugs, people, and arms.[17]

Following armed conflict, land, timber, and minerals are often in high demand as resources for recovery and reconstruction. If not managed equitably to support livelihoods, jobs, basic services, etc., then renewal of conflict is likely. In the absence of equitable governance institutions, otherwise manageable resource competition can escalate into broader social conflict. In fact, a retrospective analysis of intrastate conflicts over the past sixty years indicated that conflicts associated with natural resources are twice as likely to relapse into renewed conflict within the first five years.[18] Despite this, of the more than 800 peace agreements since 1945, fewer than 15% address terms related to "natural resources."[19] Fortunately, in recent decades, these trends have improved. While roughly half of all peace agreements concluded between 1989 and 2004 (51 out of 94) contain direct provisions on natural resources, all major agreements from 2005 to 2014 contain such provisions.[20]

Even where natural resources play no role or only a minor role as a source of tension in spurring conflict, the threat of violence or insecurity at the sub-national level can undermine the feasibility of project implementation, no matter the focus. International aid to fragile states is more than twice as volatile as aid to non-fragile states. This factor alone—quite apart from the direct impact of conflict—accounts for an estimated loss in efficiency of 2.5 percent of Gross Domestic Product for recipient countries.[21] Development agencies working in fragile and conflict-prone settings are often poorly equipped to cope with the particular challenges of achieving sustainable outcomes in these settings.[22]

c) *Ecosystem degradation, resource competition, or inequitable distribution of benefits increase vulnerability and conflict risk.*

Environmental degradation is a cause of human insecurity and in many cases serves to aggravate other sources of social division based on factors such as ethnicity, class, religion or economic position.[23] Currently, there are over 1800 resource-related conflicts worldwide,[24] many caused by extractive activity that polluted or damaged the land, air, water, forests and livelihoods of communities. Such conditions may contribute to sustained social conflict, often with sporadic violence, and in some cases, control over natural resources is a central driver of armed conflict.[25]

A comprehensive study of internal armed conflicts over the period 1946-2006 found a significant proportion were linked to natural resources: 39 percent in the Middle East and North Africa, 44 percent in Sub-Saharan Africa, 56 percent in South Asia, and 60 percent in East Asia and the Pacific. Of these, conflicts over natural resource distribution, for example, access and use rights, or distribution of revenue, showed the steadiest increase.[26]

Mediating factors related to rural incomes, land tenure, governance, strength and inclusiveness of resource management institutions, and gender equity[27] are often critical in influencing whether changes in the availability of resources foster adaptations – or spur conflict and exodus. While rarely the simple or sole cause of conflict and insecurity, environmental change (including climate change) is increasingly characterized as a "risk multiplier."[28] For example, severe and prolonged drought in Syria and the Greater Fertile Crescent in 2006 spurred massive rural to urban migration and was a contributing factor to the ongoing conflict.[29] In most cases, while natural resources may be linked to the root cause, by the time the conflict has escalated to violence, the drivers are mixed with a range of factors. This means that efforts to remedy the natural resource drivers need to complement efforts to address the political context and associated stresses.[30]

In other instances, even where violent conflict does not occur, longer-term environmental trends often act as stressors on rural livelihoods and increase the vulnerability of natural resource-dependent communities to social, economic, or environmental shocks. In dryland zones, for example, climate change and related climate variability, water scarcity and land degradation now frequently combine as factors leading to involuntary mass migration.[31]

d) Environmental cooperation can increase capacity for conflict management, prevention, and recovery.

Managing shared natural resources sustainably and equitably can motivate greater cooperation within and among communities.[32] It can also help build institutions that moderate and reduce the disruptive impacts of conflict or aid post-conflict reconciliation and rebuilding.[33] This occurs at:

- local levels, as in the interaction of farmers and herders who may share mutually dependent and symbiotic relations, which can lead to cooperation during times of prolonged drought;[34]
- within countries at significant scale, such as the national movement of community-managed forest institutions in Nepal that sustained ties of mutual support despite the breakdown of state institutions during the period of civil war;[35] and
- at the transboundary scale, as illustrated by the Indus Waters Treaty, which has moderated competition between India and Pakistan for six decades, despite ongoing tension.[36]

In developing countries where access to, and use of, renewable resources essential to rural livelihoods are highly contested, improving cooperation in their management is increasingly seen as an important element in strategies for conflict prevention, confidence building, and longer-term social-ecological resilience.[37] Where traditional or customary institutions for resource tenure, management, and conflict resolution enjoy legitimacy in the eyes of local resource users, efforts to recognize these and manage their relationship to statutory institutions of the state are critical. This is especially the case in post-conflict settings, where sources of legal authority may have eroded and reconstruction efforts often disregard traditional institutions.[38]

