Food and Agriculture Organization of the United Nations

Knowledge and Information for Sustainable Food Systems

A Workshop of the FAO/UNEP Programme on Sustainable Food Systems

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10–11 September 2014

FAO headquarters, Rome

Edited by

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and
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The joint FAO/UNEP Workshop on Knowledge and Information for Sustainable Food Systems, organized by the Sustainable Food Systems Programme and held on 10–11 September 2014 at FAO headquarters in Rome, Italy.

We would like to extend our special thanks to all the participants for their contributions and papers. Our appreciation is also expressed to the organizers of this Workshop – Alexandre Meybeck, Suzanne Redfern and Sandro Dernini. In addition, we would also like to thank Ren Wang, Assistant Director-General. We are particularly grateful to the Swiss Federal Office of Agriculture for their generous support in the preparation of this document.

Agenda

The FAO-UNEP programme on sustainable food systems, supported by the Agri-food Task Force on Sustainable Consumption and Production (SCP), is catalysing partnerships among United Nations agencies, other international agencies, governments, industry and civil society whose activities, together, can promote the necessary transition to sustainability. It has vocation to be integrated within the 10-Year Framework of Programmes on Sustainable Consumption and Production (10YFP-SCP), adopted at the Rio+20 Conference. This multistakeholder mechanism will aim at building capacity for the uptake of more sustainable consumption and production practices across food systems bringing together existing initiatives and developing new partnerships to build synergies and cooperation towards mutual objectives.

In 2013 the FAO/UNEP programme organized a first workshop on "Voluntary Standards for Sustainable Food Systems: Challenges and Opportunities".[1] The roles of public and private actors in the development, implementation, evaluation and promotion of voluntary standards were discussed. The conclusions noted that voluntary standards are key tools to share information with consumers in order to better enable them to drive production by their consumption choices. In turn it requires appropriate mechanisms to gather, transmit and share knowledge along food chains.

A second workshop on Knowledge and Information for Sustainable Food Systems will be organized on 10–11 September 2014, at FAO headquarters, Rome.

Improving knowledge collection and sharing is a key area of work to progress towards more sustainable food systems (SFS), taking into consideration the environmental, economic and social dimensions, and the need to ensure food security and nutrition for all without compromising these for future generations. The Task Force members have emphasized the need to better identify the requirements and perspectives of the various types of actors, in terms of data and means to access them, to identify and assess existing data and gaps, and to identify and assess existing knowledge-sharing tools and mechanisms. They also underlined the need for indicators to measure all impacts of food production and consumption, otherwise there is a risk of prioritizing the most easily measurable and perhaps least appropriate indicators. To be better integrated in decision-making, such indicators should link and integrate inputs and impacts with processes and outputs.

The workshop will contribute to provide perspectives on knowledge and knowledge needs for SFS, including information platforms, identification of gaps and needs, guidelines for comparing and gathering data, tools for consumer information and education, initiation of regional and national groups, and principles for credible standards, tools and incentives.

[1] http://www.fao.org/docrep/019/i3421e/i3421e.pdf

The workshop will aim to answer four crucial questions: 1) what are the knowledge needs; 2) what are the tools available; 3) what data are available; and 4) what do we need to do? The outcomes of the workshop will contribute to the finalization of the new 10YFP-SCP, which will be presented to the 10YFP Board for its approval.

Wednesday, 10 September 2014

09.30 – 9.45	Opening remarks FAO: Ren Wang, Assistant Director-General, Agriculture and Consumer Protection Department
09.45 – 11.05	SESSION 1: GLOBAL KNOWLEDGE NEEDS Chair: Patrick Mink, Federal Office for Agriculture, Switzerland
09.45 – 10.00	Feeding Knowledge Programme – the International Scientific Network on Food Security (EXPO MILAN 2015) (Damiano Petruzzella, CIHEAM-Bari)
10.00 – 10.15	FAO's common vision, principles and approach for the transition towards sustainable food and agriculture (Jean Marc Faurès, FAO, Land and Water Division)
10.15 – 10.30	Knowledge on systemic issues for multistakeholder processes: the experience of the High Level Panel of Experts on food security and nutrition (HLPE) (Vincent Gitz, Coordinator HLPE)
10.30 – 10.45	Academic partnerships for sustainable food systems (Kakoli Ghosh, FAO, Partnership Unit)
10.45 – 11.05	Discussion
11.05 – 11.20	Coffee break
11.20 – 12.40	SESSION 2: KNOWLEDGE FOR ACTORS Chair: Unati Speirs, Department of Trade and industry, South Africa
11.20 – 11.35	Sustainable solutions for tropical agriculture – Brazilian experiences (Sávio José B. Mendonça, Embrapa's management team, Brazil)
11.35 – 11.50	Accounting for water in agriculture in the context of sustainable food production under growing water scarcity (Filiberto Altobelli, INEA -National Institute of Agricultural Economics)
11.50 – 12.05	Addressing nutrient management performance (Christian Pallière, International Fertilizer Industry Association - IFA)
12.05 – 12.20	Sustainable food systems: the social dimension and gender implications (Ilaria Sisto, and Gina Seilern, FAO, Social Protection Division)
12.20 – 12.40	Discussion
12.40 – 13.40	Lunch

13.40 – 14.45	SESSION 3: INCENTIVE TOOLS AND INFORMATION NEEDS Chair: Imke Haenen, Ministry of Infrastructure and the Environment, Netherlands
13.40 – 13.55	Overview of the development of voluntary standards in USA (Elise Golan, Office of the Chief Economist, US Department of Agriculture)
13.55 – 14.10	National Plan of Sustainable and Healthy Gastronomy, Costa Rica (Roberto Azofeifa, Ministry of Agriculture, Costa Rica)
14.10 – 14.25	Knowledge and information for sustainable food systems – incentives for ecosystem services (IES) in agriculture (Bernardete Neves, FAO, Land and Water Division)
14.25 – 14.45	Discussion
14.45 – 15.50	SESSION 4: LIFE CYCLE ANALYSIS Chair: James Lomax, United Nations Environment Programme
14.45 – 15.00	LCA in the agri-food sector (Paolo Masoni, SETAC/ENEA)
15.00 – 15.15	Towards a framework for sustainability life cycle analysis: a case of the livestock sector (Carolyn Opio, FAO, Climate, Energy and Tenure Division)
15.15 – 15.30	The ENVIFOOD Protocol: facilitating consumer choice for greener products (Herbert Aichinger, Food SCP Round Table/European Commission)
15.30 – 15.50	Discussion
15.50 – 16.05	Coffee break
16.05 – 17.10	SESSION 5: FOOD LOSSES AND WASTE Chair: Florence Agyei, Environmental Protection Agency, Ghana
16.05 – 16.20	Food losses and wastage: scenario of India (Krishna Kumar Singh, Indian Council of Agricultural Research, New Delhi, India)
16.20 – 16.35	Food recovery and redistribution: identification and monitoring of (i) societal needs, (ii) institutional frameworks, and (iii) options for operational implementation (Camelia Bucatariu, FAO, Rural Infrastructure and Agro-Industries Division)
16.35 – 16.50	Food losses: a methodology for appraisal (Robert VanOtterdijk, FAO, Rural Infrastructure and Agro-Industries Division)
16.50 – 17.10	Discussion

17.10 – 18.00	SESSION 6: FOOD CHAIN APPROACHES Chair: Roberto Azofeifa, Ministry of Agriculture and Livestock, Costa Rica
17.10 – 17.25	Knowledge management for sustainable food value chain development (David Neven, FAO, Rural Infrastructure and Agro-Industries Division)
17.25 – 17.40	Implementing ecodesign in the R&D organization at Nestlé (Urs Schenker, Nestlé)
17.40 – 18.00	Discussion

Thursday, 11 September 2014

09.30 – 10.20	SESSION 7: GLOBAL ASSESSMENT TOOLS Chair: Elise Golan, US Department of Agriculture, USA
09.30 – 9.45	SAFA - The SAFA Database and SAFA Small APP for sharing knowledge, benchmarking performance and facilitating capacity-building (Nadia El-Hage Scialabba, FAO, Climate, Energy and Tenure Division)
09.45 – 10.00	Connecting the dots: incentives and challenges to use food safety and sustainability information on farm level in the entire supply chain – learnings from GLOBALG.A.P. (Kristian Moeller, GlobalG.A.P.)
10.00 – 10.15	How to assess the sustainability of diets. The example of the Mediterranean diet (Sandro Dernini, FAO, Sustainable Food Systems Programme)
10.15 – 10.35	Discussion
10.35 – 10.50	Coffee break
10.50 – 13.00	SESSION 8: WAY FORWARD Chair: Emalene Marcus-Burnett, Permanent Mission of Barbados, Switzerland
10.50 – 11.05	Using national dialogue for understanding knowledge and data gaps for transitioning to more sustainable food systems – an African perspective (James Lomax, UNEP & Unati Speirs, Agro-Processing, Department of Trade & Industry, South Africa)
11.05 – 11.20	The role of knowledge in transitions to sustainable food systems (Allison Loconto, FAO, Rural Infrastructure and Agro-Industries Division)
11.20 – 13.00	Wrap up and Conclusions

Summary report and main conclusions

The various sessions of the workshop considered knowledge for sustainable food systems from various perspectives in order to better understand gaps and needs of various categories of actors.

The first session considered global knowledge needs about sustainable food systems. The Feeding Knowledge Programme, targeting the Mediterranean region, has produced five white papers that will be presented at EXPO Milan 2015. The common vision for the transition towards sustainable food and agriculture has been developed by FAO to ground its action to increase and improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner. The work of the High Level Panel of Experts on food security and nutrition (HLPE) enables a better understanding of the relationships between food security and nutrition (FSN) and sustainable food systems and how various issues affect both of them. It also provides a very good model of science–policy interface on systemic issues with useful insight on how knowledge can be brought to and used by stakeholders and decision-makers. Finally, the potential for partnerships with academic institutions was highlighted as a way to enhance knowledge and bring results. The discussion recognized the importance of a systemic approach with broad perspectives. It emphasized the need to make information available to governments and also to local communities, in a useful/usable way. Establishing dialogue at national level can play a major role, including through national round tables. Participants also highlighted the need to inform and engage farmers as well as consumers and to develop appropriate tools and ways to bridge gaps. Among these could be education, at all levels, including in universities.

The second session examined some specific knowledge needs and how to address them. The Brazilian experience provides examples of programmes addressed to farmers such as INOVAGRO to adapt production systems for good agricultural practices. There are numerous methods and tools for water accounting from the field to the broader scale, each focusing on specific categories of actors. Key issues here are how the various methodologies relate to each other and also how to gather and make available the data needed to make them useful for each actor. As shown by the example of nutrient management, tools need to be adapted to specific actors and take into account their own main concerns and objectives. Gender equity is a key issue for any action oriented towards improving sustainability of food systems, both as an objective and a means of action given the role of women in all food-related areas. To mainstream it requires appropriate tools as well as gender disaggregated data. The discussion insisted on the importance of gender equity. It also pointed to the need for indicators of environmental impact, such as the water footprint, to better reflect local specific situations.

Session 3 considered some incentive mechanisms and tools in order to better understand their needs in terms of knowledge and information. The experience in the United States of

America about labelling show some of the difficulties that it entails, including proliferation of labels, difficulty in informing consumers and getting them to read the labels, etc. Costa Rica is launching an innovative programme using gastronomy to valorize and promote native foods and plants. The project on incentives for ecosystem services developed by FAO, with the support of the Government of Switzerland, aims to provide actors with analysis and knowledge to facilitate decision-making. The discussion covered various types of incentives and regulatory mechanisms, including bans and taxes as well as regulation of voluntary standards. It also raised the issue of the additional costs induced both by the change of practice and labelling, for instance, and of who should pay ecosystem services – consumers or citizens through taxes. Information and education can also play an important role, for instance to raise awareness on the importance of edible plants, and make them better known, through publications, workshops and training programmes.

Session 4 focused on the use of life cycle analysis (LCA) for food products. LCA is a very powerful tool to assess and compare production processes initially developed to identify hotspots in order to enable internal improvement and is increasingly used to communicate information to external users. Application of LCA to agriculture is particularly challenging and complex. LCA is very expensive and very data-intensive and time-consuming. The data that are available are derived from many initiatives and there is a need to make them comparable. FAO has developed GLEAM, the Global Livestock Environmental Assessment Model, to apply life cycle analysis to the livestock sector. The ENVIFOOD protocol, developed by the European Food Sustainable Consumption Round Table, a multistakeholder initiative, aims to provide guidance for methodologies to assess sustainability of food products, with the objective to facilitate the use of the information by consumers. The discussion emphasized the importance of a food chain approach as well as the need to have reliable figures, especially as they are increasingly used to rank foods. This raises a lot of complex issues: for agricultural products, LCA results vary from farm to farm, and can vary from year to year (depending in particular on yields). It is an expensive methodology and cannot be conducted on all farms, nor repeatedly. Therefore the number used has often been calculated in very different situations and generally cannot account for improvements realized over time. These limits require more work on the comparability of methodologies and data. They also invite being careful in the use of the results, particularly in their comparison.

Session 5 considered various approaches to food losses and waste. The first presentation presented results of quantification of food waste during festive events in India, particularly during weddings and potential remediation actions. The second presented the results of a survey conducted in 2014 on food banks and redistribution of food. It noted that there is a need to develop a knowledge base, and have multistakeholder platforms. The next presentation, highlighting that there is a important knowledge gap on FLW, looked at the methodologies to measure food losses and waste, including case studies undertaken by FAO, the FAO work on the global food loss index, as well as the work conducted with various partners on the global food losses and waste measurement protocol. The discussion emphasized the need to avoid duplication of efforts and to strengthen synergies between the various initiatives. It also highlighted some specific knowledge needs, such as the

impact (positive or negative) of trade on FLW and the potential environmental impacts of some actions designed to reduce FLW.

Session 6 covered several food chain approaches. It included a presentation on the concept of sustainable food value chains and on the knowledge platform recently launched by FAO. Nestlé presented ecodesign tools, such as EcodEx, aiming to facilitate the development of products that are more environmentally friendly, using LCA to assess the environmental impact on food products. The discussion covered issues of recycling nutrients, looked at how the ECODEX tool was implemented and the steps that could be taken to upscale its use. It also noted the need to assess exactly what is being done in order to increase knowledge and maintain consumers' interest and loyalty.

Session 7 was devoted to some global approaches/tools for assessing sustainability from different perspectives along the value chain. The first presentation described the SAFA approach and presented its new developments such as the SAFA Small App, designed to address specifically the needs of smallholders. The presentation on GlobalG.A.P. focused on its objective to make on-farm food safety and sustainability information available along the supply chain, and on potential actions to improve quality and transmission of information. It was followed by a presentation focusing on how to assess the sustainability of diets, using the Mediterranean diet as a case study. The discussion covered the aim of GlobalG.A.P to reduce duplication and harmonize existing information as well as how to combine an LCA approach with the SAFA tool framework.

Session 8 considered means to build a way forward for better knowledge and information for sustainable food systems. The first presentation discussed the lessons drawn from the experience of three national round tables organized in Africa and how national dialogue can enable the identification of knowledge needs of various actors as well as data gaps. The second presentation analysed the role of knowledge in transitions to sustainable food systems in various situations showing the role of institutional innovations.

MAIN CONCLUSIONS

Improving knowledge collection and sharing is central to progress towards more sustainable food systems. A preliminary analysis enables to characterize knowledge needs for SFS and ways to address them. The instruments and mechanisms to be put in place need to be actor centred, adapted to situations and provide for exchange of information between categories of actors including, as appropriate, methodologies to adapt the information to their various needs. These conclusions can be of use to orient and ground the future 10YFP program, both in terms of substance, and of modalities of work. They also show the need for a thorough screening of existing information, methodologies and data, building upon partnerships with research and actors networks and to develop appropriate information sharing mechanisms.

Opening remarks

Ren Wang
Assistant Director-General
Agriculture and Consumer Protection Department, FAO, Rome

Dear delegates,
Dear colleagues,
Visitors from UNEP,

Welcome in FAO for this second workshop of the FAO/UNEP Sustainable Food Systems programme.

I know you have a heavy agenda today and tomorrow, so I will be brief. I just want to make a few points.

As you know, the initial proposal for a 10YFP programme on sustainable consumption and production of food was approved in April by the board of the 10YFP. And I want to take this opportunity to thank the countries that have officially supported this proposal: Costa Rica, South Africa, Switzerland and the United States of America. Special thanks go to Switzerland, which has supported this programme since its inception in 2011. I also want to thank all of you and all those who supported and contributed to the success of this programme so far.

This workshop is particularly important for three reasons.

First of all because of the importance of the topic itself. As a scientist by training, with my experience in international agricultural research in the CGIAR system and also, and maybe even more importantly, as head of extension services in China, I have witnessed how knowledge, the way it is constructed, organized and shared, is key to any type of transformation of agricultural and food systems.

Second, because it had been identified by the Task Force as a key issue in each of your four activity areas.

Third, because it has been given even more prominence in the 10YFP itself, as approved in Rio+20. And so this workshop, ahead of the meeting of the Task Force itself, will also be useful to finalize the programme to be included in the 10YFP.

The agenda of this workshop is a good image of the challenges that the programme has to address:

- multiplicity of issues;
- multiplicity of actors;
- multiplicity of initiatives.

How to address a multiplicity of issues? How to address multiple needs of actors? While avoiding duplicating existing initiatives? Questions I hope we will be discussing over the next two days.

To a certain extent, such workshops, where multiple actors and initiatives bring their own perspectives, concerns and findings, is also the image of a way forward for the programme. The national round tables initiated in South Africa, Ghana and a few weeks ago in Mozambique are another image of it.

Last year, your first workshop was about voluntary standards for sustainability. A topic of key interest to your work, as it links, or rather, as you have shown last year, can link, sustainable consumption and sustainable production. The presentations made last year, your discussions and conclusions have been instrumental in preparing the discussions in the Committee on Agriculture that will take place at the end of the month this year.

This is in itself a considerable achievement. It shows how such a programme can be stimulating to gather knowledge in FAO and with our partners, from various perspectives, projects and initiatives to contribute to the debates. It shows how your contributions, presentations and interventions can help move forward. Understanding the needs and concerns of countries and actors and how to address them is absolutely essential to make our own work, in FAO, more effective on the ground.

I sincerely hope you have a productive discussion and a productive meeting.

Feeding Knowledge Programme – International network on research and innovation for food security

Damiano Petruzzella
Feeding Knowledge Programme, CIHEAM-Bari

ABSTRACT

The Feeding Knowledge (FK) Programme has been developed by **CIHEAM-MAIB**, in cooperation with the **Politecnico of Milan**, in the frame of the **2015 Milan Universal Exposition**, the theme of which is: Feeding the Planet, Energy for Life. **FK will be part of the intangible legacy of Expo Milan 2015**.

The FK) Programme has been built on the idea that **knowledge development and sharing** are the main tools to identify concrete solutions for food security that really meet the needs of developing countries. The Programme is thus based on the idea that to achieve sustainable development **everyone on the planet should have access to healthy, safe and sufficient food**.

INTRODUCTION

The Feeding Knowledge (FK) Programme has been developed by **CIHEAM-MAIB** in cooperation with the **Politecnico of Milan**, in the frame of the **2015 Milan Universal Exposition**, whose claim is Feeding the Planet, Energy for Life. Feeding Knowledge is a strategic initiative of Expo Milano 2015 and will contribute to building up the **intangible legacy** of the Universal Exposition, hosted by the city of Milan from May to October 2015.

Expo Milano is a non-commercial universal exposition (not a trade fair) organized by the nation that wins the candidature, with other countries participating through the diplomatic channels of the hosting nation. Expo Milano 2015 will be an extraordinary universal event displaying tradition, creativity and innovation in the business of food.

FOOD, ENERGY, PLANET, LIFE are the theme words of the EXPO Milano 2015 and key words on a journey to the roots of the boundaries of the future.

Figure 1. Expo Milano Site

CONCEPT

The FK Programme has been built on the idea that **knowledge development and sharing** are the main tools to identify concrete solutions for food security that really meet the needs of developing countries. The Programme is thus based on the idea that to achieve sustainable development, **everyone on the planet should have access to healthy, safe and sufficient food**.

The main objective of the initiative is to create opportunities for dialogue and development through collaboration among Mediterranean experts and the identification of local needs on research, innovation and transfer of knowledge.

To achieve this objective, the FK Programme has developed:

- the **International Scientific Network** on Food Security;
- the enhancement of **best sustainable development practices** of Expo Milano 2015.

These two elements are supported by an **international technology platform** (www.feedingknowledge.net), a technological eco-system that facilitates knowledge sharing and dissemination among all the actors involved in the Programme: researchers, farmers, policy-makers, representatives of institutions and extension services.

A key instrument for the assessment of local needs and knowledge sharing is represented by the creation of dedicated offices (local points) in FK in **ten target countries**. These offices aim at **networking** at the **local** and **international** levels, both with the public and the private sector. In this way FK has applied a systemic bottom-up approach in the knowledge chain, building on the analysis of local stakeholders needs. In fact, it is well recognized by literature that innovation in agriculture does not follow a linear approach, based on the enhancement of research results through the extension services and consequent adoption by enterprises. In the agro-food sector, the systemic approach is to be preferred, where innovation is the result of a network creation, an interactive learning, an exchange among heterogeneous groups of actors (institutions, research entities, extension services, agro-food operators, policy-makers), based on the collection of local stakeholders' needs.

All FK activities are developed through five research and innovation priorities for food security:

- sustainable natural resources management;
- quantitative and qualitative enhancement of crop products;
- socio-economic dynamics and global markets;
- sustainable development of small rural communities in marginal areas;
- food consumption patterns: diet, environment, society, economy and health.

TARGET AREA

The project is first focused on the **Euro-Mediterranean region** (Albania, Algeria, Egypt, Jordan, Lebanon, Morocco, Palestinian National Authority, Southeast European countries, Tunisia, Turkey). After 2015, programme activities will progressively involve **other regions of the world**.

Figure 2. "Feeding Knowledge" target area

RESULTS

Since its start (September 2012), the Programme has achieved the following results:

- Establishment of a network of experts and researchers: "Feeding Knowledge Network", focused on research, innovation and transfer of knowledge for food security. Today the Network has around 2 000 members.
- Creation of **ten national local points (institutional network)** to develop and enlarge the scientific network at the local level, to collect stakeholders needs and comments on food security issues and to cooperate with National Extension Services in the transfer of knowledge to operators and farmers. The local points have the purpose of:
  - facilitating the collection of needs and problems related to food security at national level;
  - favouring knowledge dissemination;
  - cooperating with National Extension Services through listening actions to valorize research;
  - promoting the Programme and the call for best sustainable development practices.
- Creation of an international technology platform, where network members might share ideas, information and research in order to develop new synergies. A technological system made up of: a Web platform; a social network; on-line webinars and a growing seeds section (young researcher video). The Web platform includes a research actors database and a research database (1 000 researchers). Moreover, the platform will host a repository of all the initiatives

Figure 3. Snapshot of "Feeding Knowledge" Platform

that are eligible for the call on best sustainable development practices of Expo Milano 2015 (deadline, October 31 2014).

- Support to the launch of the call for best sustainable development practices for food security (BSDP) in the frame of Expo Milan 2015. In the framework of "Feeding the Planet, Energy for Life", the announcement is intended to collect, raise awareness, and share experiences that have produced better effects, compared with the previous conditions, in their specific area: environment, social and economic context, private sector, institutions, politics, science. All the BSDP on food security admitted to the competition will be published and promoted through the Feeding Knowledge Web platform. The 15 selected will have high visibility on the Expo Milano 2015 site:
  - exhibition in Pavilion 0;
  - dedicated workshops to transfer the experiences;
  - possibility to provide dissemination and promotional materials;
  - repository on Feeding Knowledge Web platform.
- Drafting of **five white papers** (one for each thematic priority) identifying the state-of-the-art of research and giving some recommendations on research perspectives in line with the main needs of the Euro-Mediterranean region.
- Drafting of a **policy paper** for the elaboration of effective policies on research and innovation for food security.

One of the main outcomes of the Programme is the drafting of a **policy paper** giving some advice on suitable policy options for food security in the Mediterranean, based on the **recommendations** of the scientific experts gathered in the Feeding Knowledge Network and on the main **needs** of target countries collected by the ten local points.

The paper is the result of a long participatory process, made up of several steps:

- preliminary draft based on the main recommendations outlined in the five "white papers" and on the results of stakeholders interviews in target countries (200 stakeholders reached);
- open consultation on www.feedingknowleldge.net (that reached 2 000 members of the FK network);
- discussion with policy-makers, institutional actors and stakeholders who have an active role in taking decisions and approving programmes and policies for food security (event held in February 2014 at CIHEAM-Bari);
- in the next few months a second open consultation will be launched and another event for discussion and final sharing of the paper will be organized;
- during Expo Milano 2015, the paper will be endorsed by the Mediterranean Ministers of Agriculture.

POLICY PAPER STRUCTURE

Part A: The Seed

Food Security in the Mediterranean: challenges, needs, uncertainties

Part B: The Tree

B.1 Research recommendation: main outcomes of Feeding Knowledge "white papers"

B.2 Merging needs and research paths in the Mediterranean
Part C: The Fruit
Policy options for food security: how research can feed the world

TOWARDS 2015: LINKING KNOWLEDGE AND LOCAL NEEDS

Building on the results achieved, the Programme activities for the years 2014–2015 will be developed through four main pillars: (i) development of innovative instruments for knowledge sharing and dissemination; (ii) reinforcement of local points and their link to the local communities; (iii) enhancement of national and international dialogue and awareness on food security; and (iv) ensure the maximum visibility of the Programme during the Exhibition in 2015.

