UNEP

International Resource Panel

FOOD SYSTEMS AND NATURAL RESOURCES

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The authors would like to thank PBL Netherlands Environmental Assessment Agency for its support in the preparation of this report. They would also like to thank participants of the workshops organized by the IRP in Paris (5-6 September 2012); Nairobi (8-9 November 2013); Jakarta (30 April–1 May 2014); and The Hague (17-18 September 2014) for the inputs provided during the preparation of this report.
The report went through a peer review process coordinated by Elias Ayuk with the support of the IRP Secretariat. The authors thank the anonymous peer reviewers for their constructive comments.
Special thanks go to Janez Potočnik and Ashok Khosla, Co-Chairs of the IRP during the preparation of this report, for their dedication and commitment, as well as to all members of the IRP and its Steering Committee for their constructive comments.
The Secretariat of the IRP coordinated the preparation of this report with the technical support of María José Baptista.
The main responsibility for errors remains with the authors.

Printed by: UNESCO
Design/layout: Marie Moncet, SOURIBLE
Cover photos@: 1. SvedOliver, Shutterstock.com; 2. littlesam, Shutterstock.com; 3. Panom, Shutterstock.com; 4. Arjen de Ruiter, Shutterstock.com; 5 gpointstudio, Shutterstock.com; 6 Nila Newsom, Shutterstock.com.

Graphics: Filip de Bois and Arie den Boer (PBL)

The full report should be referenced as follows
UNEP (2016) Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., Van Berkum, S., Özay, L., and Hajer M.

Job Number: DTI/1982/PA

ISBN: 978-92-807-3560-4

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Summary for Policymakers

FOOD SYSTEMS AND NATURAL RESOURCES

Produced by the International Resource Panel

This document highlights key findings from the report, and should be read in conjunction with the full report. References to research and reviews on which this report is based are listed in the full report.

The full report can be downloaded at http://www.unep.org/resourcepanel. If you are reading a hardcopy, the CD-Rom can be found in the back cover.

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Preface

Dr. Janez Potočnik Dr. Alicia Bárcena

Co-Chairs, International Resource Panel

We are what we eat, they say. Our existence and, therefore, any of the aspirations we might have as a society depend on the availability of, and access to, food. At the same time, our food depends directly on the state of our natural resources. The food we grow, harvest, trade, transport, store, sell and consume is therefore one of the essential connecting threads between people, their culture and wellbeing, and the health of our planet.

Concerns from population growth, climate change, changing patterns of resource consumption, food price volatility, and malnutrition, among others, have raised the profile of the food security debate within the international science and policy communities. Goal number 2 of the recently adopted Sustainable Development Goals, crystallizes the outcome of this debate and puts it at the top of policy agendas worldwide. It is well acknowledged that without eliminating hunger, achieving food security and improving health and nutrition of the world population, the 2030 Agenda for Sustainable Development cannot be effectively implemented.

Understanding the fundamental role of natural resources in the sound functioning of our global food systems is at the heart of this new report developed by the Food Systems Working Group of the International Resource Panel (IRP). With this report, the IRP is changing the conversation. We are no longer talking about the consequences of unsustainable agriculture and fisheries only. We are talking about the natural resource use and environmental impacts of all food related activities, their governance structures, socio-economic outcomes, and the complex interlinkages between all of these.

The report finds that many of our food systems are currently unsustainable from a natural resources perspective. The way in which these food systems currently operate are responsible for land degradation, depletion of fish stocks, nutrient losses, impacts on terrestrial and aquatic biodiversity, impacts on air, soil and water quality, and greenhouse gas emissions contributing to climate change. The expected population growth, expansion of cities, dietary shifts to unhealthy and unsustainable consumption will increase the pressures even more.

There are, however, significant opportunities to decouple food system activities from environmental degradation, specifically by both increasing efficiencies and improving the management of the natural resource base. Some options include increasing efficiencies of livestock feed (farmed animals consume around 35% of the total crop production), nutrients (the global average nutrient efficiency for nitrogen and phosphorus is only around 20%), genetics and water. New farming technologies (e.g. drip irrigation, 'low till and precision agriculture') and improved varieties (e.g. more resilient to water and heath stresses) have the potential to increase the efficiency at multiple levels (lower nitrogen losses, lower water use, and higher productivity), allowing to produce more food with less resources New farm- and decision-making related innovations (e.g. use of mobile technology to provide price and weather related information to farmers, remote sensing monitoring) can help reduce on-farm food loses and improve transparency in food markets thus reducing price volatility. More energy and water efficient food processing (e.g. dry extraction of plant-sourced protein) is also possible. A reduction in food loss and waste across food systems, and a levelling off of meat and dairy consumption in developed countries could reduce the global cereal demand by 15%; while the reduction by 50% of meat and dairy consumption in these countries could lead to up to 40% lower nutrient losses and greenhouse gas emissions.

The assessment shows that there is still much more to do if we want to identify effective points of intervention along the system. While there is a large amount of literature covering natural resource use and impacts from agriculture, there are still important data gaps on other food system activities, their outcomes and their connections (e.g. cultural and health dimensions). Defining the right framework is a necessary starting point.

We are very grateful to Maarten Hajer, John Ingram, Henk Westhoek, and the rest of the team for what we believe is a valuable contribution to advance systems thinking in a topic that requires the fullest attention. Their remarkable work gives us hope that with new practices and engaged actors, it is possible to feed the global population with sufficient nutritious food while nurturing our planet, to ensure continuity of supply for future generations.

Foreword

For thousands of years, nature has gracefully provided the necessary inputs to feed us, and we have in many occasions taken these precious gifts for granted. This report, "Food Systems and Natural Resources" developed by the International Resource Panel (IRP) is an effort to account for these inputs, looking at how we are using and managing them, the consequences of that management and the options to improve the efficiency with which they are managed.

The 2030 Agenda for Sustainable Development, a historic global commitment to a world free of poverty and hunger, will require science-based decisions that balance and integrate the social, environmental and economic pillars of sustainable development. In this report, the IRP proposes a new way of looking at food, one that moves from a compartmentalized vision to a more comprehensive, complex yet realistic approach. A 'food systems lens' goes beyond the classic production-centered discussions to connect all activities concerned with the food we eat (growing, harvesting, processing, packaging, transporting, marketing, consuming, and disposing of food and food-related items) and the various socio-economic and environmental outcomes of these activities.