For environmental challenges that are inherently transboundary, investing in capacity for conflict management and mediation support is integral to long-term success.[39] For example, this applies to:

- shared river basins, where the allocation of water flows, upstream watershed protection, pollution control, and management of aquatic biodiversity all depend on joint action across multiple jurisdictions, often with sharply competing economic interests;
- forest and other terrestrial conservation efforts, including transboundary parks, which now number more than 250, spanning 460 million hectares;[40] and

- climate change mitigation and adaptation, where the distribution of costs and benefits among states and communities is a leading source of tension and an obstacle to accelerated progress.[41]

Moreover, coordinated efforts can yield massive efficiency gains, even accounting for the significant transactions costs. A study of conservation planning in the Mediterranean Basin, for example, concluded that a coordinated approach among states would cost 45% less than a collection of national plans and save an estimated $67 billion over 10 years.[42]

3. <u>Why is this important to the GEF</u>?

Environmental security **underpins the rationale for investment** in global environmental benefits. It is essential to maintain the earth's life-supporting ecosystems generating water, food, and clean air. The environment is better protected when activities to generate global environmental benefits – as in the GEF mandate – are analyzed to ensure that negative social and economic impacts are either minimized or mitigated. Reducing environmental security risks also depends fundamentally on improving resource governance and social resilience to natural resource shocks and stresses. The environment is better protected in the absence of both domestic and cross-border conflicts and in the presence of stable, effective governance. GEF investment to achieve global environmental benefits depends on effective management of environmental security risks as an element of human security.

Environmental security is also **relevant to all focal areas** within the GEF mandate. The international waters portfolio has given most explicit attention to investment in institutions for transboundary cooperation, in international river basins as well as large marine ecosystems. The biodiversity portfolio not only addresses direct threats to food security and well-being[43] but also must grapple with the indirect consequences of conservation efforts. These include the risks of "green militarization"—the expansion of armed enforcement of conservation zones—which can raise the likelihood of conflict with local communities.[44] This is especially concerning, as studies indicate there is significant overlap between biodiversity hotspots and areas of civil strife.[45]

GEF investments to address land degradation, including deforestation and desertification, offer some of the most direct routes to support the food and livelihood security of populations living in marginal environments. Critically, about 30 percent of total global land area is considered degraded, with approximately 3 billion people residing in areas with land degradation hotspots.[46] These have serious implications for food and water security, aggravated by climate change.[47] Both climate adaptation and mitigation efforts, moreover, can inadvertently spur new conflicts—for example over land tenure, access to benefits, or mining of green energy minerals—if these risks are not explicitly managed.[48]

Investments in chemicals and waste, similarly, require careful attention to the social distribution of costs and benefits. Political scientists refer to 'environmental racism' to describe the disproportionate burden of environmental harms carried by poor, often ethnic-minority, communities. For example, the export—or dumping—of electronic waste from rich, industrialized countries into Africa has been justified as legitimate recycling; yet the toxic dumps and burning of plastic coatings to copper wires is a major health hazard both to humans and the environment.[49] Newer areas of GEF engagement, such as sustainable cities, require attention to the interplay between rapid urbanization and the shrinking land base for food production, alongside other risks and opportunities for human security.[50]

Many **GEF operations are exposed to conflict risk**. An analysis commissioned by STAP[51] indicates that half of GEF recipients (77 countries) experienced armed conflict[52] since the GEF's inception in 1991, and over one-third of GEF recipients (61 countries) proposed and implemented GEF projects while armed conflict was ongoing somewhere in the country. Nearly one-third of all GEF funding has been invested in projects during years of active conflict somewhere in the recipient countries. Some projects are also implemented in sub-national areas that have emerged from protracted violent conflicts or are susceptible to relapse. In the case of land degradation projects, the situation is especially acute: an estimated 73 percent of countries with GEF land degradation projects are conflict-affected, and 66 percent of individual GEF land degradation project sites in Africa were near, or directly in, the area of one or more conflict events.[53]

For all of these reasons, addressing environmental security in an explicit, consistent and integrated manner is essential to delivering global environmental benefits – including the long-term sustainability of project investments.

4. How should the GEF Respond?

A review of the multi-agency Environment and Security initiative[54] notes, "the environment and security nexus has been evident in all post-conflict and transition countries" and "tackling the security risks that stem from environmental factors . . . requires a multi-dimensional approach that is difficult for a single organization to achieve." There is scope for GEF investment in each of the four dimensions described above in Figure 1, with particular emphasis on capability development in addressing ecosystem degradation to reduce vulnerability, and in building environmental cooperation.