USEFUL LINKS

International Technology Platform: www.feedingknowledge.net
https://www.facebook.com/Feedingknowledge
https://twitter.com/FeedKnowledge

Knowledge management for sustainable food value chain development: the FAO perspective

Jean-Marc Faurès
Land and Water Division, FAO, Rome

ABSTRACT[1]

Sustainability is at the heart of FAO's new Strategic Framework. Building on extensive work in various subsectors (crops, livestock, forestry, fisheries and aquaculture), FAO has developed an integrated vision for the development of sustainable food and agriculture (SFA). The vision is articulated around five key principles: improving resources-use efficiency; conserving, protecting and enhancing natural resources; protecting rural livelihoods and improving equity and social well-being; enhancing the resilience of people, communities and ecosystems; and good governance. It builds on the Organization's long experience in developing sustainability concepts, approaches and tools, and offers a common platform and approach to develop intersectoral synergies and address trade-offs that will eventually make agriculture more productive and more sustainable. This approach focuses on evidence, dialogue, tools and practice change in technologies, policies and institutions.

INTRODUCTION

Sustainability is at the heart of the debate leading to the adoption, in 2015, of the United Nations Sustainable Development Goals. In all sectors of the world's economy, efforts are made to design development models that combine growth with improved social well-being, reduced inequality and the protection and enhancement of the natural resources base on which we all depend.

Agriculture, forestry and fisheries are probably the sectors that have collectively the largest impacts on social well-being and on the environment. Producing food, fibre, fuel and an increasingly wider array of bioproducts is fundamental for our survival. Agriculture employs more than one in three of the world's workers; every day, they produce about 23.7 million tonnes of food, including 19.5 million tonnes of cereals, roots, tubers, fruit and vegetables, 1.1 million tonnes of meat and 2.1 billion litres of milk. Fisheries and aquaculture produce more than 400 000 tonnes of fish per day, while forests provide 9.5 million cubic

[1] This paper is based on the work of the FAO working group on the "Common Vision on sustainable food and agriculture". The report of the Common Vision is available at www.fao.org/sustainability

metres of timber and fuelwood (FAO, 2014). Agriculture and food are also deeply embedded into our societies and cultures of which they form an important basis.

At the same time, these activities are impacting on the natural resources on which they depend for their long-term survival. In many places, excessive pressure on water resources by agriculture, the world's major water user, has led to reduced water availability and overextraction, increased competition for water, the loss of freshwater biodiversity and reduced quality of water bodies, with consequences for people and for the environment. With about 1.5 billion hectares of cultivated land around the world (12 percent of the total land area; FAO, 2011), agriculture represents the primary cause of landscape transformation, and in too many cases of landscape degradation. It is estimated that about 33 percent of soil is moderately to highly degraded due to erosion, nutrient depletion, acidification, salinization, compaction and chemical pollution (FAO, 2011), 29 percent of fish stocks are overfished, and the area of tropical forests continues to decrease under the combined demand for more agricultural land and tropical wood.

The capacity of the world's food system to keep pace with demographic growth and provide more and better food for a population of 7 billion people today has been remarkable. However, while the capacity exists today to produce food for the world's population, there are still about 805 million malnourished people, and 75 percent of the poor across the world live in rural areas. Clearly, progress in agriculture has not benefited everybody equally, and current models of agricultural development leave many of those directly involved in agriculture in situations of excessive poverty and vulnerability.

As we head towards 2 billion more people by 2050, a new paradigm of agricultural development is needed that truly integrates the three dimensions of sustainability: economic, social and environmental.

FAO STRATEGIC FRAMEWORK 2014–2017

FAO's ultimate vision is that of "a world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner" (FAO, 2013a). To focus action towards its global goals of food security, elimination of poverty, and sustainable management and utilization of natural resources, FAO has set itself five Strategic Objectives under its Strategic Framework 2014–2017 , which offer a unique opportunity for addressing major agriculture-related issues in a truly integrated and comprehensive way (FAO, 2013a). They are:

1. *Help eliminate hunger, food insecurity and malnutrition*. FAO supports members in their efforts to ensure that people have regular access to enough high-quality food, through policies and political commitments that promote food security and good nutrition.
2. *Make agriculture, forestry and fisheries more productive and sustainable*. We must ensure that increased productivity does not only benefit the few, and that the natural resource base can provide the environmental services (pollination, nutrient cycling in soils, quality water, etc.) that enhance sustainability.

3. *Reduce rural poverty*. Most of the world's poor live in rural areas and reducing rural poverty, therefore, is central to FAO's mission. FAO strives to help smallholders improve farm productivity while also aiming to increase off-farm employment opportunities and find better ways for rural populations to manage and cope with risks in their environments.
4. *Enable inclusive and efficient agricultural and food systems*. With increasing globalization, agriculture is becoming part of an integrated value chain, from production through to processing and sales, of which farmers and agricultural producers are part and to which they need to adapt in order to benefit from it and contribute to its overall efficiency.
5. *Increase the resilience of livelihoods to disasters*. Farmers, fisherfolk and forest dwellers are often confronted with disasters and crises. They can strike suddenly, such as earthquakes, or unfold slowly, such as drought cycles. FAO's mission is to help countries govern, prevent and mitigate risks and crises and support them in preparing and responding to disasters.

Through its Strategic Objective 2, FAO intends helping countries to identify and implement policies, strategies and technologies that contribute to sustainable and enhanced provision of products and services from agriculture, forestry and fisheries. In order to provide an agreed framework for these activities, its first objective was to build a common vision and approach for sustainable food and agriculture.

FAO APPROACHES AND FRAMEWORKS FOR SUSTAINABLE AGRICULTURE

For several decades, FAO has developed a series of approaches and frameworks tailored to the needs of specific sectors or issues (FAO, 2013b). Over time, these frameworks have evolved to adapt to a changing global context and growing knowledge base. They form the building blocks of FAO's action in support of enhanced and more sustainable agricultural production practices, and represent a solid conceptual basis, supported by extensive experience from years of application in diverse socio-economic contexts (Figure 1).

These frameworks and approaches have been developed in response to established needs and reflect the structure of the sectors they serve. They cover the whole range of sectoral production domains (crops, livestock, forestry, fisheries and aquaculture), as well as the specific social and environmental aspects of land, water, energy, climate, biodiversity and resilience.

A careful review of these approaches shows that they are very much aligned in terms of principles and approaches, being all developed on the basis of the three pillars of sustainability (social, environmental, economic), and encompass very similar considerations on the governance dimension needed to implement them effectively. In addition, and because they have been developed through a bottom-up approach, in close correlation with the problems to be addressed, they are designed to foster and offer practical steps for implementation.

What these individual approaches cannot offer is the strategic coherence that a comprehensive approach to agricultural production systems requires in order to ensure effective impact on the ground. Connectivity between subsectors is loosely addressed, and all cross-sectoral interactions are seen only from one angle, therefore not allowing for satisfactorily addressing trade-offs or taking advantage of synergies.

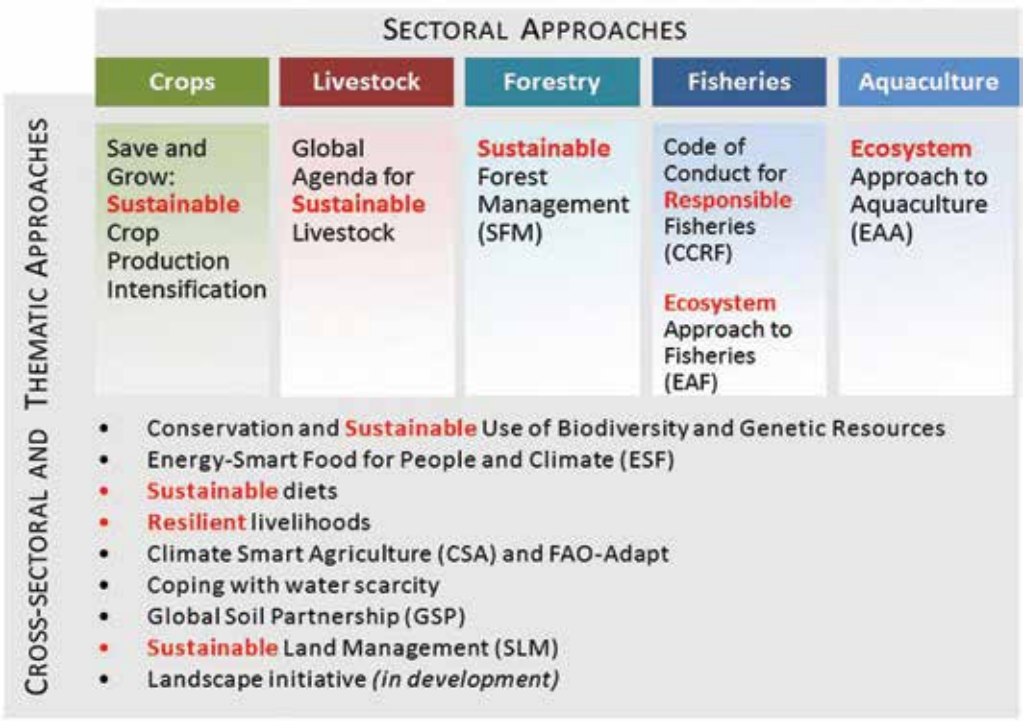

Figure 1. FAO sustainability frameworks and approaches
Source: FAO (2014).

INTER-SECTORAL SYNERGIES AND CONFLICTS IN AGRICULTURE, FORESTRY AND FISHERIES

Yet, these interactions are many, and growing, and they become increasingly complex as the pressure on resources becomes more important. Some of the most frequent types of inter-dependencies between sectors are represented in Figure 2. Typically, crop and livestock intensification often result in water pollution affecting fish habitat and aquaculture downstream. Expansion of crop and grazing land often happens at the expenses of forests, while deforestation induces soil erosion and changes in river runoff. Intensive aquaculture, both freshwater and marine, can result in water pollution, salinization of aquifers and overall water pollution.

Interactions also offer possibilities for synergies between the different subsectors. Crops, livestock and fish can be managed in a way that residues from one activity can be used as input in another. Forests can provide shelter and feed for cattle, and manure can be used on cropland. Domestic wastewater, once treated, can be used for cropping, and the nitrogen and phosphate it contains can help to increase soil fertility. These interactions, whenever possible, enhance the overall productivity of land and contribute to resource use efficiency.

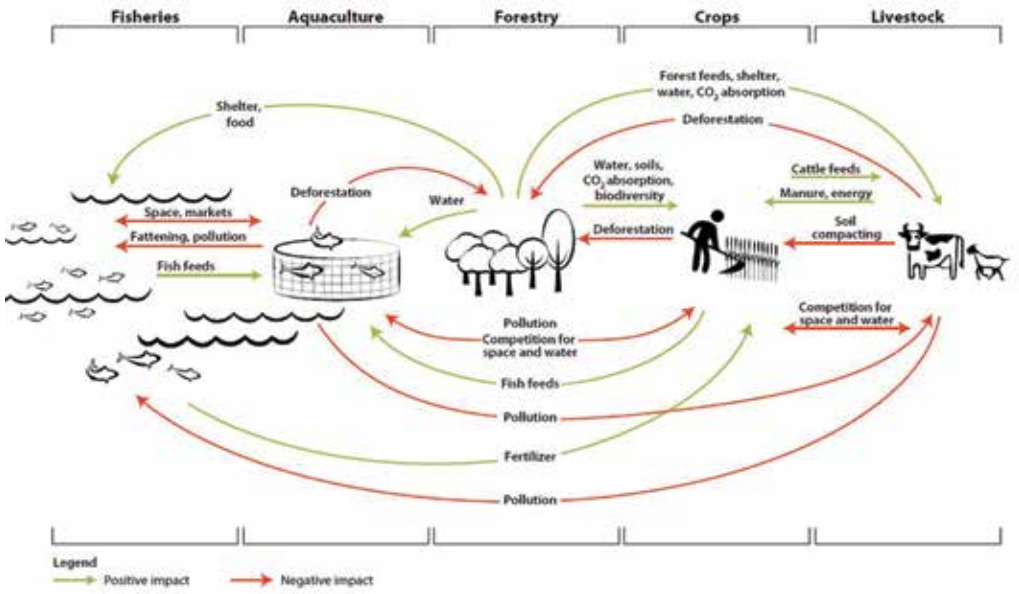

Figure 2. Interactions between agriculture subsectors
Source: FAO (2014).

BUILDING A COMMON VISION – THE CONCEPTUAL FRAMEWORK

FAO's vision for sustainable food and agriculture is that of *"a world in which food is nutritious and accessible for everyone and natural resources are managed in a way that maintains ecosystem functions to support current as well as future human needs. In this vision, farmers, pastoralists, fisherfolk, foresters and other rural dwellers have the opportunity to actively participate in, and benefit from, economic development, have decent employment conditions and work in a fair price environment. Rural women, men and communities live in security, and have control over their livelihoods and equitable access to resources which they use in an efficient way"* (FAO, 2014). Clearly, this vision captures the three dimensions of sustainability, and puts the economic, environmental and social dimensions on even grounds. Sustainable food and agriculture therefore considers both inter- and intra-generational equity considerations.

A conceptual model can help to scrutinize this vision and elaborate ways to ensure transition towards sustainable food and agriculture (Figure 3). Through this vision, agriculture is represented at the interface between the world's natural and human systems. In a word, agriculture, forestry and fisheries are the "engine" that transforms natural resources and the ecosystem services on which they are based into agricultural products that are, in turn, transformed into social and economic services.

The natural system, our environment, has been shaped by humans since at least the dawn of agriculture, about 10 000 years ago in order to provide them with food, and also shelter, clothes, fuel and a variety of other products and services. In so doing, they have managed to progressively enhance the capacity of the environment to provide these products and services, patiently domesticating the most appropriate plants and animals and selecting

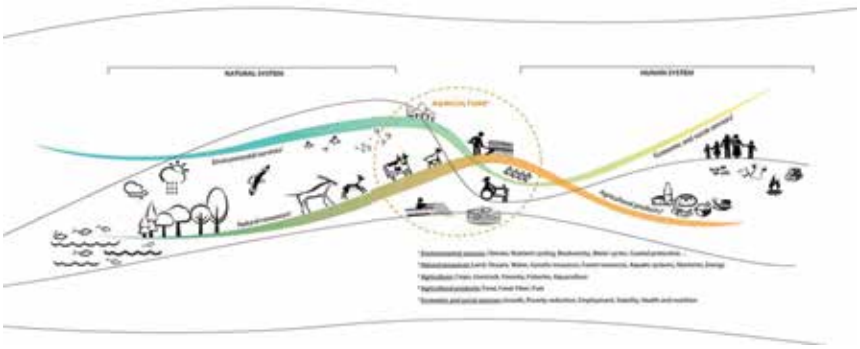

Figure 3. A conceptual model for sustainable food and agriculture
Source: FAO (2014).

among them those that most suited their needs. Today, after several agricultural revolutions that have accelerated the pace of increase in agricultural productivity, our environment provides food and other services to more than 7 billion people. Ten thousand years ago, gathering, hunting and fishing would have sustained a population of maximum 600 million people, over ten times less than today's world population (Mazoyer and Roudard, 2006).

Undoubtedly, improvements of this "engine" of transformation have been exceptionally successful, and today's agriculture machine is an extremely performing and sophisticated one. Yet, while it has to a large extent benefited the large majority of the world's population, making the process of acquiring or producing food more affordable and less risky than in the past, and offering more decent livelihood opportunities to many rural people, this process has come at a cost. Much progress must still be made in order to transition towards truly sustainable agriculture, forestry and fisheries.

FIVE PRINCIPLES FOR SUSTAINABLE FOOD AND AGRICULTURE

The conditions for sustainable food and agriculture have been captured in five "SFA Principles" that offer a platform on which to base assessments of sustainability and from which action can be derived in order to progressively evolve towards sustainable agriculture. These principles are closely aligned with the conceptual framework: the first three address the three major elements of Figure 3: the natural system, the human system, and the "engine of transformation". Two more principles cut across these three "pillars" and provide the ground for transition towards sustainable systems. The five principles are the following:

- Principle 1: *Improving efficiency in the use of resources is crucial to sustainable agriculture*. This principle focuses on the engine of transformation. Further gains in productivity will still be needed in the future to ensure sufficient supply of food and other agricultural products while limiting the expansion of agricultural land and containing encroachment on natural ecosystems. However, while in the past efficiency has been mostly expressed in terms of yield (kilogram per hectare of production), future productivity increase will now need to consider other dimensions.

Water and energy-smart production systems will become increasingly important as water scarcity increases and as agriculture will need to seek ways to reduce the emission of greenhouse gases. This will impact on the use of fertilizers and other agricultural inputs.

- Principle 2: *Sustainability requires direct action to conserve, protect and enhance natural resources*. While intensification has positive effects on the environment through reduced agricultural expansion and subsequent limitation in encroachment on natural ecosystems, it also has a potentially negative impact on the environment. The most widespread model of agriculture intensification involves intensive use of farm inputs, including water, fertilizers and pesticides. The same applies to animal production and aquaculture, with subsequent pollution of water, destruction of freshwater habitats and destruction of soil properties. Intensification has also led to the drastic reduction of crop and animal biodiversity. Such trends in agricultural intensification are not compatible with sustainable agriculture and are a threat to future production.
- Principle 3: *Agriculture that fails to protect and improve rural livelihoods and social well-being is unsustainable*. Agriculture is the most labour intensive of all economic activities. It provides, directly and indirectly, a source of livelihoods for rural households totalling 2.5 billion people (FAO, 2013c). Yet, poverty is excessively associated with agriculture, and agriculture is among the riskiest types of businesses. Agriculture can only become sustainable if it provides decent employment conditions to those who practise it, in an economically and physically safe, and healthy environment.
- Principle 4: *Enhanced resilience of people, communities and ecosystems is key to sustainable agriculture*. Several signals in the recent past have illustrated the risks that shocks can represent for agriculture, forestry and fisheries. Increased climate variabilityassociated with climate change impacts farmers and their production. Increased food price volatility impacts both producers and consumers who do not necessarily have the means to cope with them. Rather than reducing these shocks, increased globalization has probably favoured their rapid transmission across the globe, with an increasingly unpredictable impact on the production systems. Resilience therefore becomes central to the transition towards a sustainable agriculture, and must address both the natural and the human dimensions.
- Principle 5: *Sustainable food and agriculture requires responsible and effective governance mechanisms*. Mainstreaming sustainability into food and agriculture systems implies adding a public good dimension to an economic enterprise. Agriculture is and will remain an economic activity driven by the need for those practising it to make a profit and ensure a decent living out of its activities. Farmers, fisherfolk and foresters need to be provided with the right incentives that support the adoption of appropriate practices on the ground. Sustainability will only be possible through effective and fair governance, including the right and enabling policy, legal and institutional environments that strike the right balance between private and public sector initiatives, and ensure accountability, equity, transparency and the rule of law.

IMPLEMENTING THE VISION

Implementation of the five principles requires a range of actions to enhance sectoral and cross-sectoral productivity, together with social and environmental sustainability. The frameworks and approaches that FAO has developed over the last 25 years have strengthened the capacities of countries to increase agricultural productivity in a sustainable manner, and can support countries in making the transition towards sustainable agriculture. The transition to sustainability requires conviction, political commitment, knowledge and people's participation. It is therefore important that programmes aiming at building sustainability be designed and driven by the countries themselves, in order to guarantee that the approach is coherent, comprehensive and adapted to their needs and specificities.

The four areas for action presented in Figure 4 are very likely to be part of any process of transition towards sustainable food and agriculture. They represent elements that will be needed in all cases. What will change is the process by which transformation will take place and the order of, and interaction between, the different actions that will be performed.

Evidence is fundamental in all processes leading to sustainable models of agriculture, forestry and fisheries. Knowledge will be fed by science, but in a much more interactive way than in the past, leading to "co-construction" and broad sharing of knowledge. Through this process, stakeholders will develop a shared understanding of complex issues and address the uncertainty with which they are associated, possibly through the use of scenarios.

Dialogue is central to the process. A much more comprehensive approach to sustainability requires dialogue between different stakeholders across sectors and disciplines, a process of listening and sharing of values, joint problem understanding and development of agreed sets of solutions. Dialogue is also central to the process of negotiation, in particular when addressing trade-offs.

T*ools* include the guidance, standards, regulations, institutional rules and frameworks, and the incentives needed to help producers moving towards sustainable practices. Finally, *practice change* is the ultimate objective. It will be obtained through awareness raising, capacity building, innovation and the effective implementation of the above tools.

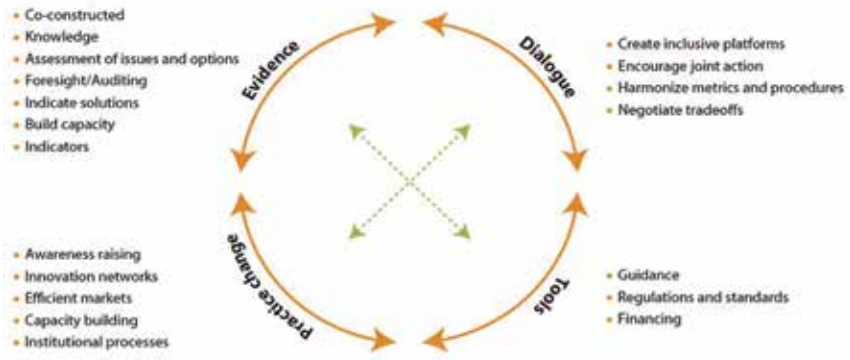

Figure 4. Four areas of action to implement sustainable food and agriculture
Source: FAO (2014).

These activities will interact with each other throughout the process. The *dialogue* will identify the need for more and better *evidence*, discuss the implications of proposed scenarios, and be used to validate the results of research and analysis. The indicators developed as part of the *evidence* will be used to measure *practice changes*, and results will be discussed through the dialogue in order to assess the impact of the different *tools* developed during the process. These *tools*, in turn, will be adapted, in the light of the *evidence* acquired during the process in order to increase their effectiveness.

CONCLUSIONS

Sustainability in all sectors of the economy is not a new concept. The United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 put sustainability at the centre of the international debate. Since then, many valid sectoral approaches have been developed in an attempt to address sustainability. This is the case for all the subsectors of agriculture (crops, livestock, forestry, fisheries and aquaculture). In parallel, FAO and many international partners have also worked towards the development of sustainability approaches addressing cross-sectoral themes related to natural resources (soil, water, biodiversity, climate, energy) as well as the social dimension of sustainability (good or effective governance, gender equality, decent employment, voluntary guidelines).

As the member countries of the United Nations are heading towards the important appointment of 2015 leading to the adoption of the Sustainable Development Goals, it is important that efforts be made to propose a common vision for a sector that is at the centre of the world's sustainability agenda. With its implications for global food security, rural poverty reduction and environmental conservation, a renewed and more integrated effort towards sustainable food and agriculture is a must.

FAO's common vision for food and agriculture was developed in response to the need to provide a strong conceptual framework for its action towards more productive and more sustainable production systems. The proposed vision builds upon decades of experience in the different subsectors of agriculture, forestry and fisheries and proposes five universally relevant principles to serve as a basis for future action. It acknowledges the increasing interconnection between production sectors and the need to develop more effective mechanisms to address cross-sectoral issues.

Implementing the transition towards sustainable food and agriculture will vary according to the socio-economic and environmental context. There is no blueprint approach, and countries will need to drive the process in the way that is most suitable for them. Four areas of action have been identified, and will be used in different ways according to local contexts. They are built around *evidence*, *dialogue*, *tools* and *practice change*. Stakeholder-led, evidence-based processes will be designed, and practice change will be promoted through the development and adoption of a series of tools that will provide farmers, fisherfolk and foresters with the incentives they need to progressively evolve towards sustainable agricultural practices.

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Knowledge on systemic issues for multistakeholder processes: the experience of the High Level Panel of Experts on food security and nutrition

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ABSTRACT

The High Level Panel of Experts on food security and nutrition (HLPE) was created in 2009 as part of the reform of the Committee on World Food Security (CFS) to: assess and analyse the current state of food security and nutrition and its underlying causes; provide scientific and knowledge-based analysis and advice on specific policy-relevant issues, utilizing existing high-quality research, data and technical studies; identify emerging issues; and help members prioritize future actions and attention on key focal areas.

Since its establishment the HLPE has produced, at the request of CFS, eight reports on various topics of importance for food security and nutrition (FSN), as well as a note on critical and emerging issues for food security and nutrition. The experience of the HLPE on FSN can be of major interest to improve understanding of sustainable food systems (SFS). First, because the two notions of FSN and SFS are closely linked. Second, because understanding FSN and SFS both require a systemic, pluridisciplinary approach with attention to global as well as to context-specific aspects. Third, because improving FSN and improving the sustainability of food systems both require the involvement and engagement of very diverse stakeholders: governments, international organizations, the private sector and civil society. This contribution presents the HLPE definition of sustainable food systems, centred on food security and nutrition, and provides a brief overview of the methods used by the HLPE to build a comprehensive understanding of systemic issues to be shared by multiple stakeholders towards collective action.

THE HIGH LEVEL PANEL OF EXPERTS ON FOOD SECURITY AND NUTRITION

The Committee on World Food Security (CFS) is the foremost evidence-based inclusive international and intergovernmental platform on food and nutrition security. It has been profoundly reformed in 2009 to be inclusive and evidence-based (De Janvry, 2013; De Schutter, 2014; Duncan, 2013; Wise and Murphy, 2012; McKeon, 2015). The Committee is composed of member states, participants and observers. Participants can also intervene in

plenary and breakout discussions, contribute to the preparation of documents and agendas, and present documents and formal proposals. It includes representatives of UN agencies and bodies with a specific mandate in food security and nutrition, civil society and non-governmental organizations, international agricultural research systems, international and regional financial Institutions, private sector associations and private philanthropic foundations.

The HLPE, established in 2009, works as the science–policy interface of the CFS at the request of the CFS to provide it with scientific and knowledge-based analysis and advice on specific policy-relevant issues. The very subtle and innovative institutional details of the CFS and the HLPE are depicted elsewhere (Gitz and Meybeck, 2011). This article focuses on the experience of the first four years of work of the HLPE, on how to generate and organize knowledge to feed into CFS's work. This experience could be particularly relevant for the sustainable food systems programme.