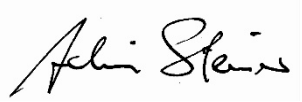
The authors provide solid evidence on the need to transition to more 'resource-smart food systems', an imperative for the achievement of at least 12 out of the 17 Sustainable Development Goals (SDGs).

Globally, food systems are responsible for 60% of global terrestrial biodiversity loss, around 24% of the global greenhouse gas emissions, 33% of degraded soils, the depletion of 61% of 'commercial' fish populations, and the overexploitation of 20% of the world's aquifers. These pressures on our natural resource base are expected to significantly increase with population, urbanization and supermarketization trends, as well as dietary shifts to more resource-intensive food. By 2050, an expected 40% of the world population will be living in severely water-stressed river basins and greenhouse gas emissions from agriculture may increase from 24% to 30%.

There are also a number of alarming disparities worldwide that reveal the impacts of current food systems on our health. Nearly 800 million people are hungry, over 2 billion suffer from micronutrient deficiencies, while over 2 billion people are obese. Ensuring access to nutritious food will often depend on the way markets function at the local, national, regional and global levels, on the social safety nets created for vulnerable groups of the population (e.g. smallholder farmers), and on their access to infrastructure, finance, knowledge and technology. In countries suffering from overconsumption, lifestyle choices and consumer information play a fundamental role.

The IRP tells us that combined action at different points of intervention and by a diversity of actors throughout the system could lead to resource efficiency gains of up to 30% for certain resources and impacts. Governments, private sector actors, civil society and consumers all have a critical role to play.

The International Resource Panel, under the leadership of the Co-Chairs Alicia Bárcena and Janez Potočnik, has produced a state of the art analysis which reveals some of the greatest complexities we are living with in the anthropocene. I wish to congratulate and thank the authors for this important piece of scientific literature, which sheds some light on the magnitude of challenges we must face and opportunities we must seize to ensure access by all people to safe, nutritious and sufficient food, all year round.



Achim Steiner
UN Under-Secretary-General
UNEP Executive Director

Key Messages

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1. Resource-Smart Food Systems are needed to achieve Sustainable Development

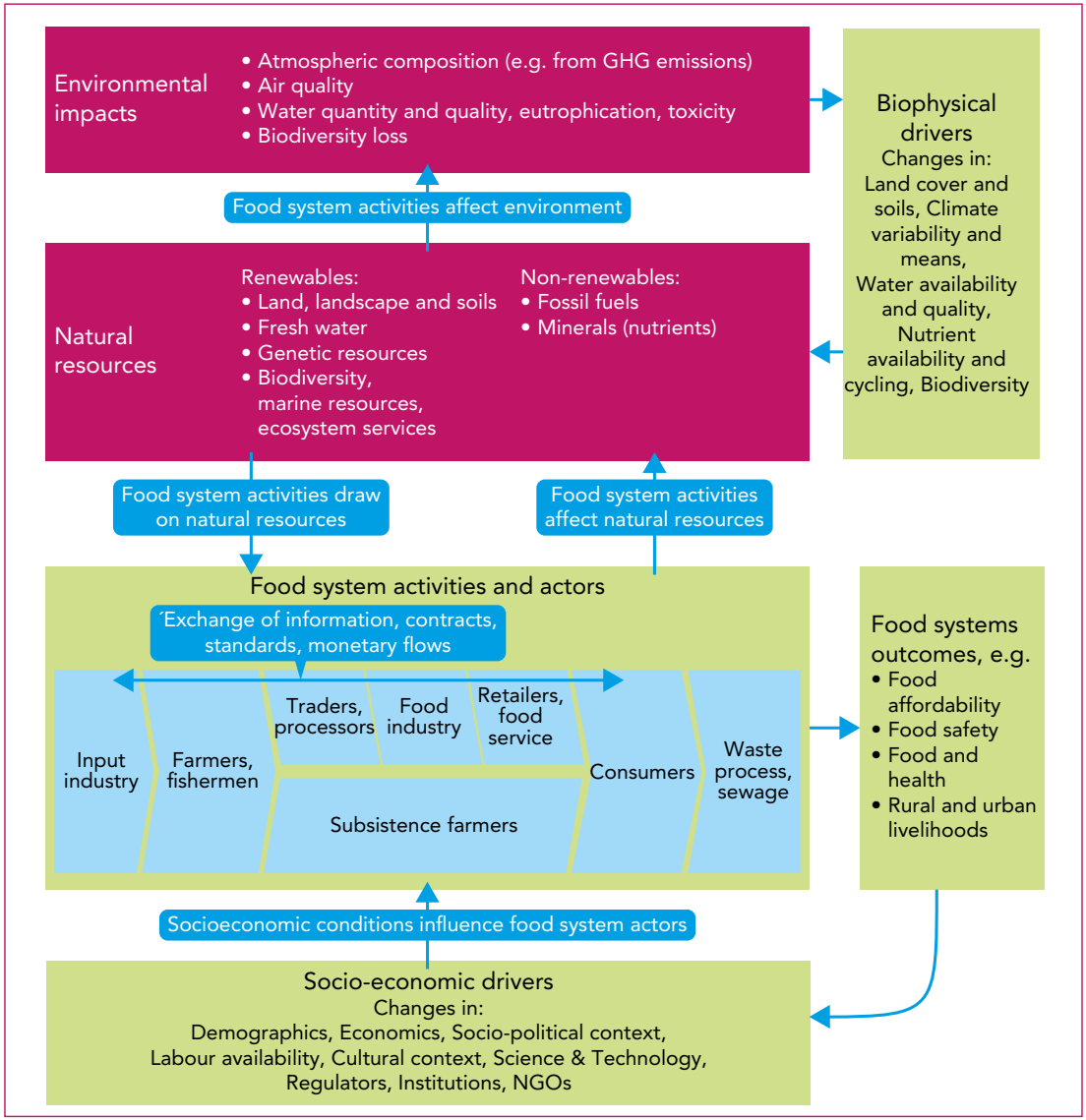
The sustainable and efficient management of natural resources is now an imperative for the achievement of all 17 United Nations Sustainable Development Goals (SDGs). Restoring and maintaining the health of the natural resource base is not only needed to adequately feed current and projected populations, but to provide a better quality of life in the years to come.

Food systems are at the heart of the 2030 Agenda for Sustainable Development, a historic global commitment to eradicate poverty and hunger while ensuring healthy, prosperous and fulfilling lives. **The food we grow, harvest, process, trade, transport, store sell and consume is the essential connecting thread between people, prosperity, and planet**.