The STAP recommends that the GEF consider the following actions – some of which could be done in the near term, while others may require additional time and effort.

a) Explicitly address environmental security

Making environmental security explicit can enable the GEF to do its job more effectively by expanding both the scope of partnerships and the level of stakeholder commitment to programmatic success. If the GEF's investment were expressed in terms of environmental security (as a component of broader human security) this would make a clearer link to the more immediate concerns of employment and livelihoods, equity, social stability and effective governance. In the near term, this could be done by incorporating conflict sensitivity, mitigation, and risk reduction into the project theory of change, in cases where interventions aim to reduce social and economic vulnerabilities linked to environmental change. This is additional to the consideration of generic conflict risk outside the scope of intervention. Doing so could potentially leverage greater support for the GEF mission as well, particularly when donor governments, development agencies, and foundations have sound evidence to link their environmental investments to human well-being outcomes. Substantial guidance, including from GEF agencies, provides tools for assessing and articulating these links.[55] In the longer term, the GEF might consider developing environmental security indicators to monitor progress.

b) Assess conflict risk routinely among investment risks beyond the scope of GEF interventions

Analysis of generic conflict risk, meaning the risk of conflict emanating from sources beyond the scope of GEF interventions, should be integrated as a routine element of GEF project design and implementation, preferably from the stage of project identification (PIF). If a project does not fully appreciate the specific context of post-conflict or fragile states when it is designed, it is more likely to fall short of achieving consistent results.[56] GEF agencies, including UNDP, UN Environment, and the World Bank, routinely carry out such analysis in their non-GEF financed portfolios. For example, UNDP's Bureau for Crisis Prevention & Recovery uses a Conflict-related Development Analysis (CDA) which provides guidance on conducting conflict analysis and applying the findings of analysis for a range of purposes. Similarly, the World Bank has developed a Pilot Toolkit for Measuring and Monitoring in

Fragility, Conflict, and Violence (FCV) Environments, designed to assist World Bank Group teams—and by extension support dialogue with partners and clients—to measure progress in affected countries.

In the near term, similar protocols could be adapted to the GEF project cycle. Recent years have seen a significant expansion of effort, including World Bank measures to make country strategies more 'fragility focused,' based on evidence that conflict prevention is a rational and cost-effective strategy for countries at risk of violence and for the international community.[57] Similarly, UNDP has consolidated expertise in conflict prevention, governance and peacebuilding to respond to threats identified as contributing to fragility and instability.[58] Over the long term, the GEF Secretariat could work with the agencies, in partnership with independent, specialized research bodies, such as the International Crisis Group[59], to develop methodologies for undertaking more detailed analyses of conflict risk for GEF projects, drawing upon the pilot experiences of GEF agencies.

c) *Strengthen analysis of factors linking environmental change and vulnerability within GEF interventions*

Beyond the more generic consideration of conflict risk addressed above, the GEF should develop and apply a suite of tools (or adapt existing tools, such as the Resilience, Adaptation Pathways and Transformation Assessment [RAPTA] framework – see Box 1) to mainstream project-level analysis on how environmental change affects the vulnerabilities of different stakeholder groups, and how project interventions may mitigate or reverse these trends. Given the importance of "mediating factors" in determining exposure to risk, adaptive capacity and ultimate conflict risk, the GEF should strengthen attention to these aspects. These include a focus on institutions governing access rights and management authority in regard to land, water, forests and other natural resources; grievance and dispute resolution mechanisms; access to policy processes and decision-making regarding the distribution of environmental benefits and harms, including pollution; and cultural, legal, or political factors affecting gender equity and the status of ethnic or religious minorities. This approach could be tested in one or more of the GEF-7 Impact Programs.

Currently, many GEF projects identify competition for resources and the potential for conflict as contextual factors at the project identification stage. Addressing these issues more directly could improve the likelihood of projects meeting their long-term objectives. Specifically, the GEF should consider how best to:

- Support the capacity of national and regional agencies to incorporate environmental security considerations into existing procedures for environmental impact assessment, particularly with regard to large-scale infrastructure or policy investments.[60]

- Tailor stakeholder analysis and multi-stakeholder dialogues to guide participatory processes in project design and implementation. These should consider the differential impacts of project interventions on key stakeholder groups and foster opportunities for social learning and adaptive co-management.[61] (See Box 1.)