The paper is organized as follows:

- First, it will show that the broad, complex notions of food security and nutrition (FSN) and sustainable food systems (SFS) share many characteristics, and are intrinsically linked, as the HLPE (2014a) proposes.
- Second, it will then depict the very challenges encountered by the HLPE, to organize knowledge on systemic issues for a multistakeholder process – oriented towards action.
- Third, building on the experience of the HLPE in preparing eight reports, with a ninth on the way, plus an analysis of critical and emerging issues for food security and nutrition, we show the ways and means used by the HLPE to precisely address these knowledge challenges.

We finally discuss how this experience can also be of possible interest for the programme towards sustainable food systems and its processes.

FSN AND SFS

Taking as a starting point the generally assumed description of food systems (see for instance Ericksen, 2008; Ericksen et al., 2010; Ingram, 2011; IPCC, 2014), in its report *Food losses and waste in the context of sustainable food systems*, the HLPE has formalized the link between the two concepts of food security and nutrition and of sustainable food systems by proposing the following definition (HLPE, 2014a):

A sustainable food system (SFS) is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised.

The bottom line is that there can be no FSN (short- and long-term) without SFS. Food security and nutrition could be what ultimately characterizes sustainable food systems. This link manifests itself in practice in various ways. For example, the HLPE has recently conducted a consultation of knowledge organizations and networks, completed by an open consultation, as part of a process of identification of critical and emerging issues **for food security and nutrition** (HLPE, 2014b).

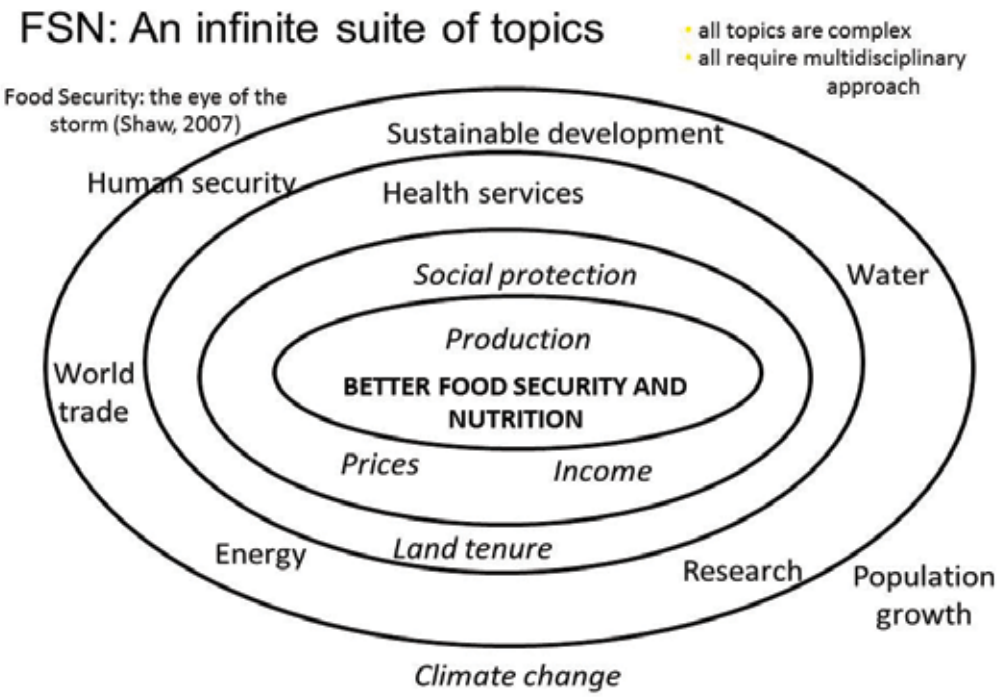

Figure 1. Food security and nutrition as inscribed within and determined by a range of topics

The synthesis of the results[1] identified five major sets of issues:

- Changing consumption patterns and food and nutrition security
- Natural resources and food security
- Livestock and food security
- Social changes in agriculture and food security
- Evolution of food systems, urbanization and globalization and food security

These issues, identified as critical for FSN, are in fact even as critical for SFS.

In fact, the range of issues that can link to FSN are many and can be seen, as in Figure 1 adapted from Shaw (2007), as inscribed in concentric circles, from the issues closer to food and agricultural production, to wider issues of importance having an influence on FSN.

FSN and SFS cannot be thought about in separate ways. Among the relationships between SFS and FSN, a very important one is that food security and nutrition enables having a people-centred approach to the sustainability of food systems (Figure 2). As a consequence, considering FSN enables a better understanding of the importance of the social dimension of SFS, which is often left behind in the traditional economy/environment debate.

[1] See http://www.fao.org/cfs/cfs-hlpe/critical-and-emerging-issues/en/ for the HLPE note, the synthesis of the enquiry and all background documentation.

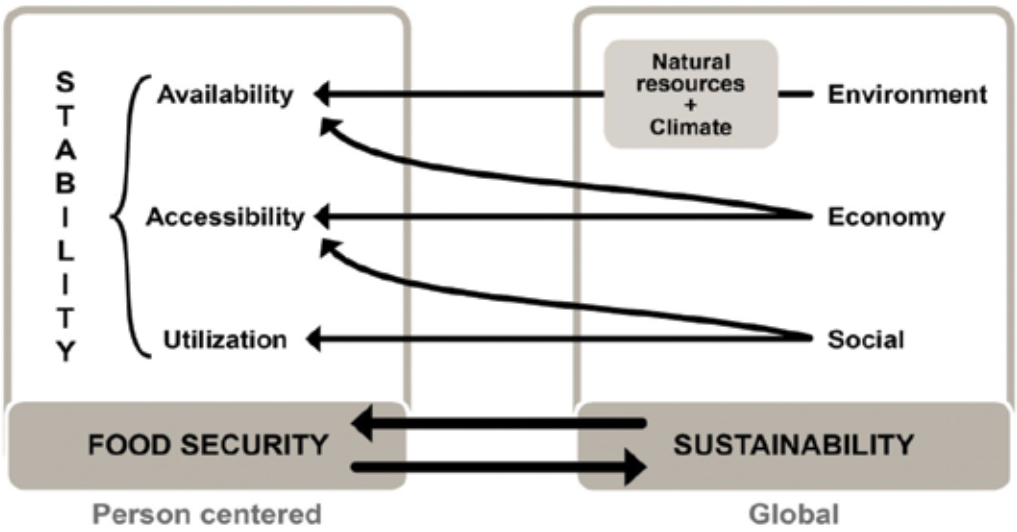

Figure 2. Linkages between the dimensions of SFN and of sustainability

Because of this "organic link" FSN–SFS, the series of HLPE reports and recommendations can be relevant to frame the various issues to be addressed in the long run to ensure sustainable food systems. Also these reports are of a global nature, oriented towards action by various actors, which is also a strong characteristic of the SFS programme.

KNOWLEDGE CHALLENGES FOR THE HLPE

The key question for the HLPE is "*how to generate, organize and present knowledge, so that all actors are in position to understand and make progress on such kinds of (difficult) issues?*"

This question of "*how to handle knowledge?*" was in fact a central one in the reform of CFS and the governance of food security (Gitz and Meybeck, 2011). What exactly are the challenges encountered?

We can highlight five of them, together with ways and means by which the HLPE addressed them, and what were the concrete approaches (Figure 3). As we will show, some of them can be useful for the SFS programme.

A first challenge is related to the diversity and complexity of issues and the variety of their relationships with food security and nutrition in its four dimensions.

A second challenge is linked to the multistakeholder character of food systems. Everybody has a role, but also a point of view, diverse interests, a separate logic. Everybody reads the problem with the angle of his or her solution. This often prevents good understanding of solutions, of what is needed to implement them, of what can impede them, what works for one but maybe not for the other, etc. – in a context where often no one has an interest to show what has not worked.

Third, the multiknowledge holder character of evidence, with two aspects:

- Knowledge comes from more and more sources, more and more disciplines (each of them increasingly specialized), different methods of work. This comes with

Figure 3. Challenges on how to handle knowledge for decision and ways to address them

various challenges, from confronting terminologies, to more difficult issues such as what are the "spaces of validity" of the different approaches to build knowledge.

- Also, we cannot be blind to the fact that many knowledge-holders are also stakeholders: they are interested and have a stake in the follow-up actions. The challenge is to find ways to eliminate this bias, in order to give really appropriate, disinterested advice.

Fourth, knowledge finds its source and has to be applied to a variety of contexts. There is a tension between the universality of a topic and the specificity and diversity of contexts.

Fifth, the tension between broadly shared objectives, such as those of sustainable development, or of food security, and the specificities and multiplicity of concerns and priorities of many different actors.

METHODS – HOW DID THE HLPE WORK IT OUT IN PRACTICE? HOW TO ORGANIZE KNOWLEDGE FOR ACTION?

To address these challenges, the CFS and the HLPE have designed an original model with very specific methods, so that knowledge can help towards shared priorities for action, both broad directions and context-specific action, including organization of priorities across levels, from global to local.

The method, or "how-to", touches on the following four dimensions, which were specifically crafted to tackle the challenges highlighted above:

- the institutional set-up of the HLPE, in particular vis-à-vis the CFS;
- the process of elaboration of reports;
- the reports themselves, and their content;
- the recommendations.

The first point is linked to the function of HLPE reports vis-à-vis the CFS, which is to be the main, or rather, unique document to serve as a base to policy discussions in CFS on a topic on which there are diverging views but on which CFS is to take consensual decisions. The work of the HLPE, at scientific level, precedes the work of the CFS, which is at political and action level. The institutional set-up guarantees the independence of the HLPE vis-à-vis political influences, while enabling the scientific process to be relevant (as it works demand-driven) to political debates.

The second point refers to several key characteristics of the process of elaboration of the report:

(i) Inclusiveness and openness, notably through the use of e-consultations to obtain input from a wide range of knowledge-holders; organizing conversations on a draft scope and then on an advanced draft also serve for different stakeholders who will participate in the subsequent policy debate to be progressively acquainted with the issues and different perspectives. The consultations also enable the HLPE to better understand, reflect and address the diversity of situations and experiences of stakeholders.

(ii) Academic credibility and integrity. The report is elaborated as per the "scientific" rules, including an evidence-based peer review. The HLPE Steering Committee continuous guidance and oversight are also exerted as per these rules.

(iii) Independence. At two levels: first, HLPE experts work, in the HLPE, independently from their governments, organization or employer, and second, the HLPE is independent from CFS as the report clearance stays with HLPE, and does not imply governmental negotiations – such as for example in the IPCC for the summaries for policy-makers, which are agreed by governments.

(iv) Absence of conflict of interest vis-à-vis the outcome and means of implementation. The HLPE as an institution does not take part in the implementation of measures decided by the CFS. This is different than other research institutions or organizations that have also a mandate in the domain of action on the ground, and which, in their analysis are keen to favour recommendations that fall within their working mandate. The HLPE does not have a stake in the implementation.

Third, the reports seek to manage the tension between "conceptual-academic" and more "operational-field" approaches. Each report needs to very clearly state the issue(s) at stake, their relationship to the four dimensions of food security, taking into account diverse scales (from local to global) and time spans (impacts can be different at short and medium range). It needs to cover the breadth of situations and experiences of the various stakeholders, including in terms of regional balance, local, national, global, situations, types

of production. To do so it often proposes a global, conceptual description, in the form of a framework, typology, which can be summarized in a figure. This also requires very clearly articulating the approach adopted by the report including methodological issues, the case being (generally) different disciplinary perspectives. Importantly, the report has to "speak to" both specialists and non-specialists of food security and of the specific topic. To do so it has to be scientifically sound and up-to-date and explain clearly even very basic notions. As many of the readers are not specialists, they need to be guided in their reading. Finally, the report has to expose the various points of view, including controversies, in such a way that all stakeholders can recognize their own position and knowledge, adequately described and in such a way that it helps others to understand their position. To do so it has to avoid being biased in its presentation of the various arguments and narratives, before proposing an evidence-based position that can, when needed, reflect controversies and diverging views. In so doing it has to be carefully balanced and often position references in relation to debates, controversies and different points of view, linked to specific intradisciplinary controversies or to the need for accommodating different disciplinary approaches or different stakeholders' perspectives and points of view.

Fourth, the recommendations, in their format, need to address the five challenges altogether, and especially the diversity of contexts, diversity of concerns and diversity of actors. They have to be short, operational, clearly addressed to actors, monitorable (to the extent possible) without mixing issues, and focus on "catalytic" actions – those that trigger change. Here the diversity of examples used throughout the text is key to better sustain/illustrate more recommendations or solutions and explain how they can be applied to various contexts. Examples have to cover a wide diversity of countries, keeping in mind the concern for a certain regional balance, situations, agricultural production, technical issues, scales and actors, etc.

WHAT CAN THE EXPERIENCE OF THE HLPE BRING TO THE SFS PROGRAMME?

The reports and recommendations of the HLPE can provide useful evidence-based, substantive background material for the SFS programme, as the themes for HLPE reports were all relevant, in different ways and degrees, to the issue of sustainable food systems.

Most importantly, some of the methodological characteristics on how HLPE reports are elaborated, and lessons learned from this, can be of interest to the activities of the programme. I would like to mention eight of them.

(i) The importance of clearly distinguishing "knowledge organization and understanding" (purpose of the report elaboration) from "negotiating" (that should take place outside the report and the process of its elaboration, and rather informed by/following the publication of the report). The space to elaborate the report should not be distorted by negotiations' interests. On the contrary, it should aim at eliciting the controversies, rationales behind, tipping points, in a way as balanced as possible, in order to help stakeholders understand why they disagree. The goal of a report with respect to controversies is here to present the different issues, to

help figure out a common understanding of why people disagree, so that the more "political" debate can be held on the basis of the report.

(ii) The need for a clear method, however simple, to ensure inclusiveness, transparency and rigour. This is all the more important as the report and elaboration process have also a "binding" (liaison) function between knowledge-holders and between stakeholders. This is linked to the point above. The evidence-based "mediation" function of a report amidst controversies can be credible only if transparent, inclusive methods are followed.

(iii) Consider systematically the way the issue considered can interact positively or negatively with the four dimensions of food security. Conceptual frameworks and graphic representations are of great support.

(iv) Consider the usefulness of a concrete "entry point" (specific issue) to consider systemic issues, especially if it is geared towards action. "Sustainable food systems" is certainly too wide as an entry point, but a specific issue in relation to them can help "grasp" what SFS means, from a specific angle. This can be done by considering this specific issue in all its relationships to the sustainability of food systems, as for instance the HLPE has systematically done for food losses and waste. The entry point can also be more notional – or cross-cutting – such as gender.

(iv) The need to leave ample space for context specificities. This can be done either by being context-specific, or by delineating a framework and typologies, where specificities can fit.

(v) Ground the usefulness of any conceptual framework/typologies in a variety of illustrative and grounding detailed examples, all situated in a clearly described context, with a broad diversity of examples, regionally balanced, covering, as appropriate, various sectors, various stages of the food value chain, different scales, with a special attention to gender and to the most vulnerable populations and situations.

(vi) Taking into consideration and responding to the specific concerns and needs of the various categories of actors participating in food systems.

(vii) Be action-oriented, by contrast to being "analysis-oriented": The analysis should feed action. Being action- or solution-oriented has proved very useful to build bridges between methods and approaches from different disciplines.

(viii) Consider the possibility of proposing solutions under uncertainty or gaps in knowledge, or when the knowledge base is not so developed.

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Academic partnerships for sustainable food systems

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ABSTRACT

The concept of sustainable food systems is relatively new. As a notion, it is an attempt to strengthen the links between food production and sustainability, food security and nutrition to develop a transdisciplinary, "holistic" view of food systems. The High Level Panel of Experts on Food Security and Nutrition has recently coined an integrated definition, whereby "a sustainable food system (SFS) is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised".

Adopting sustainable food systems may offer a fresh approach for managing food security in the face of dwindling natural resources. However, to transform the concept into workable solutions, the complexities, advantages, challenges, winners and losers need to be better understood. Academia can play an important role in promoting critical thinking and research and innovations for developing sustainable food systems in partnership with national and global organizations. FAOs own revised Strategic Framework with the five interlinked Strategic Objectives, emphasizes partnerships and provides a gateway for such an endeavour. This paper explores how academic partnerships can better support FAO in advancing the interdisciplinary systems in the food and agriculture sector.

APPROACH

Using the concept of sustainable food systems as an approach to address food security is relatively new. It is an attempt to strengthen the links between food production and sustainability, food security and nutrition to develop a transdisciplinary, "holistic" view of food systems. The High Level Panel of Experts on Food Security and Nutrition (HLPE) of the UN Committee on World Food Security (CFS) has recently coined an integrated definition, whereby "a sustainable food system (SFS) is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (HLPE, 2014a). Most recently the HLPE of CFS also identified "Pathways to sustainable food systems: the pursuit of human and environmental health for all" as one the five critical and emerging issues in the area of food security and nutrition (HLPE, 2014b).

There have been a number of attempts to capture the full complexity of sustainable food systems and what this means for food security. They have been elaborated as systems

where short-term profitability and raising yields, often a main criteria for on-farm decision-making, are in balance with a number of additional objectives of resilience, including the long-term health of the land and livestock, and resilience to climate change (Godfray *et al.,* 2010). In sustainable food systems, external inputs and waste are reduced, as well as the carbon footprint (Pretty *et al.,* 2006; McMichael, 2011). Inputs and waste are better integrated with water and energy systems through a circular rather than linear economy of resource use and output (Jones, Pimbert and Jiggins, 2011). These and many other descriptions overall highlight the concerns of inefficiency of food systems, food loss and waste, social and economic imbalances, unequal access to resources and income, among others, as key issues that hinder establishing sustainable food systems and food security and nutrition for all.

Although adopting sustainable food systems offers a fresh approach for managing food security, to transform the concept into action can be challenging, given the need for scale, commitment and involvement of multiple stakeholders necessary to bring about the change. Therefore, partnerships need to be forged in an innovative manner to mobilize the best available knowledge and capacities around the world to provide the most effective services. FAO's Revised Strategic Framework[1], with the five interlinked Strategic Objectives (SO), emphasizes partnerships and their critical role to address food security challenges. It recognizes that in order to achieve the global, regional and national development goals, the participation of actors well beyond the agriculture sector is required, broadening the range of stakeholders and competing views and interests. FAO is proactively pursuing partnerships with civil society, the private sector, academia, cooperatives and farmer organizations and Member States, and has approved Strategies for Partnership with the private sector and civil society organizations respectively.[2]

Academia in particular can play an important role in promoting critical thinking and research and innovations for developing sustainable food systems. In partnership with national governments as well as with the regional and global organizations, academia can provide the much-needed evidence-based data, strengthen skills and demonstrate novel practices that can bring about the transition. From an institutional perspective, strategic alliances with universities, research organizations and networks can add yet another important dimension to multistakeholder engagements – they can not only leverage comparative advantages, share knowledge and increase capacities, but also broaden outreach among youth and open possibilities to embed sustainable food system in the wider context of academic pursuits.

The Expert Consultation on Strengthening FAO-Academia Partnerships, held in June 2014, identified a number of areas for increasing and deepening FAO's partnership with academic and research institutions to contribute to the Strategic Objectives. They commended FAO for preparing the integrated and inter-connected SO to provide a clear direction for FAO's work and identified a number of synergies and opportunities for partnerships, recognizing the need for keeping knowledge and workforce updated to

[1] C 2013/7 Reviewed Strategic Framework: http://www.fao.org/docrep/meeting/027/mg015e.pdf
[2] CL 146/8: http://www.fao.org/docrep/meeting/027/MF999E.pdf

address food and agriculture challenges. Structured long-term partnerships with academia should address specific demand-driven needs. By leveraging comparative advantages, FAO can better support Member States to stay ahead on knowledge advances, promote evidence-based decision-making and enhance skills. Some of the key areas of engagement that can be strengthened through academic partnerships are the following:

Skill enhancement

An opportunity to upgrade technical skills is essential for managing the complexities of food and agriculture systems, including for the next generation of agriculture practitioners and thinkers. There is an immense need for capacity development on the ground. A more participatory approach in academic exchanges and capacity development is needed to increase engagement and shape the intellectual discourse on the future of food. Farmers, rural workers, local indigenous groups and community leaders should participate in innovation. Engagement of partners is essential for support to governments to develop these capacities, promote research and enhance the knowledge base of field professionals. While academia design environments conducive to higher learning and critical thinking through knowledge incubators, FAO promotes south–south and south–north triangulation and use of existing platforms to motivate youth and mobilize resources for research, expertise and technology. Participation is the key.

Knowledge sharing

The outputs from cutting-edge research, modelling and other technological advances could find a better uptake in development-related projects through interdisciplinary partnerships. Many relevant topics such as sustainability, resilience, trade-offs, ecosystem services, etc. require that social, economic and environmental aspects are taken into account concurrently in developing meaningful progammes. By bringing together a critical mass of relevant disciplines and research groups at the local level, academia-led multipartite partnerships can help promote a better understanding of SFS and its challenges in implementation. Alliances can be through different diverse modalities, building on complementarities that bring north–south and south–south institutions to jointly design and implement thematic projects that impact food and agriculture systems.

Supporting country programmes

Where many of the technologies or knowledge are already available, their wider diffusion and uptake by farmers remain a key challenge. There are still significant knowledge and technology gaps, especially in addressing methodological questions and measurements, for instance related to climate change or sustainable intensification. There is an urgent need for co-innovation and building multidisciplinary networks among research and knowledge institutions so that good practices can be spread around the globe. Through joint projects, organizations can leverage mutual advantages in support of capacity development and adoption of good practices at national level.

The gap between the research agenda and research needs must be overcome. Closer links between research, education and extension are vital for a proper application of research results. At the same time, existing outputs of research must be better applied. Where academia has developed a repertoire of tools and techniques that can be of direct benefit to the farming community, FAO could help facilitate uptake by increasing engagement of local academia. More emphasis is needed for strengthening research–extension-farmer linkages in developing countries. Academia needs to participate in this process with all other stakeholders. A particularly strong plea is for expanding opportunities for youth engagement – particularly in rural areas. More investment, peer-to-peer learning opportunities, incentives for innovations, scholarships and internships in local institutions should be expanded to address food security and related issues.

Supporting policy processes

Technical advances go hand in hand with policy decisions and resources allocation. More experts from academia consider supporting normative processes, also at the national level, identifying existing knowledge-gaps in the areas of policy-setting and monitoring and lack of information, at the country and regional level. Improving policy processes, including policy monitoring and supporting country programmes, is essential for country-led transition to sustainable food systems. This can be through improved information flow and participation, improved mechanisms to mobilize data, local knowledge and integrating the lessons learned in teaching courses dynamically.

CONCLUSION

In conclusion, a more inclusive approach is necessary to make a substantial impact at ground level. Increasing the engagement of academia in a systematic manner, including through better utilization of existing academia platforms at the national and regional levels and open dialogue, can provide a range of possibilities for addressing food security and sustainable food system challenges. Mutual benefit from such partnerships can increase knowledge and enrich practical experience to jointly address the complexities and challenges of food and agriculture systems. As a knowledge organization with its feet on the ground, FAO is fully engaged in the process.

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Sustainable solutions for tropical agriculture: Brazilian experiences

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ABSTRACT

Although there is much to improve, the Brazilian Government and many representative groups in society have spared no effort in the past 12 years to generate sustainable practices and technological solutions, understanding that these alone are not enough, but that other government actions are crucial to deploy fact sustainable production, such as public policies, credits to encourage sustainability in the field, improving the technical assistance and rural extension system and engagement in the process by the production chain and strategic members of society. There is still a lot to do to advance improvements but some sustainable practices are beginning to be deployed, with successful results not only from the legal aspect, but also special credits and sustainable technologies – for example, the new Forest Code, the Federal Program of Low Carbon Agriculture and the National Policy of Agroecology and Organic Production, among others, with many positive results in the field.

INTRODUCTION: CONCEPT AND PRINCIPLES OF SUSTAINABLE PRODUCTION

This paper describes a short and general approach to Brazilian sustainable agricultural practices, especially those conducted by Embrapa, the Ministry of Agriculture and other partners from national agribusiness. In the context of this paper, sustainable agricultural production is defined as production respecting environmental limits and social needs for present and future generations, emphasizing positive economic results. To reach sustainable production, the following principles should be followed:

- comply with environmental and social laws;
- produce more with less with production cost reduction;
- reduce social and environmental negative impacts and expand social and environmental positive impacts;
- promote adoption of sustainable knowledge and technologies through public and private rural extension;
- stimulate innovation on sustainable solutions in the field through special rural credit and other economic incentives;
- be market-driven: be much more interactive with the producers/clients chain – capturing signs from the social and economic environment.

It is therefore necessary to take into consideration the interests of producers, consumers and other stakeholders that make up parts of the supply chain.

First, it is fundamental to understand what producers want. Certainly they want more and more productivity, with the lowest production costs. Of course, being market-driven, they need to offer good products to the consumers. This is an important education process managed by government towards producers' behaviour until a new fair-trade culture is built.

On the other side, consumers want a fair price for the products, good appearance and good flavour, clean products, good nutrition, functional foods and sustainable products, respectively. This sequence follows the consumers' awareness standards.

Other partners needs must be analysed and will be tracked case-by-case, which means that the demand will define the quality and quantity of players' direct or indirect interaction along the supply chain.

BRAZILIAN AGRIBUSINESS CONTEXT

The present stage of Brazilian agriculture has resulted from a long history of more than 200 years and especially from the last 40 years. During the colonial period (until 1822), experience in agriculture was restricted to sugar cane. When European immigrants arrived in the nineteenth century followed by immigration cycles throughout the twentieth century, the rural Brazil population could combine their agricultural culture with local culture. In addition, the agricultural colleges installed from the second half of the nineteenth century until the first half of the twentieth century developed a knowledge base for developing coffee, cacao and cotton crops, and even sugar-cane and dairy production. Despite this agricultural evolution, with the exception of coffee and sugar cane, Brazilian production was limited and there was a demand for much more technology and rural infrastructure.