Food systems crucially depend on natural resources: land, soil, water, terrestrial and marine biodiversity, minerals (essential nutrients for crops and animals) and fossil fuels. The use of these natural resources goes beyond primary food production, e.g. the use of fresh water for processing and biomass for packaging or cooking. So as to ensure all people have safe and nutritious food, in appropriate amounts, these natural resources need to be managed sustainably and used efficiently, thereby reducing environmental impacts. **We therefore need 'resource-smart' food systems to deliver on the Sustainable Development Goals.**

The food sector is globally the dominant user of a number of natural resources, particularly land, biodiversity, fresh water, nitrogen and phosphorus. While food production is a major driver of biodiversity loss, soil degradation, water depletion and greenhouse gas emissions, other food systems activities also contribute to environmental degradation through water use, pollution and energy use. Therefore, the people who directly or indirectly manage our food systems are also the largest group of natural resource managers in the world and could become critical agents of change in the transformation of current consumption and production systems.

Figure 1. Conceptual Framework of Food System Activities and Natural Resources



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2. What is a Food Systems Approach and Why is it Important?

A food systems approach "gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes". (HLPE, 2014a)

Many studies assess the impact of a given food system activity (e.g. producing or transporting food) on a given resource (e.g. land, water, minerals) or environmental outcome (e.g. GHG emissions). The food system concept provides a framework to integrate such studies to provide a more complete description of the 'food' two-way interaction with both natural resources and socio-economic conditions. Its main value is therefore in showing where the feedbacks to both socio-economic and environmental drivers lie, as these interactions are often the ultimate cause for further natural resource degradation. A thorough analysis of existing food systems can assist in identifying the most important issues regarding natural resources, as well as the opportunities for effective policy, fiscal, social and/or technical interventions.

Benefits of this approach include:

- **It considers opportunities within all food system activities** (such as farming, fishing, food processing, retailing and preparing) to attain more resource efficiency across the whole system. Reducing food losses and waste offers an especially important opportunity, and this has received more attention in recent years.
- **It considers the socio-economic consequences** of certain measures or choices, such as changes in demand or the effects of changes in trade regimes.
- **It addresses more directly the important food security issues** of both undernutrition and overconsumption. A production-oriented approach fails to take into account the serious health implications that arise from current food consumption patterns.
- **It considers changes such as "supermarketization",** a trend that is particularly seen in Asia and South America. This supermarketization not only affects the power relations in the food supply chain, but very often also affects eating habits and product sourcing. A rapid consolidation process has taken place both in the input and

the processing industries, resulting in dually structured food chains with a small number of companies dominating the market.

- **It looks at multiple objectives.** This approach can help identify and map multiple social, economic and environmental objectives (e.g. food security, poverty eradication, sustainable consumption and production) and the potential synergies and trade-offs between these.
- **It deals with complexity**. There are numerous food system 'actors' who undertake 'food system activities' and behave, act and influence each other in a certain way to attain their objectives. These are however no sets of linear acts and influences that follow each other in a predictable or sequential order. Food system actors decide and behave in response to what they perceive as incentives (opportunities, challenges and risks) and constraints (environmental, institutional and financial) in a particular context. These perceptions are continuously re-shaped by non-linear feedbacks that emerge from their interactions with other segments in the food system, but also from changes in the socio-economic context. The food systems approach deals with these complexities and enables the identification of the mix of factors that clarify food system actors responses and behaviours and particular outcomes.
- **It looks at solutions from a range of viewpoints.** It helps identify several points of intervention by different actors for the improvement of food system outcomes.
- **It looks at opportunities from a business viewpoint.** The food system 'lens' helps enterprises understand better where certain policy and/or technical interventions can have the best impact for their business, and also helps them to consider what might otherwise have been the unforeseen consequences of such interventions.

What are Resource-Smart Food Systems?

A 'Resource-Smart' or 'Environmentally-sustainable' food system is a food system in which the environmental bases to deliver food security for future generations is not compromised.

Three main principles must be followed to transition towards a resource-smart food system:

1. Sustainable use of renewable resources, implying no degradation or depletion of renewable resources, such as land and soils, water and biodiversity.
2. Efficient use of all resources.
3. Low environmental impacts from food system activities.

Resource-smart food systems are not only about sustainable and efficient food production; the key challenge is to be effective in terms of overall food security, livelihoods and human health while protecting essential natural resources.

Table 1. Principles and indicators for sustainable food systems from the natural resource perspective

	Principle of sustainable use	Indicator of efficient use In italics: ambition at food system level	Indicator of reduced environmental impacts
Renewable Resources			
Land, landscapes and soils	No or very limited land degradation (in all forms) / soil erosion, prevent contamination, maintenance of landscape diversity, aiming at sustained crop yields	Optimized crop yields, closing the 'yield gap' without increasing environmental impacts No further land needed in food systems	No / limited conversion of natural areas into agricultural land; maintenance of landscape diversity
Water	No depletion of groundwater / disturbance of water systems; prevent pollution / contamination	High water-use efficiency along food chain Low total amount of water needed in food systems	Limited changes in hydrological regimes
Biodiversity	Conservation - no degradation of biodiversity	Biodiversity maintained/enhanced	Reduced disturbance / extinction of species
Genetic resources	Conservation of genetic diversity for resilient food systems	Genetic potential of crops and farmed animals exploited, not only in terms of productivity but also in terms of robustness and nutritional quality	
Marine resources	Conservation / no depletion of fish stocks – no disturbance of marine environment	Avoidance of by-catch, proper use of by-catch	Limited disturbance of marine environment
Non-renewable Resources			
Minerals	-	High nutrient efficiency along the food chain Low total amount of 'new' minerals for food systems	Reduced pollution by minerals
Fossil fuel	-	High energy efficiency / renewable energy sources Low total amount of fossil fuels for food systems	Reduced burning fossil fuels / clean burning methods (GHG emissions, air pollution)
Use of agents / synthetic components	-	Minimized use	Reduced pollution and contamination (soil, air and water quality)

(1) The columns 'sustainable use' and 'efficient use' are not meant to indicate a contradiction; in most cases both are needed simultaneously.
(2) For reasons of simplicity, this is defined in physical terms. Farmers might be more interested in outputs related to revenue or employment.