- Integrate capacity building for disaster preparedness and contingency planning into project investments where this offers opportunities to mitigate environmental damage, e.g. exploitation of biodiversity hotspots or release of chemical pollution, and to build more resilient livelihoods and reduce conflict risk.[62]

d) Contribute to conflict prevention through environmental cooperation

In all projects where conflict risk is salient (even if not immediate), there are opportunities for the GEF to contribute actively to conflict prevention, not only by mitigating the vulnerabilities affecting particular stakeholder groups but also by strengthening institutions of environmental cooperation and equitable resource governance.[63] The GEF has long been active in this domain, particularly in international waters, addressing the shared interests of many states in both freshwater and marine resources.[64] Similar opportunities exist in areas such as international safeguards addressing chemicals and waste, land restoration and biodiversity protection and in multi-focal area projects and programs addressing food and livelihood security in marginal landscapes. Ultimately, projects where groups can come together to address a shared environmental threat offer opportunities for dialogue and confidence building that can reduce the risk of destructive social conflict (including the risk of violence) and potentially benefit other areas of cooperation. For example, this type of cooperation is central to "peace parks," transboundary protected areas designed to support both conservation and conflict prevention. It is also emerging as a core element of multi-focal area projects addressing food security through improved land and water governance in conflict-sensitive environments.

Effective support requires understanding the regional political and economic drivers that influence competition and cooperation and leveraging this understanding in the design and strengthening of regional institutions.[65] Similar principles may be applied to sub-national interventions in fragile states or potential conflict hotspots, with a focus on areas where the protection or restoration of global environmental benefits may also contribute to strengthened governance or adaptive capacity among populations at risk.[66] GEF investments in areas such as climate adaptation have seen increased emphasis on capacity building.[67]

In the short term, the GEF could improve the collection, sharing, analysis, and visualization of environmental security data generated by GEF projects to identify priorities for more systemic risk monitoring. This could include opportunities for enhanced sharing of environmental security data between neighboring countries. This type of information could potentially be incorporated into the revised Project Management Information System (PMIS) to share data across the GEF Partnership.

In addition, there may be scope for GEF investment to address, through the work of GEF agencies or external partners, gaps in existing systems of monitoring and foresight assessment, such as "environmental security hotspots" specifically assessing the links between environmental resource trends and conflict risk at global and regional scales.

Over the long term, investing in the capacity to monitor resource trends, to increase transparency and access to environmental information, along with measures to enable proactive stakeholder engagement in assessing risks and developing shared action plans, can build patterns of cooperation that may prove critical when crises emerge. Where investments are planned in a post-conflict setting, they may be explicitly designed to contribute to peacebuilding, leveraging the expertise of agencies with specialized capabilities in this domain.

Box 1: **Addressing environmental security within the Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) framework**

The RAPTA framework applies resilience thinking for sustainability goals amidst a "context of uncertainty, plural values, and conflicting interests." Its suitability as a foundation for incorporating environmental security concerns stems from the approach to structuring analysis as well as the process of engagement. Regarding the analysis, key elements include:

> **Theory of change.** This considers the drivers of change and intended outcomes, which may include variables that increase or mitigate conflict risk. Demands consideration of the need for incremental adaptation versus transformational change.
>
> **System description.** This recognizes "multiple conflicting perspectives," with an expectation to "identify conflict resolution processes and assess levels of public trust in the governance system, its openness to criticism and the ability to change laws if circumstances require it."
>
> **System assessment.** This includes identification of risks, thresholds, and controlling variables, and can integrate conflict risk assessment; intended to be regularly revisited and revised.
>
> **Options and pathways**. These pursue the desired change, recognizing that transformational change is "likely to generate conflict," that there may be conflicts between interventions, and that each will require adaptation in implementation.

Regarding process, the framework emphasizes the role of multi-stakeholder engagement and governance throughout the stages of project identification, design, implementation, evaluation and learning. Key elements include:

> **Stakeholder analysis focused on entry points for change.** This asks: Who are relevant stakeholders? What are the potential barriers and opportunities for engagement (including gender power dynamics)? How should each be engaged?
>
> **Project governance arrangements linked to the broader governance context**. This recognizes that "the greater the level of change to the social-ecological system, the more attention must be paid to issues of power, decision-making and accountability."
>
> **Attention to adaptive learning and ethics.** This asks: How has the project team made the RAPTA process transparent and conducive to learning? What mechanisms enable flexibility to deal with uncertainty, and alternative ideas? What measures ensure ethical engagement?
>
> **Consideration of the requirements for dialogue.** This includes the role and skill level of facilitator and the potential need for specialized skills in conflict management, particularly where transformational change entails disrupting existing relationships.
>
> **Focus on capacity for learning.** This integrates monitoring, assessment and knowledge management into processes of stakeholder engagement, with the intention of fostering self-assessment, awareness, and capacity for implementation, including capacity to mobilize collective action in support of project goals.

See: O'Connell et al. 2016. Designing projects in a rapidly changing world: Guidelines for embedding resilience, adaptation and transformation into sustainable development projects. GEF: Washington, DC. http://www.stapgef.org/rapta-guidelines

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