Until the 1960s there was insufficient local production of food and Brazil had not reached food security. It was common to see long queues to buy food (Figures 1 and 2).

Figure 1. End of the 1940s: line to buy bread, State of Bahia, 1949
Source: Historical documents of the State of Bahia Government, 1949.

Figure 2. Food lines in Londrina, Paraná, 1961
Source: Historical documents of the Municipality of Londrina, 1970.

According to Ministry of Agriculture documents (1977), until the early 1970s Brazil was a big importer of food:

- imported beef from Australia;
- milk from Europe;
- rice from the Philippines;
- beans from Mexico;
- wheat from the United States of America, Canada and Argentina.

Furthermore, in the 1970s, the average Brazilian family spent about 40 percent of household income on food; currently, this value is only 16 percent (2013). In addition to rural credit and rural extension policies, the strong investment in agricultural research was important, which culminated in the foundation of Embrapa in 1973.

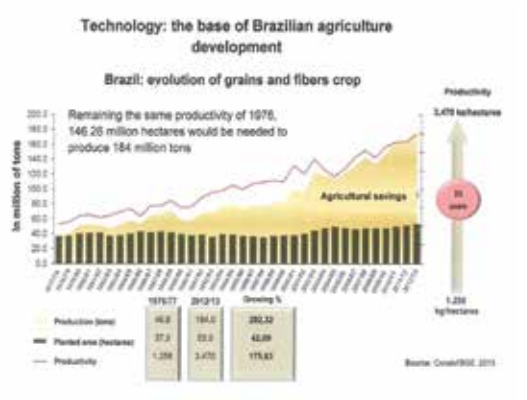

Figure 3. Technology: the base of Brazilian agricultural development Brazil: evolution of grain and fibre crops

Notes: The red line is the productivity over the years. The dark green columns represent the area occupied by agricultural production (in hectares) and the light brown stain represents the production (in tonnes).

Embrapa policies throughout its 40 years have been focused on a strong training programme for researchers, a concentrated effort to develop appropriate tropical agriculture, adoption of strategic plans since the 1980s, and a research system based on producer demand and strong financial support from the federal government.

In the 1970s and 1980s, Embrapa research had focused on the quest for productivity. In the 1990s and 2000, the goal was productivity with sustainability and currently the focus is on innovation towards sustainability, food security and nutrition.

According to the Ministry of Agriculture (2013), Brazilian agriculture represents 22.4 percent of the GDP and 37 percent of formal employment in the country; the sector is responsible for 37.9 percent of Brazilian exports although only 30 percent of Brazilian agricultural production is destined for export.

Adoption of technology in the field enables one to increase production through a productivity increase rather than by extending cultivated land. Figure 3 verifies this relationship, and shows a saving of 70 million hectares.

CONTINUOUS SEARCH FOR AGRICULTURAL SUSTAINABILITY

Understanding that sustainability is an ongoing process and that Brazil today is more sustainable than 20 years ago and will certainly be more sustainable in 20 years, the challenges are enormous, and the country must proceed with the evaluation and continuous improvement in policies and actions towards increasing sustainability of Brazilian agricultural production. Some guidelines in this direction have been set by the Ministry of Agriculture towards encouraging sustainable agricultural production.

Elaboration and implementation of public policy

Over the last 16 years, laws have established environment rules and financial support for stimulating the sustainable agriculture – e.g. Environmental Crimes Law (Law 9.605, 12 February 1998); National System of Protected Areas (Law 9.985, 18 July 2000), Forestry Code with rules to regulate land occupation (Law 12.651, 25 May 2012); Inovagro (Decree 6.065, 21 March 2007); ABC Program (Resolution BACEN 3.896, 17 August 2010); National Policy of Agroecology and Organic Production (Decree 7.794, 20 August 2012); Funding Program for Family Farming (Decree 1.946, 28 June 1996). These laws, decrees and resolutions can be found at www.e-diariooficial.com.

Some technological solutions for sustainable production

Embrapa and other partners from the National System for Agricultural Research (State and local research organizations and universities) have developed technological solutions for sustainable agriculture, especially from 1992.

Participatory strategies for and with players

Farmers, producers' associations, bank credit institutions (public and private), rural extension organizations, agricultural research institutions, agri-industries, regional and local governments have been integrated on discussions and process construction of the ABC programme, especially for the implementation strategy stage.

Wide programme of training for technicians and producers

Governmental and private extension services, as well as technicians from public and private banks, have received training on sustainable technology and knowledge.

Detailing some points on public policy

INOVAGRO (Technological Innovation for Agricultural and Animal Sustainable Production Systems) represents an important innovation step in terms of public policy for sustainable production. This programme includes:

- Public policy focused to assist farmers (individuals or corporations) and cooperatives to adapt their production systems to meet good agricultural practices, an integrated production system and animal welfare.
- It is possible to finance up to 100 percent of the project, including professional development and consulting for the project itself.
- A limit of USD500 000 per beneficiary in the case of particular projects, or of USD1 500 000 for collective projects.
- Banking interest: 4 percent per year, with a grace period of three years and a payment period of ten years.

ABC programme – low carbon agriculture

The programme focus on the following technological solutions for application to agriculture:

- integrated system on crop–livestock–forest (ILPF);
- no-till system;
- biological nitrogen fixation;
- recovery of degraded pastures;
- organic system;
- planting forests (native and exotic forest species adapted);
- sustainable use of organic manure (especially from pigs and poultry).

Figure 4. ABC Programme

ABC programme: strategy of implementation

Since 2011, 4 million hectares have been incorporated in the ABC programme and 25 482 farmers have been trained (in project formulation and use of technology). The programme has been supported by funding from the federal government and adopted the following strategy of implementation:

- campaign to raise awareness and mobilize business and family farmers, cooperatives, producer associations, state governments and municipalities;
- publicizing the programme through the media;
- mobilization of the governments of the states (through the Secretariat of Agriculture) and of their rural extension systems;
- training of technicians of banks, extension workers (from the private sector and government) and farmers.

Figure 5.
Source: Embrapa Cerrado, 2011.

Figure 6. Transformation of Brazilian Savannah: from poor soil to productive land
Source: Embrapa CNPTIA, 2011.

The local governments and other local stakeholders know their problems and challenges better than the federal government. Thus, an important aspect of ABC implementation strategy was that the local groups define the ways to follow according to an "umbrella" defined by the federal policy established by the Ministry of Agriculture.

Figure 7. Field day in Embrapa Cerrado on the the ILPF system
Source: Embrapa, 2014.

Figure 8. Quality of the root system after bacterial inoculation
Source: Embrapa Agrobiologia, 2008.

Some ABC programme technological solutions

The no-till system has proved to be more environmentally sustainable than the conventional tillage system and is currently estimated to have been adopted in 75 percent of the area annually occupied by grain crops in Brazil. The technology is based on the deployment of crops without ploughing the ground, and uses crop residues from the previous crop. The system also provides a permanent soil cover and rotation of species. Some important results have been shown, increasing the greater conservation of soil and water, maintenance of soil biodiversity and increased crop yields, as well as the facilitation of the process of planting and cultivation. Using the no-till system, the Brazilian 2012/2013 harvest produced approximately 85 million tonnes of soybeans on 27 million hectares.

There is visible progress in terms of improving soil quality when adopting the no-till system, as shown with Brazilian savannah soils in the areas covered with crops. The Brazilian savannah soils are normally acid, with a pH of 4 percent, on average; they are also poor in terms of organic matter.

As part of the ABC programme, the ILPF : Integrated system on crop - livestock – forest represents a set of production systems that combine various agricultural, forestry and livestock species, including crop rotation. It promotes greater biodiversity with economic species and generates better environmental balance compared with monoculture systems. Figure 7 shows a field day in Embrapa Cerrado on the ILPF system.

Biological nitrogen fixation (BNF) is an important Embrapa biotechnology used in the ABC programme that in 2013 saved around USD3.4 billion of imports of nitrogen fertilizers. In the same year, 24 million of hectares were planted with BNF – all soybeans.

The transformation of nitrogen from atmospheric air in forms assimilable by plants is performed by nitrogen-fixing bacteria and some blue-green algae (cyanobacteria), and the universal enzyme known as nitrogenase.

Before being absorbed, nitrogen is removed from the air and turned into water-soluble ammonia, which is used directly by the plant, when the BNF process occurs. The fixed nitrogen can also be converted into nitrate in the soil, so that it is also available to plants. In Figure 8 it is possible to observe the process of the association of diazotrophs, mainly of the genus Rhizobium, with roots of plants of the legume family (Fabaceae), which denotes

a kind of symbiosis, a term that defines a kind of beneficial relationship between the partners, in this case the plant and the bacteria.

Integrating the ABC programme, the National Policy of Agroecology and Organic Production has adopted the following strategy of implementation:

- to promote the expansion of and support for the organization of organic and agro-ecological production systems, especially focusing on financial resources for stakeholders (technicians and farmers), stimulating training, methods and techniques to change from conventional farming systems to organic systems;
- to implement public campaigns (advertising) to promote organic and agro-ecological farming;
- to evaluate and register organic producers and support organic certification for farmers.

Figure 9. Experimental field of Embrapa Agrobiology
Source: Portal Embrapa, 2008.

Figure 10. A manure treatment plant
Source: Embrapa, 2014.

In accordance with Ministry of Agriculture data, the area of organic systems in Brazil grew 300 percent in ten years. The number of organic farmers is about 35 000. Figure 9 shows a kind of organic system.

The ABC programme also promotes the sustainable use of organic manure, especially from pigs and poultry. Many pig farmers and chicken farmers generate much organic waste that historically pollutes surface water and groundwater. The ABC programme, through this waste management component, stimulates and encourages the adoption of sustainable practices, including reversal of the problem into an opportunity for power generation and organic fertilizer, thereby generating income for the producer. Figure 10 shows a sustainable model for waste treatment and power and/or fertilizer source.

An important legal base as well as a driver for sustainable production is the Forestry Code with its rules regulating land occupation by farmers. This national law establishes: that it is forbidden to cut the vegetation cover along rivers and any watercourse or wellspring; that areas with slopes above 45 degrees are forbidden for agriculture or livestock farming; that farmers must recover degraded areas along the rivers or wellspring; and must follow the map for using land according to its biosensitivity. For example: in the Amazon bioma 80 percent of forest must be preserved, including on private lands; in the Cerrado bioma (Brazilian savannah) 35 percent of natural vegetation cover must be preserved; and in other biomas, 20 percent of natural cover must be preserved. It is necessary to carry out environmental impact studies and mitigation measures for projects involving environmental impacts, even if they respect the forest code. In addition to these control measures, it is

Figure 11.Map of biomes and legal limits to deforestation (including private property).
Source: www.uff.br, 2012.

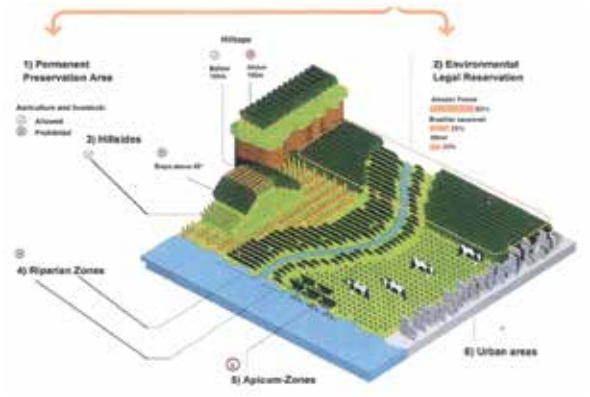

Figure 12. Brazilian Forest Code shown in a model farm
Source: http://nicholegal.blogspot.com.br/2013/01/novo-codigo-florestal-x-termos-de.html

forbidden to cultivate sugar cane in the Amazon bioma. It is important to understand that the Amazon bioma is not suitable for soybeans crops.

Figure 11 shows the Brazilian bioma control in accordance with the law.

Figure 12 demonstrates how to produce while respecting the Forestry Code, as a way to protect vegetation cover/biodiversity, water resources and quality of soil.

Definitions:

1) **Permanente Preservation Areas** - Areas with function to conserve water, the landscape in fragile soils, besides the biodiversity. In this category are: hillsides, hilltops and forests along the rivers (riparian zones).
2) **Environmental Legal Reservation** - Areas into the rural properties with native forest cannot be completely deforested. It must obey the law orientation according to the

specific biome - Amazon Forest, Cerrados (Savannah), others. Activities such as cutting wood and vegetable oils extraction or even collecting fruits are released if conducted through sustainable management.

3) **Hillsides** - Slopes with gradient greater than or equal to 45 degrees should be preserved to prevent erosion.
4) **Riparian Zones** - These areas if deforested should be recovered. If they are preserved it must be protected ranging from 30 to 500 meters depending on the river width.
5) **Apicum-Zones** – These are included into the Permanent Preservation Areas.
6) **Urban areas** – These areas should follow which defines the master plan of territorial occupation.

Embrapa and other partnerships from the national system of agricultural research have developed some biotechnologies, such as biopesticides, genetically modified organism, "green" technologies, adapted tropical seeds, and adapted technologies for climate change.

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Accounting for water use in agriculture

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ABSTRACT

In many areas, irrigation plays a key role to increase and stabilize food production. Its importance is increasing with growing food demand and with climate change. It also plays an essential role in increasing and stabilizing farmers' income, particularly where water and/or land are scarce. At the same time, agriculture is already a major water user and confronted in many areas with water scarcity and increasing competition from other users. This calls for a more efficient and sustainable management of irrigation from field to watershed, grounded on accurate knowledge and information. It requires appropriate measurement of water use, of its adequacy to meet plants' needs and adequate tools to compare the efficiency of different farms and farming systems as well as availability of data at the appropriate scales. Such information has then to be made available to relevant actors – first of all to the farmers themselves. This contribution provides an overview of various water use accounting devices and systems, at diverse scales, from farm to broader scales. It finally considers means to share knowledge and information among farmers as well as with other actors in order to improve water management for sustainable food systems.

INTRODUCTION

Water is indispensable to plant growth, in sufficient quantity and at the right time, both of which depend on plant species, varieties, agronomic practices and on climate. Irrigation plays a key role for agricultural production in many areas of the world. It allows more liberty in the choice of species, varieties and agronomic practices in given climatic conditions. It often allows for higher yields and can enable, in favourable conditions, multiple crops per year. Finally, it ensures more stable yields, in spite of climate variability, particularly rainfall pattern changes. Worldwide, irrigated agriculture occupies 16 percent of arable land and produces 44 percent of total crop production. Irrigation thus plays a crucial role for food security by increasing and stabilizing production, at global as well as at farm levels. Some of the big "bread basket" regions in the world are irrigated. It enables farmers to draw a better living from smallholdings. The existence of irrigation in itself is a factor of the "size" of holdings, as if irrigation acted as an "area multiplier": countries that have a legal definition for small holders often use different farm size thresholds for rainfed and irrigated smallholdings (HLPE, 2013). Small irrigated plots are often used for horticulture and as such play a crucial role to ensure more balanced diets throughout the year.

Increasing scarcity of water resources and growing competing demands call for sustainable management and better use efficiency. Agriculture accounted globally in 2011 for 70 percent of total freshwater withdrawals (World Bank, 2014). The irrigated area has more than doubled worldwide over the last 50 years. According to FAO's projections, global demand for water withdrawals from agriculture will increase by 11 percent from a 2006 baseline to 2050 (Bruinsma, 2009). It is estimated that, on average, a total withdrawal rate above 20 percent of renewable water resources represents substantial pressure on water resources – and more than 40 percent is "critical" (FAO, 2012a). Agriculture, industry, other sectors and domestic uses all contribute to increase the total withdrawal rate. In some regions of the world water scarcity is already putting agricultural systems at risk (FAO, 2011). In some cases, when relying on extraction from non-renewable aquifers, withdrawals can exceed 100 percent of total renewable resources.

Managing water scarcities for food production and food security calls for a more efficient and sustainable management of irrigation, from field to watershed, grounded on accurate knowledge and information (HLPE, 2015). It requires appropriate measurement of water use, of its adequacy to meet plants' needs and adequate tools to compare the efficiency of different farms and farming systems as well as availability of data at the appropriate scales. Such information has then to be made available to relevant actors – first of all to the farmers themselves, and also to decision-makers at various levels, including to justify water allocations for agriculture. Diverse methodologies, tools and indicators have been developed to assess water use, as well as efficiency and productivity related to water use, for various categories of actors: farmers, water managers, policy-makers, industry and consumers. This paper briefly considers some of them. It starts from the farm, from the means to measure water use in irrigated systems and how such information can help optimize them. It then considers some of the indicators used at broader scales by policy-makers and tools linking water use to products and consumption.

MEASURING WATER USE IN IRRIGATED SYSTEMS

A very first step in any assessment of water management is to measure water use, at the appropriate level. It is not as straight forward as it could seem. It can mobilize tools to assess water stocks, fluxes, their change over time, including taking into account water inside or outside the runoff system, such as soil moisture. At farm level, it requires availability of adequate measurement devices, properly maintained, with regular monitoring and data recording. All this can be particularly challenging, especially in developing countries. At broader levels, water catchment or river basin, it can require the exhaustive compilation of data collected at farm level, in a harmonized format. Such exercises require implementation of harmonized measurement protocols, which could involve *in situ* controls. Their optimal design very much depends on the type of irrigation, the resource used, and the existence of a water allocation or pricing scheme. Alternatively, measurements can be conducted directly on the river or groundwater levels, which can lead to an indirect estimation of the impact of irrigation practices if sufficient data is available to estimate upstream fluxes and other withdrawals. The increasing use of groundwater for irrigation in recent decades also poses problems for water accounting, since both the stock of this resource and the rate at which it is depleted and replenished are difficult to measure (FAO, 2012b).

Table 1: Tools to measure water levels, and directly or indirectly measure water use at farm and irrigation system level

Measurement devices	Description	Areas of use in the irrigation sector	Strength	Weakness
Hydrometer	Measures the level reached in the tanks, canals and water courses.	All	The survey of the data can also be done by untrained personnel. Cheap. Allows the indirect estimation of flow rates.	There could be difficulties to read the height due to difficulties to access the hydrometer, in the case of courses or wild rivers.
Level and flow sensors	Rigid rod immersed in tanks, canals, with the aim of measuring the level reached by the water in them.	All	Easy to use. Cheap. Allows the indirect estimation of flow.	Cannot be used at heights above the meter. For electronic instrument, need to ensure the power supply.
Ultrasonic level sensor	The tool is based on the response time of the echo reflected.	All	Continuous recording of the signal. Reliable. Cheap. Allows the indirect estimation of flow rates.	The reading may be difficult in case of changes in the water level of the signal.
Devices measuring pressure level (pressure gauge, piezometer, pressure cell, etc.)	The measurement of the water level is carried out in tanks and canals. The measure can be determined indirectly by measuring the pressure of the fluid. Each pressure variation causes a variation in the level.	The limitations to the use are due to the type of channel or tank to which it is applied.	The tool can be used only if the channel walls or the tub, are easily accessible and the application of the instrument is easily installable.	Difficult to use in opencanals.

The measurement of water levels, pressures and flow rates is key to evaluate the performance of water management in irrigation systems. Differents tools can be useful at farm level, or at the level of a specific irrigation system. These tools come with their own cost, functions and performance: the choice of the type of measures, the measurement technique and type of tools have to take into account the characteristics of the site and of the irrigation system, as well as economic costs of investment and maintenance. Measurement tools need to be reliable, easy to use, allow for a good recording frequency and be in line with local uses, particularly in collective irrigation schemes. Table 1 provides some characteristics of some of the main tools available.

BETTER INFORMATION TO OPTIMIZE IRRIGATION

For a determined crop and irrigation technology water use efficiency (the amount of crop grown per unit of water consumed) can be improved through irrigation scheduling to ensure closer coverage of crop water requirements, both in quantity and frequency. Traditional techniques to assess actual crop water requirements are based on observations in the field of plants and soil (including soil moisture). Procedures for estimating irrigation

Box 1: The project SIRIUS (Sustainable Irrigation Water Management and River-basin Governance): Implementing User-driven Services

The SIRIUS project, funded by EC FP7, aims to introduce innovative water management tools to support sustainable agriculture and promote efficient irrigation management practices both at farm and water basin levels. The study is carried out in eight pilot areas situated in Brazil, Egypt, India, Italy, Mexico, Romania, Spain and Turkey. The project is developing new tools and services for water managers and food producers. These include maps detailing irrigation water requirements in different areas, crop water consumption estimates, and a range of additional information products in support of sustainable irrigation water use and management under conditions of water scarcity and drought. In Italy, the project is conducted in an area of Campania. Calculation of crop water requirements is done using various canopy variables (crop height, surface albedo and leaf area index) derived from space: earth observations optical data. This information is fed into a decision support system, SPIDER (System of Participatory Information, Decision-support and Expert Knowledge for Irrigation and River-basin Water management) that, in turn, provides irrigation advice. Results of the project in this area at the end of the second year of operation showed a 20 percent decrease in use of water for irrigation during the 2012 irrigation season (Altobelli *et al.,* 2012).

requirements can also be based on the use of Earth Observation (EO) satellite-based technologies (to estimate different variables regarding the different components of the water cycle, from atmosphere to water bodies, land/soil and vegetation), applied modelling and *in situ* networks. Such a range of tools can indirectly provide insights as to the volumes of water available and used. Information technologies can make such data easily available to farmers (Molden and Sakthivadivel, 1999).

Water accounting methods based on the analysis of data from EO and description of hydrological processes can enable an assessment of the demand for water for irrigation purposes in relation to the availability of water resources. They can also be used for monitoring water use at broader levels and for evaluation of space-time efficiency of an irrigation network. Such techniques can help farmers and irrigation managers to optimize crop productivity and cost-effectiveness by providing them with irrigation scheduling information based on the actual crop development (Vuolo *et al.,* 2015) as in the SIRIUS project (see Box 1).

The effective application of improved irrigation scheduling is highly dependent on the capacity of the irrigation system to deliver water according to the schedule. In collective surface irrigated systems, individual farm irrigation schedules are often constrained (Chartzoulakis and Bertaki, 2015). Collective information services like those developed by the SIRIUS project can help link individual and collective management of irrigation.

AGRICULTURAL WATER USE INDICATORS AT BROADER SCALES

Given the importance of water for agriculture as well as the major role of agriculture in global water use, indicators of agricultural water use can be particularly useful as an element to monitor overall pressure on water resources (Gould, 1972; Parris, 2004) and to

orient both agricultural and water policies.

Some key indicators covering different aspects of agricultural water use at broader levels are listed below (Osteen, Gottlieb and Vasavada, 2003; Parris, 2004):

- **Water use intensity**. The share of agriculture water use in national total water utilization.
- **Irrigated area.** This indicator shows trends and spatial differences in irrigated areas or in the percentage of agricultural land that is irrigated.
- **Irrigation volumes**. Volume of water withdrawn for irrigation purposes in a given area and in a given period.
- **Irrigation by crop types**. As different crops are subject to different levels of irrigation it is useful to break down indicators of irrigated area or volumes by crop types.
- **Irrigation management indicators**. Defined as the share of irrigation water applied by different forms of irrigation technology. This indicator is calculated as the share of irrigation water used under different irrigation technologies and systems (such as flooding, high-pressure rain guns, low-pressure sprinklers and drip-emitters) divided by the total quantity of water used for irrigation. Scientific and well-managed irrigation methods (drip-emitters, booms and pivots) have facilitated a reduction in water use to the minimum levels required by the crop in some countries. However, this reduction in water use is often accompanied by an increase in irrigated area, so that the overall quantity of water used remains the same.
- **Water use efficiency** calculated on irrigated agriculture land is defined by two indicators: *Water Use Technical Efficiency* (WUTE), which is the quantity of agricultural production (tonnes) per unit volume of irrigation water utilized; *Water Use Economic Efficiency* (WUEE), which is the monetary value of agricultural production per unit volume of irrigation water utilized.
- **Water stress** is generally defined as the condition that is reached when a minimum shreshold of available water resource per capita (for all uses) is reached. Other definitions include the ratio of withdrawals to available ressources. The World Resources Institute (WRI) further defines levels of water stress in river basins, poiting to the fact that worldwide 18 river basins are facing extremely high water stress, meaning that more than 80 percent of the water naturally available to agricultural, domestic and industrial users is withdrawn annually – leaving businesses, farms and communities vulnerable to scarcity.

  Management of water stress can be done and assessed interalia through:

  - Minimum reference flows. Some rivers are subject to diversion or regulation for irrigation without defined minimum reference flows.

  - Policy indicators such as the percentage of river lengths that do or do not have recommended minimum flow rate reference levels, i.e. where there are no regulations to ensure the maintenance of downstream flows.

WATER USE RELATED TO OUTPUTS AND CONSUMPTION

The quantification of water use has not been well covered in life cycle analysis (LCA) until recent years (UNEP, 2012).

Virtual water (VW) and water footprint (WF) are used to characterize the amount of water needed to produce a specific product along the food chain.

The VW is the water needed all along the production chain to elaborate a specific product (Allan, 2003), and thus is "embedded in it", whatever the origin of that water, rainwater, surface water or groundwater. The concept has been particularly powefull to describe how countries can compensate domestic water scarcity by importing "water intense" commodities, particularly food (Allan, 2015).

The WF has been constructed in analogy with the ecological footprint. It characterizes the consumption of water, both "green water" (rain water) and "blue water" abstracted from rivers and aquifiers, as well as, the volume of water needed to dilute pollution, called "grey water" (linked to the activity/services or product), taking into account both the direct and indirect use of water, to an acceptable level. The WF of an individual, a community or a company is defined as the total volume of freshwater used to produce the goods and services consumed by that individual, community or business (Hoekstra and Hung, 2002). The WF is often used as an empirical indicator of water consumption. It allows to reflect on how and why water is consumed, for different goods, services or activities (Hoekstra and Chapagain, 2007). It also helps scientists and professionals to communicate (Allan, 2015).