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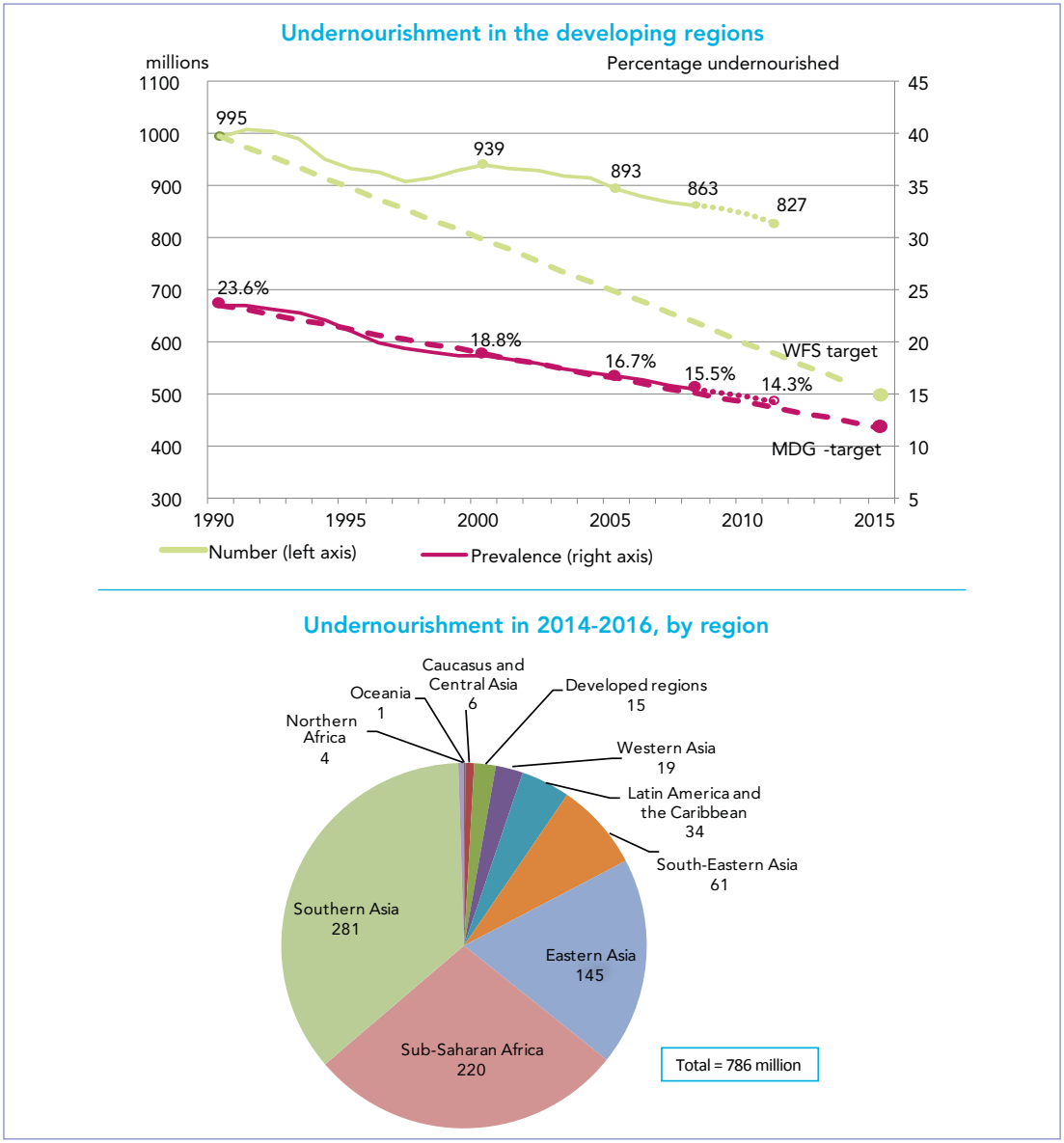
3. Food Security and Human Health both depend on our Natural Resource Base

Although much progress has been made in some aspects, **current food systems are not delivering food security and healthy food for everyone nor are they sustainably using the limited natural resource inputs** as explained above. Food production has more than doubled, diets have become more varied (and often more energy-intense) satisfying peoples' preferences in terms of form, taste and quality; numerous local, national and multi-national food-related enterprises have emerged providing livelihoods for millions. Nonetheless over 800 million people are hungry (Figure 2), over 2 billion suffer from micronutrient deficiencies, in particular vitamin A, iodine, iron and zinc, and over 2 billion people overweight or obese (Figure 3). This situation, and particularly the unhealthy overconsumption by an increasing number of people, is unsustainable and needs to change.

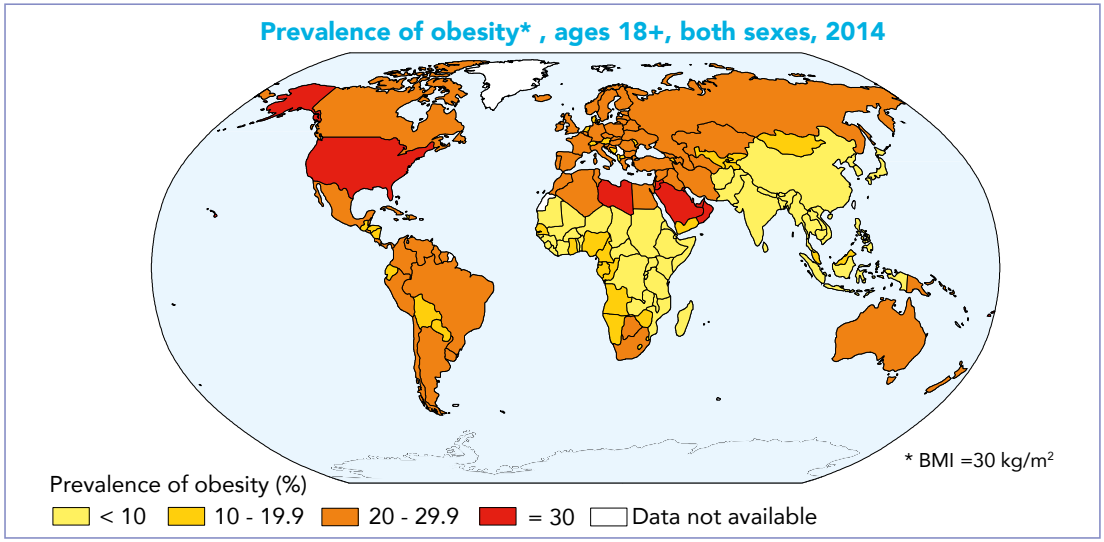
Nutrition is the cornerstone of sustainable development. To achieve the international targets set by the United Nations Secretary-General Zero Hunger Challenge and Sustainable Development Goal 2 we must re-think the way in which food system activities are structured and carried out. Ensuring access to nutritious food for all is at the core of this change and this will often depend on the way markets function at the local, national, regional and global levels, on the social safety nets created for vulnerable groups of the population (e.g. the urban poor and smallholder farmers), and on their access to infrastructure, finance, knowledge and technology. In societies suffering from overconsumption, lifestyle choices and consumer information play a fundamental role.

Figure 2. Prevalence of undernourishment



Source: (FAO, 2015)

Figure 3. Prevalence of obesity



Source: (WHO, 2014)

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4. Current Food Systems are Unsustainable and the Pressures on Natural Resources are expected to Increase

While there is still a considerable lack of reliable data on the current condition of natural resources related to food system activities, key statistics show the crucial role of these systems in the degradation or depletion of natural resources and provide evidence of unsustainable and/or inefficient practices at the global level:

- 33% of soils is moderately to highly degraded due to erosion, nutrient depletion, acidification, salinization, compaction and chemical pollution.
- 61% of 'commercial' fish populations are fully fished and 29% are fished at a biologically unsustainable level and therefore overfished.
- At least 20% of the world's aquifers are overexploited, including in important production areas such as the Upper Ganges (India) and California (US).
- 60% of global terrestrial biodiversity loss is related to food production, while ecosystem services supporting food production are often under pressure.
- Of the total input in the form of nitrogen- and phosphorus fertilizers, only 15-20% is actually embedded in the food that reaches the consumers' plates, implying very large nutrient losses to the environment. Some regions have lower efficiency and higher losses (North America, East Asia), while in Sub-Saharan Africa soil nutrient depletion (where extraction is higher than input) is common.
- Globally, food systems account for around 24% of the global greenhouse gas emissions.

Current food systems vary worldwide from 'modern' food systems in industrialized and emerging regions to more 'traditional' food systems in rural areas in developing countries. This variety in food systems, in combination with the social and natural environment in which they operate, has important implications on the possible pathways towards sustainable food systems and on the logic of intervention. In developing regions, there is a rapidly evolving

replacement of traditional food systems by modern food systems. This trend is driven by macro-trends such as urbanization, increased wealth and other socio-economic and demographic developments. These intertwined trends also imply changes in dietary patterns and 'supermarketization' in many parts of the world. These developments significantly increase the pressure on our natural resources.

The pressure on natural resources from food system activities will increase with the expected population growth (especially in Africa and Asia) coupled with dietary shifts towards more resource-intensive products (e.g. meat, dairy, fish, fruits, vegetables, processed food and drinks) associated with increased wealth; and climate change impacts on food production (Figure 4). This will also lead to higher environmental impacts due to food system activities (such as greenhouse gas emissions and nutrient leaching to ground and surface water). For example, due to the increased food demand, the cropland area is projected to grow by 10–15% up to 2050, mainly at the expense of ecologically vulnerable areas such as savannahs and forests. This increased pressure creates risks for future food production.

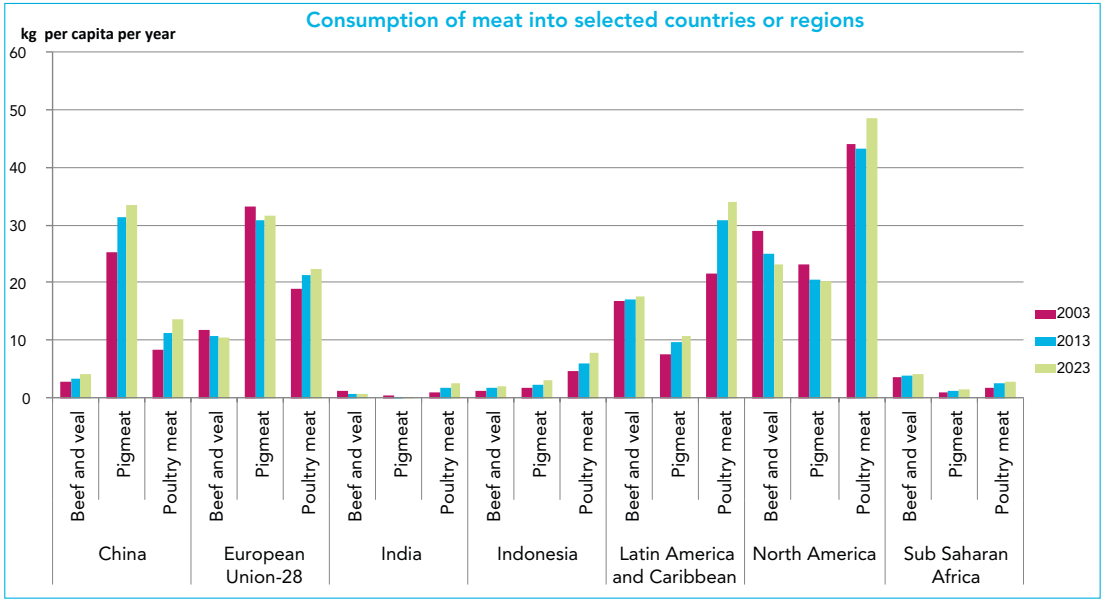
Given the limitations of a global approach, it is suggested that governments and other actors operating at a national level (or at city level) start with a comprehensive analysis of the national/regional food system. This can assist in the identification of the most significant pressures on natural resources from the system, their drivers and effective opportunities for intervention. The 'food production system' (including agriculture, fisheries and related food processing) generally does not geographically coincide with the

National and Local Food Systems

There are large regional differences in food systems, and hence the nature of their impacts on natural resources. In some regions, land degradation and biodiversity loss are the major issues, while in other regions high nutrient losses leading to declines in air and water quality are of greater concern. There are also large differences in terms of socio-economic characteristics, ranging from subsistence systems, to food systems in highly urbanized regions, with large players such as retailers and large food companies. In many cases, progress has been made over recent decades on various aspects of resource use in their food systems leading to, for example, higher crop yields (meaning more efficient use of agricultural land), increased nutrient- and water-use efficiency, improved water quality and lower greenhouse gas emissions. In other cases, such progress has been slower, or trade-offs have occurred, for example the focus on higher crop yields has led to water pollution by nutrients or pesticides or to soil degradation.

'food consumption system' and hence the importance of trade and transport infrastructure. The share of imported or exported food in the total food production and consumption does not only depend on the share of food that is produced at the given level, but also on the related socioeconomic and political contexts. The difference between nationally- (or locally-) produced food and imported food is relevant as national governments generally have more influence over national natural resources as needed to support the food system, then they have over those used to produce food elsewhere in the world. The growing urban populations are a special case as almost all of the food will come from outside the city's boundaries. In this case, a food systems approach is particularly useful.