The promotion of the WF concept and information about average WF of products have played an important role in raising awareness on the role of consumption as a driver of water use. Awareness of WF of different goods and services can contribute to orient choices towards more sustainable consumption patterns. However, its reliability depends on the degree of precision of the data used. Also, the addition of three types of water use (green, blue and grey) can make it difficult to interpret for consumers. This is why some recommend not to use it for labelling (European Commission, 2011).

Some studies use the WF of products to compare agricultural systems (Mekonnen and Hoekstra, 2014). They show that the WFs of products vary enormously across regions and within regions and that they are largely determined by agricultural management, with important potential for improvement. They note that fertilizers often improve water productivity, because yields increase. There can, however, be trade-offs as grey water increases. Mekonnen and Hoekstra (2014) identify, for crops worldwide, a potential of 39 percent of global water saving (green and blue) and 54 percent of reduced pollution, by reducing water footprints per unit of crop to the levels of the best quarter of global production. Such studies show that the WF can be particularly useful to facilitate comparisons and establish benchmarks.

The WF could be a good candidate to measure water used by irrigation (blue water) and water pollution (grey water). The later could also constitute an aggregated proxy indicator of pollution caused more generally by inputs use (fertilizers and pesticides) in agriculture and food chains, and thus indirectly also of some of its impacts on biodiversity, aquatic, but not only. To better fulfill these functions for all actors, three points need to be improved in the way the WF is calculated and used (Meybeck, Gitz and Altobelli, 2015). First, it should enable calculation of the "water footprint of the outputs of main interest", knowing that the nature of this main interest can be different for each type of actor; food for consumers, but for instance also income or jobs for farmers and

public authorities. Second, it should focus on most critical points, blue and grey water, including the need to distinguish non-renewable sources of water, such as through the identification of "red water" as suggested by some authors (Greco and Antonelli, 2013). Finally, it should enable calculation of WFs at the level of detail corresponding to the range of choices of the various actors. This will require adequate collection of data, linked to specific practices and systems, calculation of benchmarks and appropriate tools to make this information available.

DISCUSSION

Water is an essential input for agriculture both in itself and to ensure best use of other resources. The "efficiency of water" in agricultural and food production needs to take into account the numerous dimensions of its use. It is linked to the availability of other inputs, and can enhance the efficiency of the use of another resource. It also needs to take into account that agriculture delivers on a range of different objectives and outputs. Agriculture produces food and also livelihoods, jobs and income – which from a food security perspective are equally important. The level and range at which water efficientcy is calculated are central to its usefulness to inform action and choices. These aspects call for a diversified, multidimensional approach to account for resource use with appropriate tools to measure each type of resource use and impact, (Gitz, Meybeck and Huang, 2012).

Hoekstra and Hung (2002) propose distinguishing three different levels to deal with the available resources in an economically efficient way: user level, for "local water use efficiency", national or catchment level, for "water allocation efficiency" to optimize allocation depending on the value of water in its alternative uses, and worldwide level where "global water efficiency" can be pursued through international trade. The overall efficiency in the appropriation of the global water resources can be defined by the combination of local efficiencies, meso-scale water allocation efficiencies and global water use efficiency.

At each level, all actors need to be able to adequately monitor and record water use. Being able to link it to outputs can facilitate comparisons and the establishment of benchmarks. Most of the methodologies and tools have been developed for a precise use, having in mind a specific category of actors (HLPE, 2015). Table 2 compares the main categories of metric tools for water management and use.

As shown by this table each tool has a different main purpose, with advantages and limitations. The selection of accounting tools has to take into account the specific needs, priorities and capacities of the various categories of actors. Information prepared for a specific category of actors is not necessarily easy to transfer to another category. For instance, information about water volumes used for a product would be difficult to use as a basis for consumer aimed labelling or certification but could be used rather for consumer education; consumer aimed certification and labeling schemes should rather incorporate information about water stewardship (European Commission, 2011).

Concerted action to improve the sustainability of water use thus calls for two apparently contradictory tendencies for water accounting: methodologies and tools adapted to the

Table 2: Comparison of metric tools for water management and use

Tools	Description	Purpose	Main users	Advantages	Limitations
Water efficiency	Indicator of water used by a system with respect to water as input.	Measure the efficiency of systems (such as irrigation systems) in their capacity to provide water where intended, in order to compare options and improve the system.	Engineers Practitioners Farmers	Simplicity and well adapted to its specific public.	Needs to be very clearly caracterized (pipe level, basin level etc..). Only indirecty linked to output or to FSN.
Water productivity	Indicator of output (physical, economic social, etc.) of a system with respect to water as input.	Measure the benefits provided by liter of water in a certain system, in order to compare options and improve the system.	Engineers Practitioners Farmers (the case being, other decision-makers)	Focused on output, and as such clearly of interest for FSN.	Diverse approaches of the concept , especialy how to treat multiple dimensions. Important data needs.
Water footprint	Indicator of the total volume of fresh water that is used directly or indirectly to produce a product.	Measure the aggregated direct and indirect water consumption of countries or individuals (given their consumption). By extension, evaluate the impact of the consumption of a certain product.	Consumers	Simplicity of the information provided. Concept aligned with other footprint indicators. Popular.	Does not properly account for local-specific impacts. Very data-intensive.
Water in Life Cycle Analysis	Indicator of the resource use and environmental impacts caused by the production, consumption and disposal of a product from cradle to grave.	Measure of the efficiency (economy) of a process with respect to resource use and/or impacts (generally environmental).	Businesses	Comprehensive, detailed method. Well described methodologies.	Very data intensive. Results often challenging to communicate to non-specialists.
Virtual Water	Measure of the water "embedded" in produce.	Describe indirect consumption of water by countries, through trade, exports and imports.	Analysts	Simple, popular	Does not properly take into account local specific impacts.

very needs of the different categories of actors and, at the same time, ways to share and exchange information. It also calls for ensuring, as much as possible:

- The comparability of results, at least at the same level and inside a category of actors.
- The collection and transmission of data and/or information from one category of actors to another, by appropriate means.
- The availability and accessibility of clear and transparent methodologies as well as of data.

This requires a very clear understanding of the purpose, and limits, of each methodology and tool.

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Addressing nutrient management performance

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ABSTRACT

Nutrient stewardship is the efficient and effective planning and management of plant nutrients in a manner that improves the social, economic and environmental performance of mineral and organic fertilizers. The fertilizer industry promotes nutrient stewardship as a measure to improve nutrient use efficiency (NUE). There are currently calls to use NUE as the sole indicator of nutrient performance. The fertilizer industry believes that indicators of efficiency must be complemented by indicators of effectiveness reflecting: (i) productivity per unit land area; and (ii) maintenance of an appropriate level of the soil's nutrient-supplying capacity. NUE is not a system-wide and performance-wide (agronomic, economic, social and environmental) indicator. Because of its limitations, it should only be used in combination with other types of indicators relating to crop productivity (e.g. yield per area unit) and soil fertility (e.g. soil organic carbon). Therefore, before setting potentially arbitrary and global quantitative NUE targets, the fertilizer industry recommends a multistakeholder effort to undertake a scientifically driven consultation to agree on NUE indicators, their measurement and targets, and needed complementary indicators.

Recognizing that there are various barriers and constraints to improving NUE in practice, Fertilizers Europe has set up an EU Nitrogen Expert Panel to bring together experts from science, industry and government with the specific objectives to communicate a vision on how to improve the NUE in the food chain in Europe, to generate new ideas and recommend effective proposals and solutions, and finally to act as referee in controversial issues and to communicate as authority.

The first mandate and sessions are dedicated to establishing a definition and framework of NUE as an indicator for food system performance. The initiative has a European scope to develop and agree upon a widely-accepted operational framework for NUE as a performance indicator to serve not only countries and regions but also sectors and farms. In the first phase, NUE will be estimated at regional and national level based on data and information from Eurostat, the Organisation for Economic Co-operation and Development (OECD) and FAO.

INTRODUCTION

Plant nutrients play an essential role in a sustainable food system by increasing agricultural productivity, improving the nutritional value of foods and supporting farm families through increased incomes and better nutrition.

- The effective and efficient use of plant nutrients supports sustainable agriculture by increasing yields on existing arable land.

However, plant nutrients need to be managed efficiently and effectively.

PLANT NUTRIENTS: FERTILIZERS

Sixteen macro- and micronutrients are essential for the growth of most plants. They are derived from the surrounding air, water and soil – but often not enough (or in forms that the crop cannot use) to sustain crop yields. Thus other sources such as organic materials (manures) and manufactured fertilizers are needed. By adding fertilizers, crop yields can often be more than doubled or even tripled especially in sub-Saharan Africa (SSA). It is estimated that over 50 percent of the food that we eat today is produced globally thanks to fertilizers. Fertilizers, therefore, represent an essential ingredient in the drive towards world food security.

The nutrients in manufactured fertilizers are in known quantities and form, so these can easily be managed to sustain crop growth and at the same time prevent losses to the environment. The global fertilizer industry produces about 180 million tonnes of fertilizer nutrients annually. Nutrient losses cannot be entirely avoided; thus nutrient management is crucial to prevent misuse and any negative impacts on the environment.

Nutrient management/stewardship refers to the efficient and effective planning and management of plant nutrients in a manner that improves social, economic and environmental performance of mineral and organic fertilizers through site- and crop-specific implementation of universal scientific management principles related to source, rate, timing and placement.

WHY DO WE NEED NUTRIENT STEWARDSHIP?

Farming systems and practices are very diversified – within a country, region and globally. Thus, nutrient management/stewardship is undertaken differently in these different farming scenarios, offering different challenges and opportunities.

In developing countries, smallholders dominate the farming community. The world counts 1.5 billion farmers, and 70 percent of them are smallholders. Farms are normally small ranging on average from half a hectare to two hectares; lands are rented, employ manual labour and are mostly family-managed by women, with "limited" to "no" access to modern technologies, knowledge, finance and markets.

On the other hand, in developed countries, hundreds or thousands of hectares of farmland are owned by one farmer or by corporations; they are highly mechanized, with access to modern technologies, information and markets.

Thus, to change farming practices on 1 million ha (in developing countries), one has to reach out to 1 million farmers in India and SSA, a few thousand farmers in Europe and North America, and only a few hundred in the Brazilian Cerrados.

ANOTHER REASON FOR THE IMPORTANCE OF NUTRIENT STEWARDSHIP

If we take a world view of nitrogen use, what is striking is the diversity of the issue. Figure 1 illustrates nitrogen imbalances. It shows that some regions of the world use, regrettably, too little nitrogen (in red on the map), whereas others have an excess nitrogen input (in green). (Similar imbalances also exist for phosphorus and potassium).

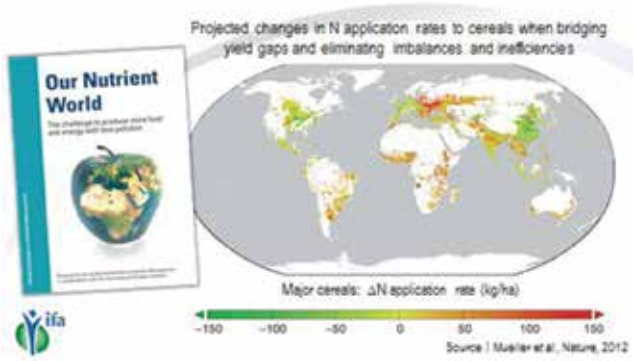

Figure 1. Unbalanced – over/under/misuse – of plant nutrients
Source: Mueller *et al.* (2012).

The report *Our nutrient world* (Sutton *et al.*, 2013), with its policy-related recommendations, signals that discussions on nutrient stewardship/management have moved beyond the scientific domain into the policy realm. Besides the International Nitrogen Initiative (INI) and Global Partnership on Nutrient Management (GPNM), there are numerous other initiatives under way that raise concerns about environmental implications of nutrient over-, under- and mis-use.

A new global effort is needed to address "the nutrient nexus", where reduced nutrient losses and improved nutrient use efficiencies across all sectors simultaneously provide the foundation for a greener economy to produce more food and energy while reducing environmental pollution (Sutton *et al.*, 2013).

Nutrient use efficiency (NUE) is also suggested by UN ECE (1999 protocol to the 1979 Convention on LRTAP to abate acidification, eutrophication and ground level ozone – Guidance document) as an indicator of nutrient management performance.

NUTRIENT USE EFFICIENCY

NUE can be measured in different ways. The output/input ratio is the easiest calculation to implement with existing data, and it is scalable from the farm to the global level. It answers the question "how much nutrient is removed in the harvested product compared with the nutrients in the fertilizer applied".

NUE is an important measure of the economic, social and environmental performance of agricultural systems; however, it is not a sufficient indicator in itself as it does not convey the overall performance of the agricultural system.

NUE should not be used and interpreted in isolation. Indicators of effectiveness must complement indicators of efficiency. Indicators of effectiveness must reflect productivity per unit land area and maintenance of the soil nutrient supply capacity. Such indicators might include, but are not limited to:

- crop yield;
- actual yield relative to attainable or potential yield;

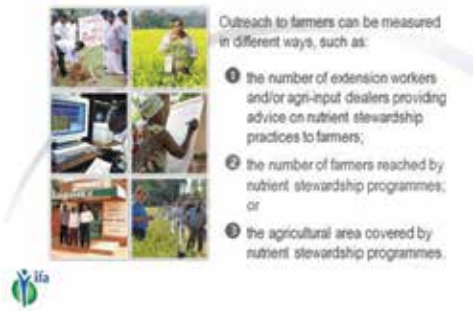

Figure 2. Outreach to farmers: a better indicator

Figure 3. Nutrient stewardship initiatives around the world

- animal productivity per unit land area;
- soil test levels for nutrients, as appropriate to the region.

A NUE indicator should not aim at measuring actual performance or setting quantitative targets as such. Instead, the indicator should be used to monitor the long-term NUE trend in the regions under investigation.

The way farmers manage plant nutrients is the main contributing factor to overall nutrient use efficiency and effectiveness. Therefore, using an indicator reflecting the adoption and use of nutrient stewardship is an interesting alternative to NUE.

A major challenge to improving the way nutrients are managed is transferring knowledge to hundreds of million farmers worldwide. With the deterioration of many public extension services in the last decades, there is a great need to improve outreach and enable adaptive management by farmers around the world, in particular by the approximately 70 percent of the world's farmers that are smallholders.

Measuring the effectiveness of outreach programmes – in support of nutrient stewardship – would produce a relevant indicator to measure progress on nutrient management because the adoption of best practices in the four areas of nutrient management (right product, right rate, right time, right place) has a direct influence on nutrient performance, taking into account its economic, social and environmental dimensions. Figure 2 shows possible indicators to measure outreach activities.

Globally shared goals such as those envisaged for the Sustainable Development Goals help align global efforts to end poverty and hunger and improve the sustainability of agricultural systems and prosperity of rural livelihoods.

By concerning ourselves with ensuring proper and balanced nutrition globally, we can inform and sway policy-makers not only to focus on nutrient losses and targets and indicators but also on nutrient stewardship programmes.

Nutrient stewardship programmes around the world aim at developing knowledge on fertilizer best management practices and in partnering with other stakeholders to transfer knowledge to farmers worldwide.

For example, Fertilizers Europe has set up such nutrient stewarship programme, where indicators and monitoring tools are developed; a nitrogen use efficiency indicator is currently under work in one of the programmes.

INFINITE FERTILIZERS AND NITROGEN USE EFFICIENCY

Figure 4. Infinite fertilizers

Fertilizers Europe's vision of infinite fertilizers is based on our belief that the European fertilizer industry has the responsibility not only to ensure the safe and efficient production of our products but also to influence how they are used to produce a varied range of healthy, high quality food for European consumers.

This requires us to consider the entire food production cycle and increasingly close cooperation with all the players involved in it. By installing our initiatives – carbon footprint calculator for production, Product Stewardship Programme, DAN (directly available nitrogen) and the Cool Farm Tool – we can ensure that we are working towards optimal solutions. Our concept of "infinity" allows us to follow the full life-cycle from all angles. In this context, developing a nitrogen use efficiency indicator is a major project.

TOWARDS A NITROGEN USE EFFICIENCY INDICATOR

There are various barriers and constraints to improving nitrogen use efficiency in practice, due to the tendency of academia, governments, industry and practitioners to work in isolation, and due to bureaucratic inertia. Some of these barriers can be overcome by bringing key experts from the different communities together and with dedicated leadership.

Key people from the science, policy and industry communities in Europe have been invited by Fertilizers Europe to establish an ***EU Nitrogen Expert Panel***. The general objective of the Expert Panel is to contribute to improving nitrogen use efficiency in food systems in Europe, through: (i) communicating a vision and strategies on how to improve nitrogen use efficiency in food systems in Europe; (ii) generating new ideas, and recommending effective proposals and solutions; and (iii) acting as referee in controversial issues, and by communicating as an authority. The Panel, comprised of 12 experts from science, four from policy and three from industry, gathered for the first time in September 2014.

They already agreed on a methodology for a nitrogen use efficiency indicator for crop production at national scale, to be used by policy and practice.

CONCLUSION

We must continue to focus our efforts on promoting fertilizer as a vital ingredient to global food and nutrition security, and as an important catalyst for agricultural development.

Better monitoring nutrient management performance is necessary. NUE as an indicator has limits and must be complemented by indicators of effectiveness to be meaningful.

Outreach to farmers is essential to improve nutrient management performance. An indicator reflecting adoption of nutrient stewardship would better reflect nutrient management improvement.

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Gender equality as a means to achieve sustainable food systems

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ABSTRACT

The overall purpose of this paper is to raise awareness among governments, international agencies, industry and civil society on the relevance of addressing gender equality as a means to reach sustainable food systems, both in terms of food consumption and food production. Sustainable food systems can only be successful if both men and women are actively involved and can equally benefit. We will analyze the specific gender implications on the social, economic and environmental dimensions of sustainability and provide a set of tools to address gender inequalities. By closing the existing gender gaps, decision-makers can increase agricultural production with benefits for the most vulnerable men and women, their communities and society as a whole.

The paper begins with a brief outline of FAO's vision for sustainable food and agriculture, and describes how gender fits into the equation, providing some evidence on the important role women play in the agriculture sector. It follows with a brief overview of how gender impacts on the three dimensions of sustainability, within the context of sustainable food systems, showing the close linkages between gender issues and sustainability. This leads on to a more detailed analysis of the gender dimension of food consumption, agricultural production and food systems more broadly, looking at relevant areas such as nutrition, natural resource management, agro-food value chains and food loss. The second part of the paper provides some concrete suggestions and recommendations for addressing gender inequalities to make food systems more sustainable, and a comprehensive annotated list of capacity development tools.

RELEVANCE OF GENDER EQUALITY FOR SUSTAINABLE FOOD AND AGRICULTURE

FAO's vision for sustainable food and agriculture and the gender implications

To achieve an agriculture that is highly productive, economically viable, environmentally sound and based on the principles of equity and social justice, the following five principles were identified by FAO: (i) improving efficiency in the use of resources; (ii) conserving, protecting and enhancing natural ecosystems; (iii) protecting and improving rural livelihoods and social well-being; (iv) enhancing the resilience of people, communities and ecosystems; and (v) promoting good governance of both natural and human systems (FAO, 2013a).

FAO's vision for sustainable food and agriculture

FAO's vision for sustainable food and agriculture is to have a world in which food is nutritious and accessible to **everyone** and natural resources are managed in a way that maintains ecosystem functions to support current and future human needs.
In this vision, farmers, pastoralists, fisherfolk, foresters and other rural dwellers can actively participate in, and benefit from, economic development, have decent employment conditions and work in a fair priced environment. Rural women, men and communities live in security, and have control over their livelihoods and equitable access to resources that they use in an efficient way.

Source: FAO. 2014. Building a common vision for sustainable food and agriculture. Principles and approaches.

Social sustainability can be defined as the ability of a community to develop processes and structures that not only meet the needs of its current members but also support the ability of future generations to maintain a healthy community, promoting a good quality of life and **equitable**, diverse, connected and democratic communities.

Although gender equality fits conceptually under the social dimension of sustainability, it is actually relevant to all three dimensions of sustainability, which are interconnected and interlinked, and influence each other. In this paper we will explore the gender implications on the social, environmental and economic dimensions of sustainability.

One of the reasons why the agriculture sector is underperforming is related to the persisting gender inequalities in rural societies which result in women having less access to productive resources, services and employment opportunities. As a result, women farmers have lower yields than men, which negatively impacts on their livelihoods and health, as well as those of their households and society as a whole. Increasing women's access to land, livestock, education, financial services, extension, technology and rural employment would boost their productivity and generate significant gains in agricultural output, food security, economic growth and social welfare.

As stated in the 2011 *The State of Food and Agriculture 2010–2011* report, if women had the same access to productive resources and services as men, they could increase yields on their farms by 20–30 percent. This could raise the total agricultural output in developing countries by 2.5–4 percent, which could in turn reduce the number of hungry people in the world by 12–17 percent, or 100–150 million people (FAO, 2011a). For these reasons, particular attention still needs to be paid to the economic and social empowerment of rural women and girls.

The majority of rural people in developing countries rely on natural resources for their survival, but still too often have limited access to social infrastructures such as education, health services and transport facilities. To maximize their potential and increase yields on their farms, both women and men need to have access to and control over arable land, water and other productive resources. New technologies, extension services, education, training

and information are needed to bring them up-to-date innovative agricultural practices that can reduce their workloads and support more effective and efficient production.

Women constitute 43 percent of the agricultural labour force (FAO, 2011a) and play a major role in agriculture and for food and nutrition security. In addition to their roles as farmers, rural women are responsible for household duties such as caring for children and the elderly, collecting fuel wood and water, and cooking for the family. This means that on average, women work longer hours than men, and face an excessive work burden. Nevertheless, men still represent a large majority in leadership roles in local governments and institutions. Women's historic underrepresentation at decision-making level has resulted, among others, in severe gender inequities in access to land and other productive resources and services.

Rural women and men have diverse roles in agriculture, and different types and levels of knowledge, needs, interests and perspectives. For example, in the livestock sector in sub-Saharan Africa, women are traditionally responsible for milking dairy animals, while men are responsible for their commercialization and slaughter (FAO, 2013b). Similarly, in the forestry sector, women are more likely to collect berries, fruits, or twigs and small branches for fuel from a tree, while men will cut down the same tree to sell as firewood or for use in construction (UNESCO, 2013).

When striving to make food systems more sustainable, it is therefore crucial to take gender differences into consideration, addressing the specific roles, needs and priorities of both men and women to ensure that they are adequately represented in decision-making and planning processes so that they can equally benefit from and contribute to any proposed intervention. Closing the gender gap would produce significant gains for society by increasing agricultural productivity, reducing poverty and hunger and promoting economic growth.

Gender in the three pillars of sustainability

Gender inequalities affect women and men on different levels in the field of sustainable food systems and are caused by a number of factors: cultural norms influence the dynamics within households and the division of labour between men and women. This division too often causes women to face an excessive work burden or to end up in low-paid, low-skilled and insecure jobs along the value chain. In many developing countries, women farmers lack access to the resources and services they would require to yield the maximum potential from their crops; in non-farm jobs women lack the training, information or networks they would require to move into more secure and better-paid jobs. Nonetheless, women's contributions are substantial, and their participation is indispensible for the overall functioning of global food systems. Their knowledge and experience are specific and unique, and their insights are required at the decision-making table, to avoid severe negative implications.

Gender inequalities are far-reaching, and their knock-on effects encompass all three (social, economic and environmental) dimensions of sustainability. Figure 1 illustrates and summarizes how gender, in the context of sustainable food systems, impacts on the three dimensions of sustainability.

For example, when women's perspectives are not taken into account, their specific contribution to agricultural production is threatened, and the risks of biodiversity loss and

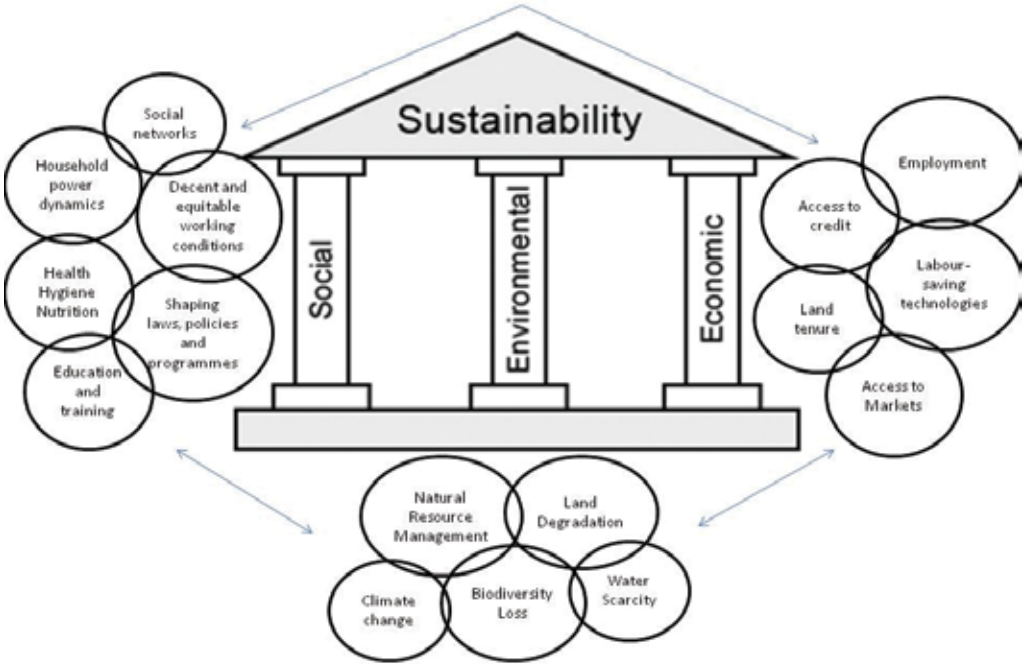

Figure 1. Gender in the context of sustainable food systems

malnutrition are compounded. This affects both the environmental and the social dimensions of sustainability (see example from Mali described below). Similarly, when water management systems are not user-friendly to women, their children are enlisted to help them walk long distances to fetch it, at the expense of going to school. This threatens their education, which affects the social dimension of sustainability. When women producers lack access to social networks, markets and technologies, the food they produce is more likely to perish before it can be eaten, affecting the economic dimension. Women's scarce representation in national and local institutions means that their unique perspectives and specific needs are often overlooked. This can result in gender-blind decisions about land tenure, biodiversity conservation and advisory services, to name a few. Such decisions impact on all three dimensions of sustainability.