Figure 4. Per capita consumption of meat in selected countries or regions (in 2003, 2013 and 2023)



Source: (OECD & FAO, 2014)

5. How to Decouple Food System Activities from Environmental Degradation?

5.1. Biophysical Options

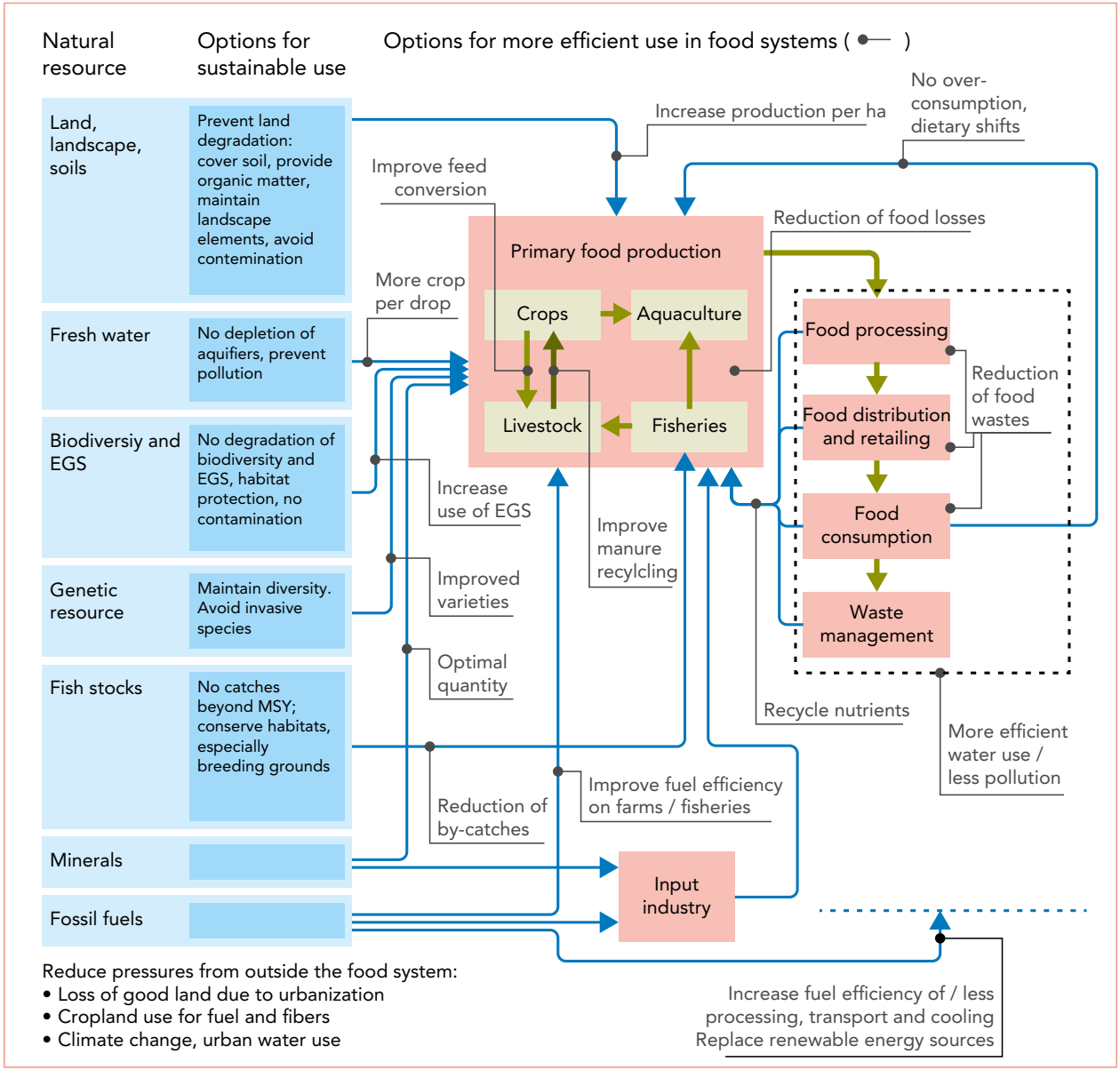
There are many opportunities to change the current trajectory through improved (more sustainable and efficient) management of natural resources. Although good integrated assessments of the combined potential of various options are lacking, findings from studies looking at individual options to increase resource efficiency indicate that these could lead to an estimated 5–20% improvement in efficiency; **when combined, the increase could be up to 20–30% for certain resources and impacts** assuming limited rebound effects.

Sustainable Management and Efficient Use of Natural Resources in Food Systems

Sustainable resource management is about preventing degradation of resources (land, sea, ecosystem services), by reducing overexploitation (for example through regulation, pricing strategies or resource valuation) and adopting effective management practices of landscape elements such as wooded areas, hedges and wetlands.

Increasing the **efficient use** of all resources in all food system activities will help move towards a more sustainable use of renewable resources (e.g. fresh water reserves), lower environmental impacts (e.g. eutrophication from nutrient run-off and lower greenhouse gas emissions) and a lower depletion rate of non-renewable resources (e.g. fossil fuels and minerals).

Figure 5. Options for sustainable and efficient use of natural resources and reduced environmental impacts in food systems



Options towards environmentally-sustainable food systems are very context and location dependent, but could include (Figure 5):

- 'Sustainable intensification' of crop production (e.g. higher yields without increasing environmental impacts).
- More effective use of ecosystems services (e.g. integrated pest management to reduce pesticide use).
- Better feed conversion (without reducing animal welfare) and higher productivity of pastoral systems.
- Higher nutrient efficiency along the food chain (e.g. better recycling of minerals in animal manure, use of by-products or food wastes as feed or compost, recycling of minerals from cities, etc.).
- More efficient aquaculture systems, with lower nutrient losses and less impact on coastal systems.
- More energy- and water-efficient food processing.
- Reduction of food losses in farms and fisheries, and reduction of food waste throughout food systems.
- Reduction of overconsumption and change of unhealthy dietary patterns (e.g. shift in affluent societies from animal-based to more plant-based diets).

For analytical purposes, the authors propose four main option categories: options to reach a sustainable use of natural resources, options to increase resource efficiency in primary food production, options along the supply chain to increase resource efficiency (including recycling) and options outside the food system. A number of possible measures within each one of these categories are presented in the figure above.