Gender equality is therefore a win–win opportunity towards achieving sustainable food systems. The following sections will illustrate these points in the context of sustainable food consumption, agriculture production and food systems more broadly. We will also suggest measures that policy-makers and development stakeholders can take to help make food systems more sustainable.

Gender and sustainable food consumption

There has been a significant improvement in the overall nutritional status of the world's population since the 1992 International Conference on Nutrition. Millions of people have been lifted out of poverty and hunger (down 21 percent from the 1 billion hungry in

1990–92 to 805 million in 2012–14).[1] Today more people are eating better than ever before; they have more balanced diets and safer foods, and are better able to meet their nutritional needs. As a result, people are living longer and healthier lives, thanks also to improvements in water and sanitation, health services and rising incomes.

However, not everyone has benefitted from such development and many have been left out. Progress in reducing hunger and undernutrition has been uneven and unacceptably slow. Some 805 million remain undernourished and 2 billion people are estimated to suffer from micronutrient deficiencies. To have so many people be hungry and malnourished in the 21st century is unacceptable. Moreover, alongside the problems of undernourishment and micronutrient deficiencies, today, many countries in the world are facing increasing problems of overweight and obese populations, often starting during childhood, creating a "double burden" of nutrition-related ill-health. Almost five million children under the age of five die of malnutrition-related causes every year in the developing world, and more girls die than boys.[2] Having an adequate quantity of food does not automatically translate into acceptable levels of nutrition.

Malnutrition reflects socio-economic and gender inequalities in access to food, incomes, productive resources and other essential goods and services. Women are at greater risk of malnutrition than men. At specific stages in their lifecycle, they require more dietary iron than men and, when pregnant or breastfeeding, they need more protein. Still, women typically eat a lower quantity and variety of nutritious foods than men, and have limited access to information about nutrition. In rural developing communities, the nutritional needs of a woman are compounded by her multiple responsibilities in the field and at home as a worker, mother and caretaker. Moreover, in many societies, men and boys are given priority when meals are served. This can contribute to higher undernutrition among women and girls. According to UNICEF, malnourished mothers are more likely to give birth to underweight babies, who are 20 percent more likely to die before the age of five (UNICEF, 2007). Good nutrition and health depend on the safety of the food consumed – contamination leads to illness and death in children. Efforts to improve food safety must take into account existing gender roles in the food chain, and provide nutrition education and training in food safety, processing and storage to both women and men.

Initiatives to improve nutrition must therefore consider the social, economic and biological differences between men and women and the gender inequalities that stand in the way of good nutrition. FAO has found that projects that promote gender equality and women's empowerment can significantly improve nutritional status and well-being for the entire household. The recognition of women's circumstances and of their critical role in food production and provision, and in household work, calls for the design of gender-responsive policies and programmes to improve nutritional outcomes; women and girls' increased access to education, so that they are informed about their own and their families' nutritional needs; and for the development of innovative agricultural technologies that meet

[1] http://www.fao.org/about/meetings/icn2/faq/en/
[2] http://www.fao.org/docrep/012/al184e/al184e00.pdf

women's needs, save them time, and improve their productivity and incomes. Women's empowerment and the recognition of their voices in decision-making from the household to the political level are essential for poverty alleviation and the eradication of malnutrition.

Gender and sustainable food production

As stated above, women play a major role in agriculture. Additional care must be taken to ensure their voices are heard in the design and implementation of policies and investments to increase agricultural productivity and reduce hunger and rural poverty. Land, water, climate and biological diversity form the natural base of agriculture, and are essential to rural development and sustainable livelihoods. The increasing demand for food, fibre and energy and the growing exploitation of natural resources is disrupting agro-ecosystems, eroding biodiversity and depleting land and water. Those impacts are exacerbated by climate change.

Understanding the roles and responsibilities of rural men and women is a starting point for reversing environmental degradation and for guaranteeing food and nutrition security for their households and communities. Below, we will analyze the gender implications for some factors affecting food production systems, with a focus on water scarcity, land degradation, biodiversity loss, agro-food value chains and food losses.

Water scarcity

Most of the world's 1.2 billion poor people, two-thirds of whom are women, live in water-scarce countries and do not have access to safe and reliable supplies of water. Securing adequate access to water is critical for achieving food security and improving rural livelihoods. Despite women's main role in food security through their knowledge of crop production, local biodiversity, soils and local water resources, they are often excluded from decision-making processes in agricultural water management systems and other initiatives on natural resources allocation. Women often have no choice in the kind or location of services they receive (FAO, 2012). In a world where water resources are becoming progressively more scarce, this problem is often exacerbated, with increasing competition resulting in growing inequity in access to water resources.

Unlike men, whose water-use priorities revolve mainly around agriculture or livestock, rural women use water for multiple purposes in agriculture and in the domestic sphere. At household level, women and girls are generally tasked with fetching water. This includes walking to far-off water sources, waiting for water distribution at the tapstand, and carrying water back to the household. As overseers of family health and hygiene, women also have a particular influence on the providence of water-related diseases, such as diarrhoea, malaria and hepatitis A. This is of particular relevance, given that 80 percent of all sickness in the world is attributable to unsafe water, poor sanitation and water-borne diseases – killing 3.4 million people every year (UNEP, 2004).

In many societies, men are primarily responsible for water-related decision-making and management at community level. It is crucial that women be more involved in decision-making processes, to ensure that water resources are user-friendly for women, and meet their needs for safety and time-efficiency. Moreover, women-targeted education on

hygiene and sanitation will help reduce the prevalence of water-borne diseases, improving the health of present and future generations.

Significant improvements can be seen in the sustainability of water delivery systems if women are actively and directly involved in their development. This contributes not only to increases in the supply of water available for use at home and for agriculture, but also to alleviating the workloads of women and young people, giving women the time to focus on other tasks, and children the opportunity to go to school.

Land degradation

Environmental changes have a differentiated impact on men and women and can lead to transformation of gender roles, with women assuming more work and responsibility. The magnitude of these changes varies geographically and culturally. In areas affected by desertification, as soil fertility decreases and crop and livestock productivity declines, men increasingly migrate in search of an income in urban areas, leaving women to assume responsibilities traditionally held by men, in addition to their existing agricultural, domestic and reproductive roles. Women become de facto heads of the household. Women's access to community services, decision-making power, financial, technological and other resources remains very restricted, which affects their ability to influence the rehabilitation of land they farm on. This not only exacerbates the challenges they face as they need to assume additional responsibilities (IFAD, 2010) but also imposes substantial risks for environmental sustainability.

Involving rural communities, especially the "voiceless" men and women in resources management and in decisions regarding environmentally sound practices and techniques aimed at combating desertification (such as land reclamation, reforestation, irrigation systems and post-harvest storage) is a powerful way to mitigate the conditions and the impact of land degradation. Past experience shows that everyone benefits when women and men jointly participate in efforts undertaken to restore the productivity of degraded land, and when women are directly involved in the planning phase and in dryland development activities (IFAD, 2010). Increased access and more equitable control over resources help women and men to make up for detrimental environmental impacts as farmers can select from a wider range of ways to deal with degradation, and may lead to increased self-confidence and improved natural resource management, financial management and negotiation skills.

The United Nations Convention to Combat Desertification (UNCCD) promotes a "bottom-up" approach that directly involves both women and men at all levels in programmes to rehabilitate and restore their natural resources. It also stresses the importance of ensuring that women's specific knowledge and needs are taken into account when designing technologies and policies, to ensure that they are relevant to them and build on their insight (UNCCD, undated).

Biodiversity loss

In smallholder agriculture, for centuries women farmers have developed specialized knowledge and skills relating to the selection and conservation of genetic (plant and animal) resources and biodiversity. Women often have a more specialized knowledge of wild

plants used for food, fodder and medicine than men. However, this knowledge is being eroded by modernization, underestimation and lack of awareness, which lead to further marginalization and a rapid loss of biodiversity and local practices, posing a grave threat to long-term food security.

Rural men and women are often among the world's most poor and vulnerable groups and their livelihoods are intimately intertwined with the utilization of biological variety. In this respect, changes in biodiversity patterns will first and foremost affect the viability of rural survival. Preserving agricultural biodiversity is therefore crucial for sustainable rural development, food security and poverty alleviation. For this reason, greater attention must be paid to the complexities of agricultural systems and to the different roles and knowledge systems that men and women hold within them.

The majority of plant biodiversity research is not gender sensitive. This has led to incomplete or flawed scientific results that fail to capture the breadth of diversity, characteristics and uses of plants, the causes of genetic erosion, and the possible approaches for preserving biodiversity.

Agricultural, environmental and other related policies and programmes must differentiate clearly between male and female farmers, as food producers and providers, recognizing their specific contributions to the management and sustainable use of agro-biodiversity.

To enhance rural people's food security and promote the sustainable management of agro-biodiversity, the capacity of institutions in the agriculture sector to apply gender-sensitive approaches needs to be strengthened so that men and women farmers' differential needs, concerns and knowledge are recognized in national programmes and policies.

FAO's activities include: training on how to document local knowledge and use gender analysis and participatory methods for both research and action processes;

Mali: Changes in Agricultural Production, Gender Relations and Biodiversity Loss

A case study of the Bamana region in Mali shows how men dismissed agrobiodiversity and the local knowledge held by women. The introduction of exotic vegetables for market production, mainly a men-driven enterprise, led to a shift from subsistence production of a wide variety of indigenous food plants to market gardening of a limited number of exotic food varieties. This process has led to a change in gender roles, with men taking over women's traditional vegetable gardens to establish commercial enterprises. Although traditionally responsible for growing local plant varieties for direct consumption, women were displaced to marginal lands. This has implications for women's contribution to the food security of their house-hold (reduced income and food production for household food consumption) and their social standing in the community. Moreover, women's exclusion from the garden realm may lead to changes in culinary patterns, a possible decline in nutritional status, and a reduction in local plant diversity and overall environmental stability.

Source: Gender in Agriculture Sourcebook (taken from Wooten, 2003).

technical assistance to target the gender-based differences in farmer's knowledge related to agro-biodiversity conservation and management (e.g. use of medicinal plants, local seed management etc.); and enhanced communication and information exchange, based on local knowledge systems in agriculture within and between communities, or with institutions that interact with farmers and policy-makers.

To safeguard agro-biodiversity it is essential to protect and promote the diversity found in integrated agricultural systems, so that men and women farmers can better respond to changing conditions, alleviate risk and maintain and enhance crop and livestock production, productivity and sustainable food systems.

Agro-food value chains

The recent rise of global agricultural supply chains, prompted by the stark increase in supermarket retailing, has resulted in more wage employment opportunities for both women and men in developing countries. In many cases, this has had a positive impact on women, by increasing their autonomy, independence and bargaining power within the household.

Nonetheless, worldwide, women have less job security than men, are more often employed in temporary or seasonal work, and earn lower incomes than their male counterparts. They are more likely to work in low-skilled occupations and tend to get locked into them with little room for movement or progression, due to gender stereotypes and the lack of education and training opportunities. Meanwhile, men tend to be concentrated in higher status, more remunerative contract farming and control household land and labour. As companies grow and technological equipment becomes available, low-skilled occupations such as those involving processing and packaging are the first to be automated, leaving women the most likely to face redundancy and unemployment.

Although efforts to include smallholder farmers in agricultural value chains have increased, gender inequalities have resulted in women smallholders losing out on opportunities to engage in the more profitable value chains. Their lack of access to land, bank loans and productive resources, markets and business development services means that women's businesses lag behind, which produces inefficiency in the value chain, increases their workload and reduces development opportunities. To organize markets in gender equitable ways it is important to see how to increase women's participation in agricultural enterprises and to effectively reduce inequalities in accessing inputs and services that limit productivity.

Promoting gender equality in value chains has been recognized as a "win–win" opportunity for workers and firm owners alike: a more inclusive workforce and entrepreneurial base responds to the social justice case by addressing discriminatory beliefs and practices, and promoting dignity of work and economic equity for all. Large-scale studies have also found that economic growth and gender equality go hand-in-hand, and that gender inequalities are costly and inefficient.

Many efforts are being made to ensure more inclusive value chains. There is as yet little evidence to determine whether increasing the extent and scope of women's participation in food value chains enhances food security in the household. Among the challenges laying ahead, there is the need to develop value chains in crops with added nutritional and health benefits (e.g. value chains for staple foods such as millet, sorghum, roots and tubers and

indigenous vegetables). There is also an increasing interest in expanding the value chain for more climate resistant crops such as sweet potatoes and other tubers, which have the potential to increase women's income and the nutritional status of their household members. These and other strategies should be envisaged to encourage women to benefit from expanding economic opportunities. Addressing gender inequalities in food systems will help fight the social injustice that many women are facing, while also helping to build more robust, efficient and sustainable value chains.

Gender and food loss

Accurate estimations of the magnitude of losses and waste are lacking, particularly in developing countries. Nevertheless, there is no doubt that food loss and waste remain unacceptably high. FAO estimates yearly global food loss and waste by quantity at roughly 30 percent of cereals, 40–50 percent of root crops, fruits and vegetables, 20 percent of oilseeds, meat and dairy products, and 35 percent of fish (FAO, 2011b).

Food loss and waste heavily depend on the specific local situation (HLPE, 2014). In low-income countries, food losses result from wide-ranging managerial and technical limitations in harvesting techniques, storage, transportation, processing, cooling facilities, infrastructure, packaging and marketing systems.

Social and cultural conditions are often the underlying causes of food losses, due to the different productive and social roles of men and women in food systems. Women play a major role in the production, post-harvest and processing stages, and in many low-income countries they are responsible for growing and processing crops that are most susceptible to post-harvest loss such as tubers, fruit and vegetables. In Africa, for example, women are largely responsible for processing cassava, whose high perishability makes it particularly susceptible to post-harvest losses.

Even though women play a major role in preventing food losses, they face many barriers that affect their productivity and efficiency in food production, which can lead to food losses. For example, they have limited participation in producers' organizations – which can offer storage facilities, and lack training opportunities about food standards, so their produce cannot make it to the next stage of the value chain (HLPE, 2014). For this reason, it is important to provide extension information on improved technologies and practices for efficient processing to both men and women within the household, and take special measures to address their specific constraints. Many efforts have been made to help female farmers mitigate against food loss. For example, a SEED-awarded initiative in the United Republic of Tanzania undertaken by Rift Valley Foods supplied women with access to solar drying technology that could dry and preserve surplus fruits.

WHAT CAN BE DONE TO PROMOTE SUSTAINABLE FOOD SYSTEMS?

Enabling both rural women and men, especially small-scale farmers, to achieve their productive potential requires many reforms to overcome the constraints they are still facing. Gender-responsive policies and interventions should be tailored to specific socio-cultural contexts, in order to provide an enabling environment towards sustainable development.

Sex-disaggregated data

Sex-disaggregated data shed light on the gender inequalities that contribute to low agricultural productivity, by revealing gaps in access to resources and exposing institutional and operational constraints faced by male and female producers. Producing agricultural statistics through a gender lens can improve the understanding of decision-makers of agricultural producers, both male and female, and reveal the underlying causes of productivity deficits and gender inequalities, in order to develop better tailored and more gender-responsive policies and programmes. Gender statistics can also capture changes in gender gaps over time, across regions, or in response to various structural factors. By using sex-disaggregated data, decision-makers can design better targeted interventions to increase the food and nutrition security status of men and women at the household level, or ensure that services are delivered equitably.

For example, if we want to investigate the gender perspectives of food access, we first need to identify the specific gender issue to be assessed (e.g. levels of food consumption of

Possible interventions to promote sustainable food systems:

1. Review national laws and policies to facilitate the equitable access to productive resources, services and employment opportunities for both rural men and women. This implies raising awareness among decision-makers and existing institutions on the impacts of their interventions on different socio-economic groups and in particular on small-scale farmers and vulnerable men and women. Special efforts are needed to make them aware of their rights in terms of land, water and other productive resources and services, so that the existing inequalities can be overcome.
2. Special efforts are needed to strengthen the capacity of local institutions such as producers' organizations, labour unions, trade groups, as well as advisory services, financial organizations, etc., so that they can better target the support they provide to the specific needs of rural women and men.
3. Invest in technologies and research tailored to the interests and priorities of both men and women (e.g. labour- and water-saving technologies) to increase their productivity and overcome their specific constraints.
4. Strengthen the human capital of women and girls to address their multiple challenges. This implies investing in their education and training, developing their technical and functional skills (e.g. negotiation and leadership skills) so that they can play a more active role in decision-making and in planning interventions that are tailored to their specific needs and priorities.
5. Invest in women's economic empowerment so they can participate more actively in food systems and better contribute towards the sustainable development of their households and communities.
6. Develop capacity for the collection, analysis and use of sex- and age-disaggregated data to better analyse the gender implications of policies and investments in agriculture and food and nutrition security.

female-headed compared with male-headed households). Data could then be collected to measure the food quantities consumed per adult, disaggregated by sex and age of the head of the household and the type of household. Possible instruments to be used to measure data are household income and expenditure surveys, living standards survey, food and nutrition security surveys, or thematic agricultural surveys.

Countries can facilitate an enabling environment for the collection, analysis, management and dissemination of data for agriculture and rural development by:

- reviewing existing sources to identify appropriate measures for determining policy and technical frameworks for compiling, analysing, presenting and disseminating data;
- strengthening the user-producer interface to create better opportunities for producing good-quality and reliable statistics on gender in agriculture;
- placing emphasis on coordinating, integrating and re-tabulating sex- and age-disaggregated demographic, labour force and agricultural data at sub-national levels;
- carrying out more specialized surveys on gender relationships and related concerns in agriculture;
- organizing pilot/small surveys for collecting time-use data;
- organizing household enquiries that provide an overview of rural peoples' health including nutrition and food security;
- collecting more detailed information on smallholder farmers.

National policies, strategies, programmes, regulations and incentives will be truly sustainable only if they adequately address the gender implications of food consumption and production, so that both men and women have control over their livelihoods and equitable access to resources and services. The list of resources below can help bring about equitable and sustainable food systems.

Available knowledge and information resources for sustainable food systems

Over the years, many different capacity development tools have been developed to support national and international partners in better addressing the gender gap in the agriculture sector, and in food and nutrition security. A sample of some relevant tools is described below.

E-learning course on gender in food and nutrition security

This course was developed by FAO with the European Commission to meet the needs of policy-makers in ministries, project staff, statisticians and other stakeholders such as civil society, private sector organizations, university students and staff from international and national organizations wishing to update their knowledge and skills and be able to formulate, implement and monitor gender-responsive policies, programmes and projects, and produce gender statistics related to food and nutrition security, and to agriculture.

Gender in agriculture sourcebook

This sourcebook was produced by the World Bank, FAO and the International Fund for Agricultural Development (IFAD) (World Bank, 2008), as a guide for practitioners and technical staff in addressing gender issues and integrating gender-responsive actions in the design and implementation of agricultural projects and programmes.

Socio-economic and gender analysis (SEAGA)

SEAGA (FAO, 2003b) is an approach elaborated by FAO with the International Labour Organization, the World Bank and the United Nations Development Programme and other organizations to enhance the capacity of development specialists and humanitarian officers to incorporate socio-economic and gender analysis into development initiatives and rehabilitation interventions. It provides field workers, development planners and policy-makers with practical tools including handbooks and technical guides on gender analysis in specific sectors.

CoOPequity tools for gender-sensitive organizational development in producers' organizations and cooperatives

CoOPequity is an approach developed by FAO within the framework of the EU/FAO Global Governance for Hunger Reduction Programme to strengthen governance, equity and gender-equality within Producers' Organizations (POs). This CoOPequity toolbox (FAO, in press) includes: gender-sensitive assessment tools for analysing the extent to which gender issues are taken into account in POs; training modules for gender sensitive organizational development; and guidelines and training modules on multi-stakeholder platforms for policy dialogue involving POs.

Improving opportunities for women in smallholder-based supply chains: business case and practical guidance for international food companies

The study by the Bill and Melinda Gates Foundation explores the business case for food companies to support women in smallholder-based supply chains, and presents good practice guidance (through 40 good practice examples and seven case studies) on how they can encourage greater participation of, and support for, women in their smallholder-based supply chains (Chan, undated).

Good practice policies to eliminate gender inequalities in fish value chains

The paper highlights major gender inequalities in fisheries and aquaculture value chains that result in a marked underperformance by women (FAO, 2013c). It aims to build a solid business case about the benefits of exploiting the hidden economic and social potential of fisheries and aquaculture by providing good practice policies aimed at policy-makers and other stakeholders operating in the fisheries and aquaculture sector, with a particular focus on producers, workers, employers and other stakeholder organizations.

Passport to mainstreaming gender in water programmes: key questions for interventions in the agricultural sector

This booklet (FAO, 2012) was developed for field staff involved in water management projects. The ultimate beneficiaries are women and men in rural areas who will profit from equal and efficient water distribution, leading to higher yields, improved food security and poverty reduction. The passport focuses on six issues related to water programmes for agriculture: (i) access to land and water; (ii) farming context; (iii) multiple use of water; (iv) management of irrigation systems; (v) water distribution, irrigation practices and

maintenance; and (vi) other environmental issues, with specific questions to guide the users in addressing the gender aspects.

UNDP resource guide: mainstreaming gender in water management

The guide is a reference document designed to facilitate access to available literature and resources regarding gender and integrated water resource management to improve the sustainability and effectiveness of water-related activities through incorporation of gender equality and diversity, and improve understanding and awareness of gender concepts through an easy reference to existing materials, cases and tools (UNDP, 2006).

Building on gender, agrobiodiversity and local knowledge: a training manual

This training manual is based on experiences collected in many training workshops carried out under the FAO-LinKS project in Eastern and Southern Africa (FAO, 2006). The manual constitutes a conceptual guide for trainers to lead them through the issues of gender and local knowledge that are important elements for agrobiodiversity management and food security.

Gender and land rights database

This database[3] provides easy-to-access, up-to-date information on gender and land rights, to better understand the existing disparities on land access, as one major cause for social and gender inequalities in rural areas. Gender differentiated rights to land have implications on rural food security and nutrition and the well-being of rural families and individuals. The database focuses on six categories: national legal framework, international treaties and conventions, customary law, land tenure and related institutions, civil society organizations, and selected land-related statistics.

Agri-gender statistics toolkit

This database[4] was developed by FAO in support of enhanced production and use of sex-disaggregated agricultural data. It presents examples of gender relevant questions and tables developed by national statisticians and FAO for agricultural censuses undertaken in Africa between 1993 and 2006. Statistics producers and users alike called for the development of such a database to improve the production of reliable sex-specific agricultural data needed for targeted and gender-responsive policy formulation and planning of agricultural and rural development.

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Development of Voluntary Sustainability Standards and Labels in the United States of America

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Largely excerpted from *The Economics of Food Labeling*, by Elise Golan, Fred Kuchler, and Lorraine Mitchell with contributions from Cathy Greene and Amber Jessup. Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 793, January 2001 (reprinted in Journal of Consumer Policy Vol. 24 (2): 117–184).

ABSTRACT

In the United States of America, private companies have considerable freedom to differentiate and market products to cater to consumer demand. This is particularly true for products differentiated by process attributes that do not affect the composition of the food product, such as free range, fair trade, non-genetically modified organisms, and deforestation-free. The past decade has seen enormous growth in these types of process claims, largely backed by private, voluntary standards and private third-party certifiers. US Government intervention in private market development of this sort is primarily restricted to keeping competition fair and labels truthful. It rarely intervenes to promote or mandate process labelling as a means to achieve environmental or social outcomes. The potential benefits of such policy intervention hinge on the power of information either to persuade a critical number of consumers to change their consumption choices or to persuade a critical number of producers to proactively change their production processes. Empirical evidence suggests that labels alone are rarely so potent.

BACKGROUND

In the United States of America, private companies have considerable freedom to differentiate and market products to cater to consumer demand. This is particularly true for process attributes that do not affect the composition of the final food product, including most sustainability attributes such as "dolphin friendly" or "rainforest alliance." Product differentiation for process attributes typically requires that the producer/manufacturer establishes standards and then certifies that the standards have been met.

In some cases, regulators or lawmakers may determine that markets are failing to respond to consumer demand for products with wider social and environmental benefits. In these cases, regulators may consider creating their own sustainability standards and labels. Or, regulators may propose their own labels if they determine that markets are becoming inefficient due to competing or poorly defined sustainability standards and labels.

The question is, "when is government intervention in voluntary sustainability labelling and standard setting the best policy tool"? Some answers from an economic viewpoint are provided in *The economics of food labeling* (Golan, Kuchler and Mitchell, 2001). The material below is excerpted from this publication.

INTRODUCTION

There is a lot to know about the food we eat. For example, the ingredients for a jar of spaghetti sauce, a box of cereal or a cup of coffee could come from around the corner or around the world; they could be grown with numerous pesticides or just a few; they could be grown on huge corporate organic farms or on small family-run conventional farms; they could be harvested by children or by machines; they could be stored in hygienic or pest-infested storage facilities; or they could increase or decrease the risk of cancer. A description of any one food product could include information on a myriad of attributes.