5.2. Institutional Pathways

By using the food system lens, effective interventions can be identified towards sustainable food systems. These actions can be initiated by various actors from governments, companies and civil society. **Governments** have an important task in setting the institutional and regulatory framework. A good starting point is an analysis of the current food system and its implications for natural resources. Especially in developing countries, poor tenure rights (of land and water) and access to natural capital, coupled with weak regulation, poor levels of education and limited access to input and output markets do not encourage sustainable resource use. The environmental costs (externalities) of the food system are hardly included in food prices.

The pricing of environmental externalities, reinforcement of legislation to prevent pollution and other forms of environmental degradation, and the removal of harmful subsidies (e.g. fossil fuels) could provide important incentives to improve resource efficiency. Governments play an important role in education, which is relevant both for food producers, as well as for food consumers. Children need to be taught how to prepare food from basic ingredients, and need to be aware of its nutritional aspects.

In all countries there is currently a large number of laws, financial and other regulations that are influencing directly or indirectly food systems and the use of natural resources. These can be policies at the international level (e.g. trade regulations), at the national level, but also at the local level (e.g. local farming extension services, location of restaurants, urban waste management, etc.). Aligning these policies in such a way that these better contribute to sustainable food systems is thus an important mission for authorities at various levels of government. Governments have also a role in stimulating and facilitating innovations, new initiatives, collaboration and cooperation along the system. In general, special attention is needed for the role of women, as they are usually critical participants in food production and main managers of food consumption in their households.

A number of concrete actions that governments could implement are:

1. Removal of subsidies that encourage unsustainable production or practices (e.g. fossil fuel subsidies).
2. Creation of adequate legal frameworks to secure property rights and land tenure and regulate access to and use of water, biodiversity, and ecosystems services.
3. Creation of adequate legal frameworks to regulate environmental impacts from food systems (e.g. regulation to prevent nutrient losses at all stages, but easpecially in the livestock sector).
4. Investment in management practices and research development to enable a more effective use of biodiversity and ecosystem services in food production.
5. Investment in technology and research development for locally suitable seeds and breeds (with proper infrastructure, distribution system, quality assurance and certification schemes).
6. Creation of incentives for local or regional sourcing and investment in sustainable local supply chains.
7. Attraction of investments in rural infrastructure, small enterprise development (e.g. inputs, local storage and processing facilities, logistic and transport).
8. Facilitation of collaborative schemes between different food system actors (e.g. cooperation agreements among retailers to establish marketing codes of conduct).

9. Creation of incentives for cities to become innovation incubators where ideas on sustainable food systems are tested (urban farming, education campaigns, sustainable sourcing, food environment regulations, etc.).
10. Adoption of consumption-oriented policies (e.g. to promote consumption behaviour research, stricter marketing rules for unhealthy food, create a food environment which stimulates healthy and sustainable diets).
11. Creation of adequate monitoring systems of the status of the natural resources needed in food systems, as well as their environmental impacts;
12. Creation of education programmes on the links between natural resources, consumption patterns and health.

The global community has called upon all businesses "*to apply their creativity and innovation to solving sustainable development*". **Private actors** are crucially important players in food systems, as food systems are in effect a collation of enterprises. The current business logic of many food systems does not always give actors the right incentives to promote more sustainable practices. However, many companies are increasingly seeing it in their long term interest to invest in more sustainable supply chains. Private companies could undertake actions such as paying farmers and fishermen for better management of natural resources, helping smallholder farms and small agri-food businesses in developing countries invest in more sustainable activities including improving water and energy use-efficiency in food storage and processing, and in other post-farm-gate activities. Private actors have a key role in reducing food waste, especially in modern food systems, as well as in making healthy and sustainable food choices easier for consumers.

In many developing countries, smallholder farmers are not connected to modern food value chains that largely target urban consumers or export markets. Actors as retailers and food companies could invest in local supply chains, while assisting farmers to increase production in a sustainable way.

In affluent sections of society – both in 'developing' or 'developed' regions – the high consumption of animal based products, as well as of ultra-processed food (often containing 'empty calories') brings disproportionate environmental costs, and moreover undermines public health due to obesity-related diseases. This high consumption is partly driven by food companies influencing demand towards products with attractive profit margins.

Finally, actors from **civil society** can stimulate governments and private actors to take action, either in the form of constructive dialogue or by awareness raising and campaigning. They also can stimulate certain niche players, and thus challenge incumbent actors to act more swiftly.

Draft framework for analyzing national food systems, with focus on national resources

On the present prevailing food systems

1. What is the prevalent type of food system? Who are the principal actors? What is the relation between national food production and food consumption?
2. How is food production (farming, fishing) organized? What farms and fishery types are dominant? What is the size and nature of livestock and aquaculture production?
3. Where is primary and secondary processing done and by whom?
4. Where is food being transported from and how?
5. How is food consumption being organized? What is the share of supermarkets and out-of-home consumption in total expenditures?

On natural resources

1. What is the nature and extent of land use: is there expansion or contraction of the agricultural area? What is the situation regarding land degradation? How are crop yields compared to similar regions / potentially attainable yields? How is pasture land being used?
2. How are fisheries managed? What is the status of fish stocks? Is there aquaculture, and what are the related environmental impacts?
3. What is the situation regarding plant and animal breeds: availability, diversity, quality, genetic potential?
4. What is the nutrient use efficiency, amount of nutrients (minerals) being used, nutrient losses?
5. Is water being used sustainably and efficiently in irrigation and food processing? Are groundwater levels being monitored? Is there potential for expansion of irrigated area?
6. What are the amounts and proportions of fossil and biomass fuel used in which food system activities?
7. What are the overall environmental impacts: GHG emissions, nutrient losses, pesticide emissions, soil and water quality?
8. How are property rights and land tenure organized?