Consumers, firms, third-party entities and governments all play a role in determining which of a food's many attributes are described on food labels. Consumers use their purchasing power (their consumption choices) and political activities to help determine which attributes are described on labels. Private firms seek out attributes that are attractive to consumers and voluntarily provide information about these attributes when the benefits of doing so outweigh the costs. Third-party entities, including private organizations, governments and international organizations, contribute to enhancing the intelligibility and credibility of information about some food attributes through standard setting, certification and enforcement. These services can increase the amount of information supplied by labels. Governments may require that information on some attributes be included on food labels.

MANDATORY LABELLING

Most demands for mandatory labelling (including those of "consumer right to know" and calls for fair competition) arise in two general economic situations: when the market does not supply enough information to allow consumers to make consumption choices mirroring their individual preferences (asymmetric or missing information); and when individual consumption decisions affect social welfare differently than they affect the individual consumer's welfare (externality problems). In both of these situations, social costs and benefits may suggest a different labelling outcome than the one resulting from a private firm's labelling decision. Each situation is examined below.

Mandatory labelling to correct asymmetric or imperfect information

Properly functioning markets provide a valuable service to society. In properly functioning markets, consumers are able to purchase the goods and services that best match their preferences. As a result, society's resources are used in ways that match consumers' preferences. However, sometimes the market supplies too little information to enable consumers to make consumption choices reflecting their preferences. One such situation occurs when there is *asymmetric information*, that is, the seller knows relevant information about a product that the buyer does not know (for example, someone selling a used car has information about the car that the buyer does not have). In cases of asymmetric information, resources are used less efficiently than with perfect, symmetric information.[1]

Asymmetric information may particularly be a problem in markets for foods with negative credence attributes or for markets in which information has a public good aspect. In these cases, firms may have no incentive to provide consumers with information. As a result, consumers may end up purchasing goods that do not match their preferences. In this case, the market does not work efficiently: goods that would be profitable with full disclosure may go unproduced while those of lesser value to consumers are produced instead.

In some cases of asymmetric information, the government may decide to intervene in the market to require producers to disclose critical information. Mandatory labels targeting asymmetric information are designed to provide consumers with greater access to information and to increase the efficiency of the market. The objective of government intervention in these types of cases is not so much to alter consumption behavior but to increase *informed* consumption (Magat and Viscusi, 1992, develop this point).[2]

Another type of information problem that may occur in food markets is that of imperfect information. Unlike the case of asymmetric information, where producers know relevant information about the product that consumers do not, in cases of imperfect or missing information, relevant market information does not exist or is contradictory. This situation could arise when the long-term health effects of a food or food attributes are unknown, or when scientific opinions differ about the health consequences of consumption. In these cases, the government might require full disclosure of even preliminary or contradictory information to provide consumers with the fullest information possible. Hadden (1986, p. 263) argues: "It is a perversion of the intent of information provision to wait until full knowledge is available before labeling products." Indeed, if such information is valuable to consumers, it could improve market efficiency as in the case of asymmetric information.

Mandatory labelling to correct externalities

Individual food consumption decisions can have a wide variety of social welfare consequences, including effects on the environment, health and productivity, labour conditions, and farm and industry structure. For example, consumers who choose diets high in saturated fat increase their risk of heart disease and cancer, creating costs not just

[1] One of the best-known studies of the effects of asymmetric information is Akerlof (1970). For an overview of asymmetric information, see Carlton and Perloff (1994) or Varian (1993).

[2] In some cases, government labelling requirements may force firms to generate new information or present information in a new format.

for themselves, but also for employers and public health systems. Conversely, diets high in oat bran may lower the risk of heart disease, creating productivity gains and medical-care savings that benefit the whole society.

When the food consumption choices of consumers affect the welfare of others, and these welfare effects are not priced, then consumers may consume more or less than is socially optimal. If the price of the food were changed to fully reflect these welfare effects, then the market outcome would be socially optimal. For example, if the price of saturated fat were raised to reflect the costs of public health impacts, then less saturated fat would be consumed. Economists describe situations in which action of one economic agent affects the utility or production possibilities of another in a way that is not reflected in the marketplace as *externalities*.[3]

Where private consumption decisions result in externalities, social welfare may be maximized by a labelling choice that differs from the one generated by private firms. In the diet example, the potential social benefits of providing dietary information on labels include a healthier, more productive population and reductions in medical costs. These potential benefits may be larger than the increase in profits that compose a private firm's labelling benefits. As a result, the social benefits of labelling may outweigh the social costs even though the private benefits do not outweigh private costs. The opposite could also be true, with negative net social benefits and positive net private benefits. For example, the social costs of labelling red wine with the information that moderate consumption lowers the risk of heart disease may be greater than the social benefits. The potential social costs of such a label include increased rates of birth defects, car accidents and alcohol-related health costs, while the potential social benefit is the reduction in heart disease. The private firm's costs of redesigning labels are potentially much lower than the benefits of increased sales.

In externality cases where private firms do not supply relevant information, the government may decide to intervene in labelling decisions to try to maximize net social benefits. Government-mandated labelling can be a useful tool for achieving social objectives because of the potential power of information to influence consumption decisions. In this role, labelling falls into that category of government policy dubbed by Magat and Viscusi (1992) as: "information provision programs to alter people's economic behavior".

The primary difficulty in regulating to achieve a social objective comes in clearly identifying "the social objective". Although particular special or public interest groups may advocate labelling as a means of influencing consumption decisions to align them with a particular social objective, such objectives may not be widely valued. Society is composed of a diverse variety of individuals and interest groups. It is not a trivial task to design regulation that truly reflects widespread public interest. This is not to say that it is difficult to identify activities that affect social welfare. In fact, if social welfare is defined to include the "public purse," it may be difficult to find an activity that does not qualify (Shultz, 1980). What is difficult is determining if the benefits of a given social objective merit the costs of government intervention in the market.

[3] A seminal analysis of externalities is Bator (1958). See Just , Hueth and Schmitz (1982), for a thorough description of economic implications of externalities.

Is labelling an effective policy tool?

Even if informational and social welfare considerations indicate that there may be a role for government intervention, labelling may not be an effective policy tool. Magat and Viscusi (1992) argue that information policy such as labelling generally is not very effective and there are some circumstances, such as when people do not read or do not care about the information on the label, in which it may not be effective at all.

Empirical studies have found labels to be both successful (Ippolito and Mathios, 1990, 1995) and unsuccessful (Variyam, Blaylock and Smallwood, 1995, 1997; Moorman, 1996) in educating consumers and changing consumption behaviour. These and other studies highlight the observation that consumers often make hasty food choices in grocery stores and usually do not scrutinize food labels (see Aldrich [1999] for a summary of research on consumers' label usage). These studies also illustrate the fact that the format and context of the information are important elements in maximizing the possibility that labelled information will influence its audience.

Consumers are more likely to read and understand labels that are clear and concise (a point argued by Hadden, 1986; Viscusi and Magat, 1992; Noah, 1994). A large number of warnings or a large list of detailed product information may cause many consumers to disregard the label completely. Even if consumers do consider each piece of information on a label, they may find it difficult to order the information according to importance. For example, out of ten warnings on a label, consumers may have difficulty picking out the most important. As a result, consumers may underreact to important information or overreact to less important information (Noah, 1994).

While clear, concise labels could possibly be designed to address problems of asymmetric information, problems for which information exists, it is unlikely that labels would be successful in addressing problems of imperfect information. By definition, the information available in these situations is unclear. Not only is it difficult to convey such information on a label, it is difficult for consumers to decipher it. Consumers have a particularly difficult time making sense of small probabilities or of information about an issue that lacks scientific or political consensus (for analysis of how consumers react to risk information see Slovic, Fischhoff and Lichtenstein, 1980; Viscusi and Magat, 1987; and Magat and Viscusi, 1992). As observed by Hadden (1986, p. 196), "It is unreasonable to expect individuals to process information that has confounded the experts". Providing information that leaves consumers confounded is unlikely to lead to improvements in market efficiency.

A more comprehensive and better targeted approach to inadequate information might include research and science education programmes that stress the probabilistic nature of scientific knowledge. As noted by Slovic, Fischhoff, and Lichtenstein (1980, p. 178), "It is important to recognize that informing people, whether by labels, package inserts, or more extensive programs, is but part of the larger problem of helping people cope with the risks and uncertainties of modern life".

Labels may also be a poor means of addressing problems of externalities and advancing social objectives. Individuals tend to weigh their individual private costs and benefits, exclusive of externality costs, when making consumption decisions. Even if certain

individuals alter their behaviour to reflect externality costs completely, the fact that others do not means that the objective will probably not be met. For example, while some consumers may purchase only free-range chickens, the goal of more humane treatment of chickens will not be achieved as long as most consumers continue to purchase coop chickens. Differing preferences for the targeted consumption good may also lead to less than optimum results. For example, even if all agree that a slimmer, fitter population is a good social (and personal) objective, some consumers' preferences for fatty foods and inactivity may outweigh their valuation of the social objective.

Labels may also be unable to change behaviour enough to meet a social objective if some consumers free-ride on others' socially responsible behaviour. For example, although a consumer may feel that sea turtles should be protected and that strict laws protecting them should be enforced, he or she may decide that eating one small bowl of turtle soup will not really make a difference. The uneven distribution of collective benefits also mitigates against the achievement of social goals through labelling. Even if individuals have similar preferences over the social outcome, the fact that some benefit more than others probably means that not everyone will change their behaviour to match the social optimum (Hadden 1986, p. 38).

Economic theory identifies a number of policy tools that may be more suited to redressing externalities than information remedies. Bans, quotas, production regulations or standards, and Pigouvian taxes,[4] may all be more successful than mandatory labels in adjusting consumption and production to better match socially optimum levels.[5]

Regardless of the objective, effective labelling hinges on the existence of standards, testing, certification and enforcement services. To establish credible, effective mandatory labelling, the government must ensure: that the quality standards in question are clear and achievable; that testing services, if necessary, are available to measure the validity of labelling claims; that producers (and consumers) are able to certify or otherwise prove the validity of the quality claim; and that a mechanism for enforcing labelling rules exists, including a mechanism to punish producers who make fraudulent claims. The government must either perform these services (and find a way to finance them) or accredit third-party agents to perform them (as described by branch 4 of the labelling tree). Mandatory labelling laws that are not supported by standards, testing, certification and enforcement services could result in confusion and actually increase transaction costs.

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National Plan of Sustainable and Health Gastronomy: enabling conditions for organic and sustainable family farming

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Ministry of Agriculture and Livestock, Costa Rica

ABSTRACT

The National Plan of Sustainable and Healthy Gastronomy of Costa Rica promotes enabling conditions for organic and sustainable family farming through several initiatives to contribute to national goals of competitiveness and low carbon development. The Plan is a public–private initiative that simultaneously combines the strengthening of gastronomy as a value in the national tourism proposal with the objectives of sustainable food production, biodiversity conservation and environmental protection. Its main objectives are to:

- support the conservation of species of wild and cultivated biodiversity of relevance to food in Costa Rica and their sustainable use for the benefit of the sovereignty and food and nutrition security;
- foster productive practices based on sustainable farming techniques that contribute to the maintenance of agro-ecological cycles;
- strengthen the development of the domestic market for products with social and environmental added value;
- promote family agriculture participation in the value chain in agri-food systems;
- stimulate better practices in the agri-food consumption systems.

The goals of the Plan are aimed to stimulate sustainable production, the rescue of traditions and the renewal of the gastronomy of the country, linking various sectors of national development in sustainable agricultural production, food security, health and nutrition, culture, sustainable management of biodiversity, tourism and gastronomy.

COSTA RICA TOWARDS SUSTAINABLE DEVELOPMENT

Costa Rica is going forward on a development path in low carbon emissions and resilience to climate change. In the framework of the national strategy to become a carbon neutral country in 2021, various sectors of the national economy have included innovations in their process of production of goods and services to reduce their ecological footprint and improve competitiveness.

Historically, the agriculture sector have had high importance, for social, economic and environmental development of Costa Rica. According to data from the Planning Secretariat

for Agricultural Sector (SEPSA, 2013), in 2011–2012 agriculture and agro industry contributed 14 percent of GDP, occupying fifth place. In terms of employment, it takes the second place, with 13 percent of the economically active population.

It is a dynamic sector that has to address big challenges and opportunities, accentuated by the current global trends towards sustainable consumption and production, as well as by the necessity to reduce greenhouse gas emissions and to adapt production systems to the impacts of climate change.

Figure 1. Innovation in food supply : one of the early results of PNGSS
Source: CACORE.

In the first decade of the twentieth century, the development of the agriculture sector has been experimenting with changes towards strengthening sustainable and organic production through the implementation of best agricultural practices and certification of production processes under various standards, several productive activities oriented mainly towards the international markets, and has made significant improvements in terms of competitiveness. Since 2004, the country has initiated new governmental programmes of incentives for ecosystem services in agricultural production, aiming to develop investments with positive environmental impact in conventional systems, as well as to develop organic production.

In the framework of the policies for the agriculture, food and rural sectors 2010–2012, family farming is integrated as one of the pillars of national agricultural development. Due to its social, economic and environmental functions and to the significant role it has historically played as part of democracy, social peace and the sustainable development of the country, Costa Rican society, through the Government of the Republic, supports various programmes to strengthen agricultural production in family farming systems.

The creation of employment, provision of healthy foods, strengthening of the family unit, protection of natural resources, recycling of nutrients, diversification of products, conservation and use of genetic resources, protection of biodiversity, development of systems at a low level of external inputs, valorization of local energy, creation of opportunities for young rural people, reproduction of local culture and distribution of wealth are some of the important functions associated with the practice of sustainable agricultural production in Costa Rica.

NATIONAL PLAN ON SUSTAINABLE AND HEALTHY GASTRONOMY

One of the economic actors of the country that decided to be part of national efforts towards low carbon development is the Chamber of Restaurants and Allied Workers (CACORE). In 2011, through an alliance of CACORE, the Club of Epicurean Gastronomy, the Costa Rican Tourism Institute (ICT) and the National Biodiversity Institute (INBio), the National Plan for Healthy and Sustainable Food (PNGSS) was launched, as a joint effort to provide the tourism sector, both national and international, with the gastronomy of the country, based on the biodiversity of food produced in the country that has been part of the Costa

Figure 2. Tacaco. Fruit of curcubitacea climbing plant, endemic in Costa Rica
Source: R. Azofeifa.

Rican diet for decades but for various reasons is vanishing in the country's agri-food chains.

In 2012, the Ministry of Agriculture and Livestock, the Ministry of Health, the Ministry of Environment and the National Institute for Vocational Training (INA) were invited to become part of the Plan, as key actors for its development. This innovative proposal, supported by actors from both the public and private sectors, is intended to stimulate agri-food production chains to use environmentally friendly products (either endemic, native or introduced) through their production in family farming systems, consumption in households, the development of local markets and the development of linkages that help reduce the environmental footprint of distribution channels as well as food losses and waste.

SUSTAINABLE AND HEALTHY GASTRONOMY: THE CONCEPT

Costa Rican cuisine is a manifestation of the various foods of the country, both collectively and with local nuances. It is based on the pre-Hispanic indigenous diet enriched throughout history with the broad dietary diversity of the country and ingredients and preparation techniques brought by migrant groups at different times, resulting in foods and beverages that are used in everyday use and in a festive context, through which the Costa Rican population shows its own identity.

Consumers of Costa Rican cuisine include the population in general and international tourists that visit the country, which is why it can be encountered on the family table as well as in popular public places and public restaurant services.

According to FAO, "sustainable consumption and production of food and agriculture is a holistic concept, driven by the consumers, which refers to the integrated implementation of sustainable patterns of consumption and production of food, respecting the capacities of natural ecosystems".[1]

In this context, healthy and sustainable gastronomy is expected to support the conservation of agro-biodiversity in Costa Rica. Moreover, it is expected to favour local and family farming, buying local or regional food at low prices, thus contributing to the improvement of livelihoods and income of the population linked to the agri-food sector and to rural areas.

MAIN CHALLENGES

The National Plan on Sustainable and Healthy Gastronomy as a proposal for organic and sustainable family farming is an important driver of sustainable production and consumption

[1] http://www.fao.org/ag/ags/sustainable-food-consumption-and-production/en/

in the country, not only because it enables the joining together of diverse public and private actors interested in the sustainable development of the country (tourism, biodiversity, environment, healthy and nutrition, culture, agriculture, agricultural trade, etc.) but also because it has been a catalyst of various chains in terms of production and consumption of sustainable agricultural products.

In spite of the interesting progress of the PNGSS, there are various challenges that the Plan will have to address and surmount. The most significant challenges are described below.

- Information for consumers. To motivate consumers towards sustainable and healthy gastronomy requires an ongoing effort of information dissemination on the benefits of the production and consumption of sustainable products, from the point of view of the production process as well as from consumption. It will require public–private investment, by various means, to orientate information and communication towards consumers.
- Traceability. A system to ensure traceability of the product is needed, from the farm to the consumer's table. It is necessary to be able to demonstrate to food consumers that the products are the result of sustainable processes of production in family farms.
- Nutritional information. To be able to give nutritional information about products and dishes prepared with sustainable products will require investment in research to ascertain the nutritional properties of the various products.
- Ecolabelling and standards for sustainable products. It is necessary to develop standards that are easy and inexpensive to implement and, moreover, that are known and trusted by the consumers.
- Regulation of demand and supply. There is a need to establish a system of information and knowledge that enables regulation of demand and supply of products, as well as to plan production in order to satisfy demand.
- Incorporation of other actors in the food chain. There is a need to motivate the participation of other actors who are suppliers in the food supply chain for restaurants and other consumption points, so that they implement best practices for transparent and management of food products, in order to guarantee their integrity.

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Incentives for ecosystem services

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ABSTRACT

Transition to sustainable food systems requires a coordinated approach to increase productivity and resource use efficiency reducing negative impacts on the agro-ecosystem. Farmers require incentives to improve their practices, and commit to long-term change. These signals may also come from other sectors of society, which are also users of the agriculture products and services they produce. FAO is working on Incentives for Ecosystem Services (IES) from Agriculture to establish the basis for informed decision-making by public and private actors on the remuneration of ecosystem services contributing to food security and sustainable agriculture development.

WHY DO WE NEED INCENTIVES FOR ENVIRONMENTAL SERVICES IN AGRICULTURE

Transition to sustainable food systems is ever more pressing, in light of persistent food insecurity, global population growth and climate change. Farmers face barriers in the adoption of sustainable production practices supporting ecosystem services provision. To overcome these barriers they require a coordinated package of policies and incentives. Overcoming lack of information on most appropriate practices, or initial increase in input or management costs, requires short-term incentives such as training and financial assistance. In cases where the new practices require a permanent reduction in income, alternatives must be in-built to compensate this loss (Figure 1; FAO, 2007).

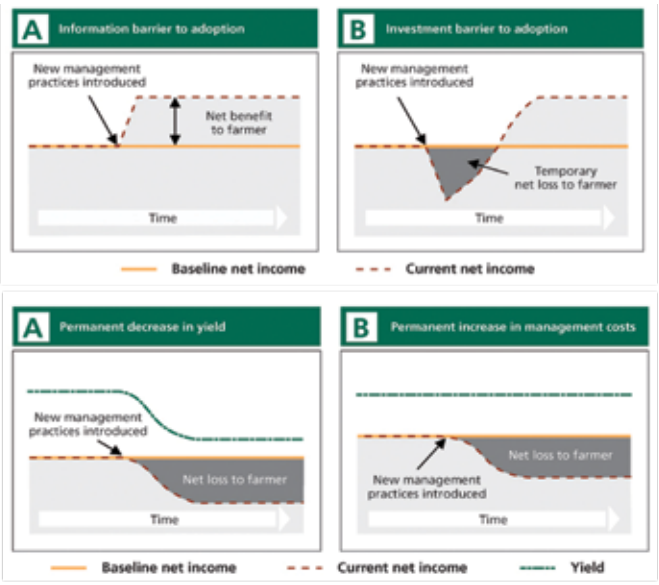

Figure 1. Barriers to adoption of improved management practices
Source: FAO, 2007.

In the initial phase of the transition, farmers may need to invest in rehabilitation or upgrading of their land and water management structures, or set aside sensitive land and forest. This will require incentives such as cash for labour, or assisted access to credit to overcome immediate adoption barriers and short-term higher management costs/lower income (from lower yield, or land set aside). In a second stage, farmers will need assistance to make the most of this new equilibrium and sell the additional production now possible, due to higher yields or new crops made possible with better water retention and soil fertility. If the areas set aside also require continuous costs, these also need to yield some kind of permanent benefit, either through subsidies or new income generating activities generated (eg. ecotourism along new biological corridors in on-farm protected areas).

Sustainable management of long-term productive and food secure agro-ecosystems benefits farmers as well as other sectors of society. According to FAOs current strategic thinking, sustainability in agriculture requires direct action to conserve, protect and enhance natural resources (FAO, 2014). Reducing erosion from steep cropland, preserving forest and biodiversity benefits us all, sooner or later. Therefore, water users downstream, tourists coming from urban areas and companies with an interest in compensating their climate change impacts have a direct interest in supporting the sustainable management of agro-ecosystems.

As the last meeting of the Sustainable Food Systems Programme (FAO, 2013), it was concluded, farmers require "a well-coordinated progressive and pragmatic approach (...) applying a holistic entry where production, organization, marketing, certification and finance and institutional strengthening are included" (FAO, 2013). To offer such a package, cross-sectoral coordination and combined investment from both the public and the private sector will be required. Payments for environmental services (PES), in combination with other policy instruments like (IES) can offer a channel for such a coordinated approach.

WHAT WE ALREADY KNOW: TOOLS AND EXPERIENCE WITH PES AND OTHER INCENTIVES

IES mechanisms are now widespread across the globe.[1] From large publicly funded programmes such as the Mexican national programme for forest conservation and water protection, investing USD100 million a year[2], to nascent initiatives relying solely on private sector contributions (e.g. multinational flower growers investing USD10 000 a year in the soil conservation in the 3 400 km² catchment of Lake Naivasha in Kenya[3]) and private standards such as the Nespresso AAA.[4]

Tools and methods are available and used to assess environmental services provided by farmers. In Kenya, the Green Water Credits research project mapped areas of the

[1] For an overview visit the following databases:
www.watershedmarkets.org
http://www.watershedconnect.com/projects/ and http://www.forestcarbonportal.com/
http://www.fao.org/nr/aboutnr/incentives-for-ecosystem-services/case-studies/en/

[2] For more see: http://www.fao.org/fileadmin/user_upload/pes-project/docs/FAO_RPE-PES_PSAH-Mexico.pdf

[3] Case study under review, early version available at: http://www.fao.org/fileadmin/user_upload/pes-project/docs/FAO_RPE-PES_WWF-Kenya.pdf

[4] See case study at: http://www.fao.org/fileadmin/user_upload/pes-project/docs/FAO_RPE-PES_Nespresso.pdf

upper Tana River basin, that, if treated with soil and water conservation measures, would yield highest hydrological benefits to the hydropower plants downstream– 70 percent of all hydroelectricity produced in Kenya relies on the upper Tana River.[5] FAO and the Verified Carbon Standard have developed a methodology to account for the climate change benefits of Sustainable Grassland Management, and carbon finance can now support farmers in reducing high altitude grassland degradation.[6] In East Africa, ICRAF and its Pro-poor Rewards for Environmental Services in Africa (PRESA) network[7] have been working to calculate the magnitude of their adoption barriers and required compensation and incentives. However, progress in integrating these findings in public agriculture and environmental policies has been slow. Pilot projects have not yet succeeded in securing sufficient and permanent budgetary allocations from the private sector. Worldwide, incentive schemes are relying mostly on public funds (Bennett and Carroll, 2014). Since in developing countries, these are often in form of international loans or grants, securing sustainable financing is key.

A major bottleneck preventing this lies in designing incentive schemes that combine poverty alleviation goals (primary for public authorities), with environmental additionality (priority for private investors), without providing enough evidence of the latter to secure long-term private sector contributions as an input factor (FAO, 2011).

To move forward with this potentially win–win instrument, we need to improve knowledge on the impact of sustainable management practices for long-term food security and resilience to climate change. FAO is in a prime position to improve this knowledge, by tracking the impact of its own field projects. The guidelines for environmental and social impact assessment currently being developed by FAO, could provide a good basis for an FAO-wide impact assessment system. In addition, the FAO network of Farmer Field Schools, and its partnerships with methodologies such as WOCAT[8] and TECA[9], could be instrumental in data collection at the local level. Knowing and comparing farmers' adoption barriers and incentive preferences[10] would allow us to design the required package of incentives to compensate farmers for the short-term losses, and give them time to realize the long-term benefits.

WHAT NEEDS TO BE DONE

The private sector may invest in sustainable agriculture due to mandatory regulations to reduce their environmental impact, or lower their environmental footprint and increase social benefits (certified or not) ahead of upcoming regulation and differentiate themselves from competitors or wanting to open new market opportunities. They may also do so

[5] http://www.greenwatercredits.net/content/kenya
[6] http://www.v-c-s.org/methodologies/methodology-sustainable-grassland-management-sgm
[7] presa.worldagroforestry.org/
[8] https://www.wocat.net/
[9] http://teca.fao.org/
[10] See for example the experience with reverse auctions, by Bioversity on agrobiodiversity conservation: http://www.bioversityinternational.org/pacs-related-publications/ and by ICRAF on soil and water conservation: http://presa.worldagroforestry.org/?page_id=238

Table 1: Drivers of ES investment by the private sector, combining policy requirements and voluntary measures.