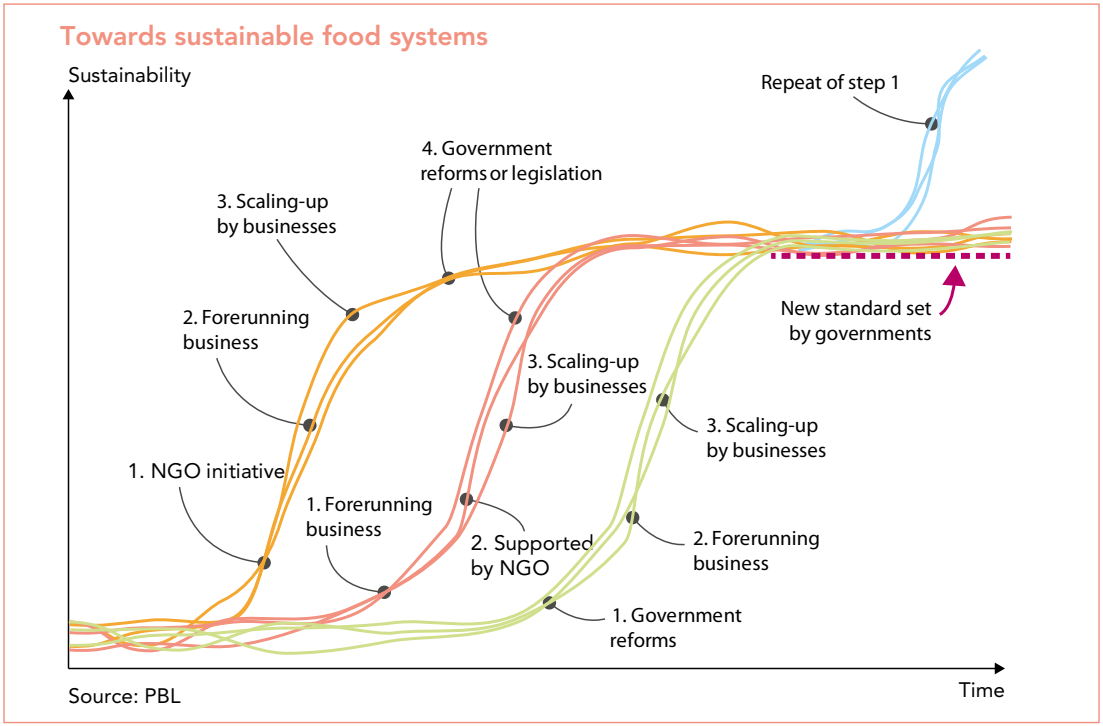
With respect to food demand

1. What is the food security situation (stability of food availability, food access, food utilization)?
2. What is the nutritional security situation (prevalence of undernutrition, overnutrition, other forms of malnutrition? What is the trend in diets over the last 10 – 20 years? What are the expectations for the future? What is the share of livestock products in diets?
3. How much fossil fuels and packaging are used in food consumption?
4. How much food waste occurs? What is happening to food waste, food residues and human excreta?
5. What is the fate of nutrients entering urban food systems?

With respect to actors, institutions, regulation

1. What kinds of regulation are in place to regulate food system activities, and the use of and access to natural resources?
2. What kinds of environmental regulation are in place? How are they implemented and enforced?
3. Which subsidies are installed? What is the tax regime? Are there import and export tariffs?

Figure 6. Spiral movements created by the co-evolution of different pathways



(1) Small actions and innovations are gradually taken over by frontrunners (private actors), governments respond by institutional arrangements to enable scaling up, until the practice is applied by 80–90% of the industry.

Twelve critical shifts towards Resource-Smart Food Systems

1. **Reduce** food loss and waste.
2. **Reorient** away from resource-intensive products such as meat, 'empty calories' and ultra-processed food; and *rethink* the 'food environment' (the physical and social surroundings that influence what people eat, especially relevant in urban areas) to facilitate consumers adopting more healthy and sustainable diets.
3. **Reframe** thinking by promoting 'resource-smart food systems' in which 'Climate-Smart Agriculture' (CSA) plays one part, and search for linkages to new dominant values such as 'wellbeing' and 'health'.
4. **Reconnect** rural and urban, especially in developing regions, where urban actors (e.g. supermarkets) could invest in regional supply chains and improve the position of smallholders.
5. **Revalue** the pricing of environmental externalities, *reinforce* legislation to prevent pollution and other forms of environmental degradation and *remove* subsidies that provide disincentives for better resource efficiency.
6. **Reconnect** urban consumers with how their food is produced and how it reaches their plates, and inform them about both the health and environmental consequences of dietary choices, protect peri-urban zones around cities and use them for local food production.
7. **Research** the current functioning of the local, national or regional food systems and their impact on national resources.
8. **Reconnect** mineral flows between urban areas and rural areas, as well as between crop and livestock production.
9. **Reform** policies on land and water rights, *develop and implement* policies at all levels of governments (multilateral, national and local) to enable better resource management and encourage synergistic 'adaptive governance' by the wide range of non-state actors (i.e. businesses and civil society) within the food system.
10. **Reinvigorate** investment in rural infrastructure, education, training, technology, knowledge transfer and payments of environmental services.
11. **Research and innovate,** to decouple food production from resource use and environmental impacts, and to replace certain inputs (such as pesticides) with ecosystem services.
12. **Rebuild** feedback loops by functional and informative monitoring and reporting, at various levels, such as countries, cities and companies.

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Global food systems have radically changed over the last 50 years. Food production has more than doubled, diets have become more varied (and often more energy-intense) satisfying people's preferences in terms of form, taste and quality, and numerous local, national and multi-national food-related enterprises have emerged providing livelihoods for millions. Nonetheless, over 800 million people are still hungry (70% of which live in rural areas in developing countries), about two billion suffer from poor nutrition, and over two billion are overweight or obese.

The resource use implications and environmental impacts of these food systems are significant. In general, of all economic activities, the food sector has by far the largest impact on natural resource use as well as on the environment. An estimated 60% of global terrestrial biodiversity loss is related to food production; food systems account for around 24% of the global greenhouse gas emissions and an estimated 33% of soils are moderately to highly degraded due to erosion, nutrient depletion, acidification, salinization, compaction and chemical pollution.

This report looks at food as a crucial connection point (a 'node') where various societal issues coincide, such as human dependence on natural resources, the environment, health and wellbeing. Rather than looking separately at resources such as land, water and minerals, the International Resource Panel (IRP) has chosen a systems approach. The report looks at all the resources needed for the primary production of food, as well as for other food system activities (e.g. processing, distribution) considering not only the set of activities, but also the range of actors engaged in them and the outcomes in terms of food security, livelihoods and human health.

The IRP assesses the current status and dynamics of natural resource use in food systems and their environmental impacts and identifies opportunities for resource efficiency improvements in global food systems, responding to policy-relevant questions like *what do sustainable food systems look like from a natural resource perspective? How can resource efficiency improvements be made to enhance food security? How to steer transition towards sustainable food systems?*

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Job Number: DTI/1982/PA

ISBN: 978-92-807-3560-4