Priority to environmental additionality Conditionality and enforcement			Priority to poverty alleviation	
	Regulatory compliance average daily dietary intake in Italy	**Flexible early and cross-compliance**	**Voluntary investment in ES linked to production Cost-sharing Cost-abatement Risk-management**	**Voluntary investment in ES de-linked from production Benefit-sharing Compensation Rewarding Recognition**
Investment linked to production process	+ +	+	–	– –
Environmental additionally	+ +	+	–	– –
Conditionality and enforcement of ES practices	+ +	+	–	– –
Social additionality	– –	–	+	+ +
Cross-sectorial planning and investment	– –	–	+	+ +
Examples of drivers of ES investment by the private sector	Enforced forest conservation laws Water tariffs Pollution fines Environmental safeguards the company has to comply with • directly (from their own operation) • or indirectly through their customers	Pollution Credits Tradable rights Quality standards Tailored investment of EIA commitments Pre-compliance with upcoming regulation Voluntary standards to reduce Ecosystem Service Footprint	ES investment calculated based on environmental performance or activity-based MRV (strict PES) To secure long-term production factors (water, landscape, soil, etc.)	Investments to managing reputational risk Green and social investment opportunities, outside core business

as providers of technical assistance in accessing markets or rural finance. The ministries of environment and water have a strong interest in cooperating with the ministry of agriculture to increase the sustainability of the sector and the environmental impacts of this activity. In the absence of enforcement and when compliance with conservation and polluter-pay requirements are not implementable due to high social costs and lack of alternatives and assistance, incentive schemes can secure mutual environmental and social benefits. Table 1 shows the range of drivers of ES investment by the private sector, combining policy requirements (left) and voluntary measures (right). Interventions that are mainly focused on poverty alleviation (far right) are less concerned with the environmental benefits of the same practices, while regulations to protect environmental values may overlook the private cost of their compliance.

Figure 2. The flow of incentives, from public (top) and private (bottom) sector, to assist in the transition to sustainable agriculture

For example, enforcing protected area regulations by fining herders encroaching its formal boundaries in times of draught is likely to have much higher social costs than environmental benefits. Conversely, offering better access to school or health services to communities surrounding the park, as an incentive to reduce encroachment, will certainly have social benefits, but it is unlikely to help them comply with the requirement not to enter the park at times of need, since this does not reduce their need for fodder and water in times of draught. Regardless of their good intentions to honour the commitment to the agreement, they are still left without a less environmentally damaging alternative.

A combination of better policy instruments and pooling of social and environmental investments from the public and private sectors may help to overcome these trade-offs and secure better provision of ecosystem services, at lower social costs (FAO, 2011). IES schemes offer the required platform to combine both ends of this spectrum, using incentives to reduce the drivers of non-compliance, co-financed by the consumers of the products and services provided by agro-ecosystems.

In Brazil, the Rio Rural Development Programme, in Rio de Janeiro State, provides an integrated platform for existing public investments in improved livestock breeds, access to marketing and rural credit, with flexible compliance of forest and water protection laws. The latter are also co-financed by water users and private companies with Environmental Impact Assessment (EIA) and compensation commitments (Figure 2 and 3; FAO/SEAPAC, forthcoming).

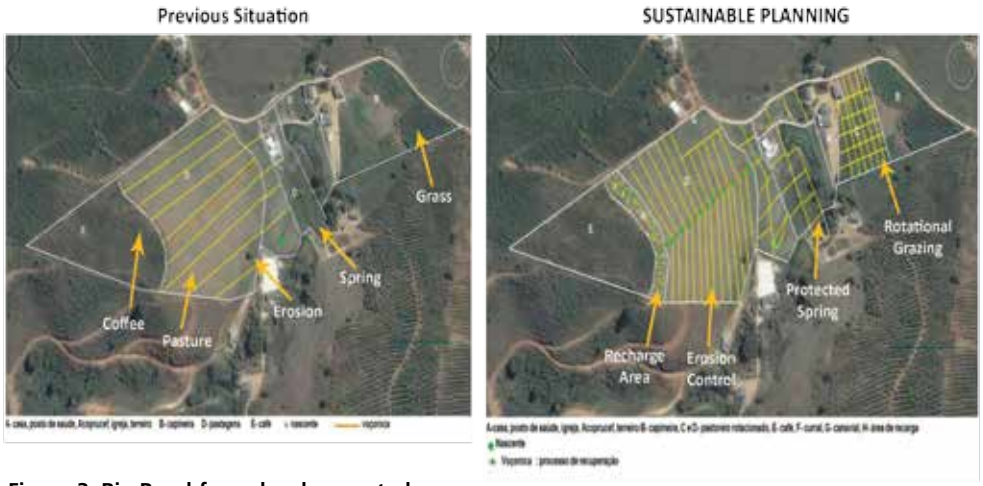

Figure 3. Rio Rural farm development plan
Source: FAO/SEAPAC, forthcoming.

In India, to reduce land degradation from overgrazing in semi-desert Himachal Pradesh, farmers agree to stall-feed a lower number of more productive buffalos to allow for natural forest regeneration and reforestation.[11] They do so by becoming part of a ten-year integrated watershed management project that invests in earthen dams along the water lines to store water for their cattle, fish farming and to irrigate kitchen gardens and the fodder crops needed to set aside the degraded public forest land from extensive grazing.[12]

To offer such an integrated approach there is a need for close collaboration across natural resource and finance ministries, and between these and the private sector. Bringing these different institutions together requires great coordination efforts, and needs legislation and mechanisms for pooling and transferring funds among them. Experience with PES and other incentive policies has tested different combinations of (i) institutions supporting the design and implementation of the scheme, including cross- sectoral programmes that enhance the performance of the scheme and continuous impact assessment; and (ii) underlying policies and regulations that facilitate funds to flow from ES users to providers; and finance the operation of an IES scheme.

WHAT ARE WE DOING

With financial assistance from the Swiss Federal Office of Agriculture, FAO Land and Water Division is hosting a project on Incentives for Ecosystem Services (IES) analysing, in partnership with field partners, with experience in this type of mechanism (Figure 4).

This will assist member countries in strengthening the policies, laws, management frameworks and institutions needed to provide incentives supporting producers and

[11] Himachal Pradesh Reforestation Project UNFCCC Reference No.: 4174: https://wbcarbonfinance.org/Router.cfm?Page=BioCF&FID=9708&ItemID=9708&ft=Projects&ProjID=33738
[12] Himachal Pradesh Mid-Himalayan Watershed Development Project overview page: http://www.worldbank.org/projects/P093720/himachal-pradesh-mid-himalayan-watershed-development-project?lang=en

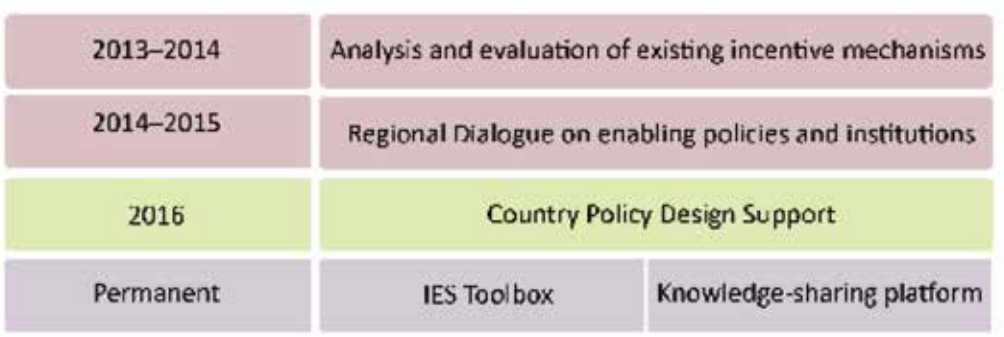

Figure 2. The flow of incentives, from public (top) and private (bottom) sector, to assist in the transition to sustainable agriculture

resource managers in the transition to sustainable agriculture sector production systems. Based on a set of case studies,[13] the team is analysing the role that IES can play in this process, and the enabling conditions that can maximize its social and environmental benefits. This analysis will be informed and verified by a dialogue process, at national and regional levels. In a second stage, the project will work closely with the countries that have an interest in co-financing work on design of IES incentives for sustainable agriculture, and its enabling policies and institutions.

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[13] http://www.fao.org/nr/aboutnr/incentives-for-ecosystem-services/case-studies/en/

Life cycle assessment in the agri-food sector

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ABSTRACT

The economic, social and environmental importance of the agri-food sector is well known. The present challenge is how to provide a growing population with good, safe, healthy food while decreasing the pressure and impacts on ecosystems, resource and human health.

Life cycle assessment (LCA) is the appropriate method to identify, with a high degree of detail, environmental hotspots, compare techniques and crops, and inform with scientific data the decision-making process both at farm level and for policy-makers. However, LCA application in the agri-food sector is a complex and challenging endeavour. Aspects such as unclear identification of the system boundaries, definition of the functional unit, relevant emissions being difficult to measure, and the complexity of the biological processes to be modelled are some examples of specific challenges. Moreover, present development of knowledge does not allow for the quantification of effects of different agriculture practices on biodiversity, long-term soil quality, soil erosion, etc.

The main methodological issues involving biological processes and technical systems are mentioned, together with a list of major ongoing international initiatives.

INTRODUCTION

EXPO Milano 2015 is the Universal Exposition with the theme of Feeding the Planet, Energy for Life. The Expo will host over 130 participants for 184 days on an exhibition site covering one million square metres. It is expected to welcome over 20 million visitors (http://www.expo2015.org accessed November 2014). This is just one apparent signal of the perceived importance of the services that the agriculture sector provides as a source of food, feed, fibres and energy to a population expected to increase to 9 billion people from 7.6 billion today, with continued improvements in living standards. The bad side of the news is that agriculture is responsible for a large share of the impacts of human activities on the environment, resources and human health. For example, the food, drink and tobacco sector is responsible for 18 percent of greenhouse gas emissions, 30 percent of acidifying air pollutant emissions and material extractions, and 60 percent of water use and land use of the impacts caused by the consumption by household in Europe (Figure 1) (EEA, 2014).

A famous quote from Lord Kelvin is: "If you cannot measure it, you cannot improve it". Life cycle assessment (LCA) is the appropriate method to identify, with a high degree of

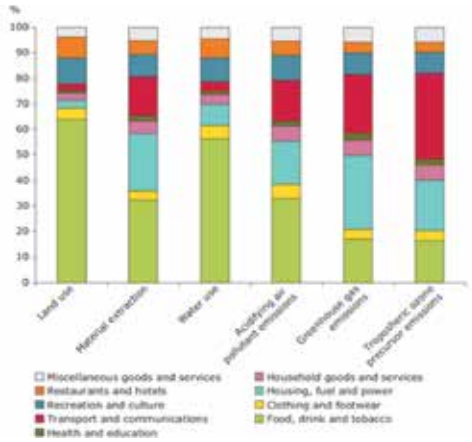

Figure 1. Share of the EU-27' global environmental footprint caused by different household consumption categories in 2008
Source: EEA Environmental Indicator Report 2014.

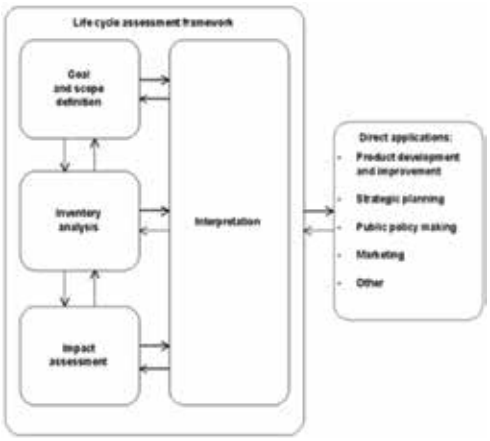

Figure 2. Life cycle assessment framework and applications
Source: ISO 14040.

detail, environmental hotspots, compare techniques and crops, and inform with scientific data the decision-making process both at farm level and for policy-makers (Guinée *et al.*, 2011). Figure 2 shows the LCA framework, as standardized by ISO.[1]

LIFE CYCLE ASSESSMENT

Conceptually, LCA is an inventory of material and energy flows coming in and out from any process of the life cycle of a product system (from cradle to grave). By using specific environmental models, potential impacts from emissions and resource use are quantified. LCA consists of four main phases: goal and scope definition; inventory quantification, by modelling the technological relationships comprised in the life cycle of the product system; life cycle impact assessment; and results interpretation. The process is iterative, with possible iteration of single steps when deeper analysis is required to achieve the stated goals of the study. An LCA study always requires cooperation among methodology, product and technology experts.

LCA avoids problem shifting in environmental analysis; supply, use and end-of-life stages are taken into account, with a system perspective, evaluating a complete set of impact indicators. For example, biofuels reduce CO_2 emissions but require more land for their production, they lead to other climate changing emissions such as nitrous oxide, and they have toxic emissions as from pesticides. Without a system and holistic perspective, existing trade-offs could be missed. Moreover, LCA helps in identifying and managing the complexity that is always behind an agricultural product system. Figure 3 shows, as an example, the flow diagram of buffalo milk and meat production.

[1] ISO 14040:2006 Environmental management – Life cycle assessment – Principles and framework; ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines.

LCA is a methodology first developed for industrial applications. Agri-food and agri-energy applications are particularly complex due to specific aspects related to the nature of the agricultural process. Some key aspects are:

- Technical definition of the system boundaries. There are no simple physical boundaries around an agricultural system.
- Definition of the functional unit (unit of analysis). Unit of mass of crop, nutritional aspects both at serving size or diet and unit of cultivated area are all examples of possible functional units, to be selected taking into due consideration the goals and the expected application of the study.
- High variability of soil characteristics.
- Diverse agricultural/management/crop rotation practices. For example, Table 1 shows the variability in input in six farms for buffalo milk and meat production from the same region in Italy. Table 2 shows the variability in output in the same six farms. Table 3 shows the variability in the resulting impacts, with coefficient of variance (CV) ranging from 21.9 percent up to 51.7 percent.
- Complex relationships among input (nutrients, soil, weather, etc.) and output (crops and emissions). While in industrial processes very often a physical or chemical relationship can find a connection between output and input (i.e. stoichiometric relationship between CO_2 emissions and carbon content in a fuel), in agriculture, the relationships are difficult to model.

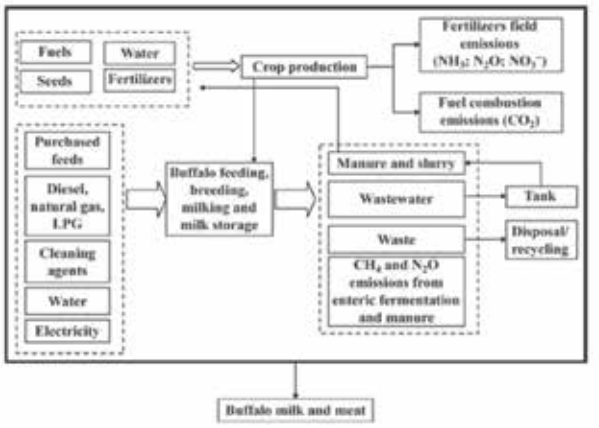

Figure 3. Cradle-to-farm-gate system boundaries of the production of 1 kg of normalized buffalo milk

Note: The solid line represents the system boundaries of the study. LPG = liquefied petroleum gas.

Source: Pirlo *et al* (2014).

Table 1: Example of large variability in input in buffalo farm management in a single region of Italy

Item	Farm						
	Unit	1	2	3	4	5	6
Total cultivated	ha	45	35	38	20	24	157
Maize + Italian ryegrass or whole cereal silage	ha	39	34	36	18	21	3
Synthetic N fertilizer	kg of N/ha	310	227	349	307	201	4
P fertilizer	kg of P_2O_5/ha	78.8	79.0	70.8	78.2	80.3	0.0
Buffaloes	No.	254	401	465	220	365	460
Diesel	1 000 L/yr	18.2	15.6	28.2	57.0	18.0	44.3
Electricity	MWh/yr	8.6	34.1	12.0	7.5	7.6	8.6
Purchased feeds	t/yr	82.1	140.2	83.3	87.3	205.0	132.0

Source: Pirlo *et al* (2014).

Table 2: Normalized buffalo milk (LBN) and meat (as BW) output in the six farms of Table 1

Item	Farm						
	Unit	1	2	3	4	5	6
Total LBN production	t/yr	184.9	371.7	407.0	291.9	206.4	347.3
Average LBN production per lactation	kg/cow	2 032	2 495	2 713	3 243	1 376	1 646
Mill fat concentration	%	8.0	8.5	8.3	8.5	8.5	7.6
Milk protein concentration	%	4.6	4.5	4.4	4.6	4.9	4.3
Total meat	kg/yr	5 900	31 500	29 500	12 450	17 000	29 500

Source: Pirlo *et al* (2014).

Table 3: Environmental impacts of the production of 1 kg of normalized buffalo milk (LBN) at the 6 buffalo farms

Item	Farm								
	Unit	1	2	3	4	5	6	Mean	CV (%)
Global warming	kg of CO_2 Eq	5.56	5.19	3.76	3.99	6.81	5.10	5.07	21.9
Abiotic depletion	kg of Sb Eq	3.7E-3	3.4E-3	2.9E-3	4.7E-3	5.8E-3	4.7E-3	3.5E-3	51.7
Photochemical ozone formation	kg of C_2H_4 Eq	8.9E-4	6.6E-4	4.2E-4	5.2E-4	9.1E-4	6.7E-4	6.8E-4	28.8
Acidification	kg of SO_2 Eq	3.4E-2	5.4E-2	6.4E-2	4.1E-2	9.8E-2	5.9E-2	6.5E-2	30.3
Eutrophication	kg of PO_2^{3-} Eq	3.3E-2	2.6E-2	3.7E-2	2.5E-2	5.5E-2	2.2E-2	3.3E-2	36.5

- Relationship between agricultural practices and long-term soil quality. For example, organic practices are thought to preserve the fertility of the soil while the use of a high input of chemical fertilizers could be the cause of soil mineralizing.

Specific complex aspects responsible for relevant emissions/impacts difficult to measure are:

- Soil erosion: can be responsible for a large share of the eutrophication impact. Through soil erosion, nutrients are removed from the cultivated system via water and soil and lead to the fertilization of neighbouring water bodies and soil systems. However, it is very difficult to generalize erosion rates and deposition rates, as they are highly dependent on regional conditions such as climate, relief, soil type, crop cultivated and vegetation. The range of variability could be up to more than a factor 6 (Figure 4).
- Direct and indirect deforestation: not a negligible contribution to climate change
- Manure management: responsible for emission of NH_3 (acidification and particular matter), N_2O and CH_4 (climate change).
- Fertilizer use: emissions are dependent on many local and temporal variable conditions with strong effects on eutrophication and climate change.

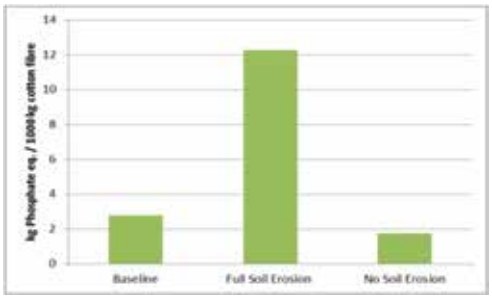

Figure 4. Eutrophication potential with different soil erosion assumptions

Source: PE International (2014).

Figure 5 shows how the nitrogen cycle can be modelled in an LCA study.

- Enteric fermentation: responsible for high share of the climate change due to livestock, and dependent, among other factors, on diet.

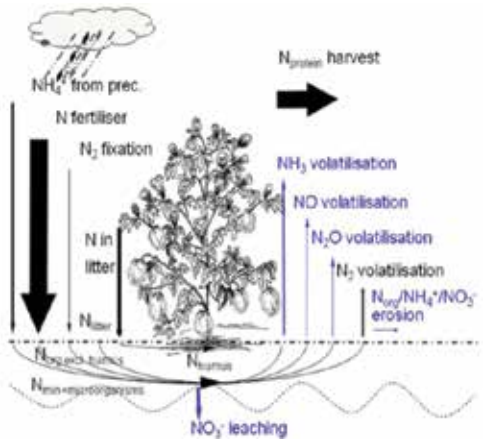

Figure 5. Schematic view of nitrogen cycle in agriculture

Source: PE International (2014).

MAJOR INTERNATIONAL INITIATIVES ON LCA IN THE AGRI-FOOD SECTOR

The complexity of LCA in agriculture is the main reason behind several international initiatives aimed at reaching a harmonized methodology for an improved comparability of the results. Among them the most relevant are:

- The Livestock Environmental Assessment and Performance (LEAP) Partnership led by FAO.[2] LEAP is developing sector specific guidelines and methods for the life cycle assessment of GHG emissions from livestock food chains, such as small ruminants, poultry, large ruminants, swine and feed.
- The UNEP-SETAC Life Cycle Initiative.[3] In 2002, the United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched an international life cycle partnership, known as the Life Cycle Initiative (LCI), to enable users around the world to put life cycle thinking into effective practice. In particular its goal is facilitating the generation and uptake of science-based life cycle approaches and information for products for business, government and civil society practice worldwide as a basis for sustainable consumption and production.
- The Sustainability Consortium is a private organization of diverse global participants that work collaboratively to build a scientific foundation that drives innovation to improve consumer product sustainability. They develop transparent methodologies, tools and strategies to drive a new generation of products and supply networks that address environmental, social and economic imperatives.[4]
- The European Food Sustainable Consumption and Production Roundtable is an initiative, co-chaired by the European Commission and food supply chain partners, which aims to establish the food chain as a major contributor towards sustainable consumption and production in Europe. They developed the ENVIFOOD Protocol, a scientifically reliable, practical and harmonized methodology for the environmental assessment of food and drink products. It represents an intermediate step between

[2] http://www.fao.org/partnerships/leap/livestock-partnership/en/, accessed November 2014.
[3] http://www.lifecycleinitiative.org, accessed November 2014.
[4] http://www.sustainabilityconsortium.org, accessed November 2014.

ISO standards, the European Commission's Product Environmental Footprint and product-specific rules.[5]

- The European Commission's Product Environmental Footprint. The Single Market for Green Products communication (EC, 2014) proposes a set of actions to overcome problems deriving from a confusing range of choices of methods and initiatives to prove the product's green credentials. In particular it establishes two methods to measure environmental performance throughout the life cycle, the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) (EU, 2013); it announces a three-year testing period to develop product- and sector-specific rules through a multistakeholder process. PEF and OEF methodology has been developed building on the International Reference Life Cycle Data System (ILCD) Handbook (EU, 2012) as well as other existing methodological standards and guidance documents (ISO 14040-44 (see footnote 1), PAS 2050 (BIS, 2011), BP X30 [16], WRI/WBCSD GHG protocol (WRI/WBCSD, 2014), Sustainability Consortium (see footnote 4) , ISO 14025,[6] Ecological Footprint,[7] etc). The PEF and OEF are presently under test on pilot cases. Among them, those directly linked to food, beverages and feed are: beer, coffee, dairy, feed for food producing animals, fish for human consumption, meat (bovine, pigs and sheep), pasta, packed water, pet food (cats and dogs), olive oil and wine.

CONCLUSIONS

LCA in agriculture, because of the complexity of the systems to be analysed, requires further research work on: harmonized models for evaluating emissions not directly measurable, a better understanding and modelling improvement for emissions from manure, digestate and fertilizers, soil erosion, direct and indirect deforestation, the development of site-specific impacts; improvement for toxic impacts and effects on biodiversity. Moreover, agriculture deploys a complex basket of services, not limited to the production of healthy food, feed and fibres. Aspects such as natural landscape protection and modification, culture and traditions safeguards and taste valorization should be included in a sustainability assessment that should not be limited to efficiency aspects only.

However, LCA can help in understanding environmental strengths and weaknesses of the different agricultural practices, avoiding problem shifting. But environmental analysis cannot be limited to a single indicator (carbon footprint), in particular in agriculture, where other impacts (acidification, eutrophication, toxicity, land use) are often very important.

A full sustainability assessment would require, besides a complete environmental analysis, an evaluation of economic and social impacts. Tools such as life cycle costing and social life cycle assessment are available, but not fully satisfactory for a complete sustainability assessment purpose. The next steps towards a fully operational and scientifically sound methodology for assessing the sustainability in agriculture are:

[5] http://www.food-scp.eu/files/ENVIFOOD_Protocol_Vers_1.0.pdf, accessed November 2014.
[6] ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations -- Principles and procedures.
[7] http://www.footprintnetwork.org/, accessed November 2014.

- Complete the methodology harmonization.
- Data harmonization for a true interoperability of databases. Presently many database with agricultural processes described in the data sets are available, but not always of sufficient quality. Moreover, they are often very expensive, and they adopt proprietary formats and different nomenclatures, making the use of data from different sources very complex and costly.
- Develop a life cycle sustainability analysis, as proposed by CALCAS Project (Zamagni *et al.*, 2009; Stefanova *et al.*, 2014), capable of modelling and help understanding of the complex environmental, social and economic mechanisms related to agriculture.

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Towards a life-cycle based environmental sustainability framework for the livestock sector

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ABSTRACT

The livestock sector is one of the fastest growing subsectors of the agricultural economy and, while it makes a major contribution to global food supply and the agricultural economy, it also consumes significant amounts of natural resources and produces or interferes with physical flows that impact on the environment. There are several approaches to assess the sustainability aspects of production and consumption of food products. Life cycle assessment (LCA) is a tool that can be used to evaluate the sustainability of a product. This paper presents a framework for the assessment of environmental sustainability of the global livestock sector. The framework, which embraces the life-cycle thinking, illustrates how LCA can be applied to provide information and knowledge to drive sustainable agricultural innovation and practise change.

INTRODUCTION

Population growth, income gains and urbanization are translating into increasing demand for livestock products, particularly in developing countries. Livestock is now one of the fastest growing subsectors of agriculture: a doubling of demand for animal-source foods is expected for developing countries and a 70 percent increase for the world as a whole (Alexandratos and Bruinsma, 2012). While the livestock sector makes an important contribution to global food supply and economic development, it also uses significant amounts of natural resources and impacts on the environment (see for example FAO, 2006). One of the most important global impacts arises from the emission of greenhouse gases (GHG) during livestock supply chains, which are estimated to make a significant contribution to overall anthropogenic GHG emissions (FAO, 2006). This has resulted in efforts to make consumers aware of GHG emissions' associated products they eat through environmental labelling of products (e.g. certain supermarket chains in the United Kingdom). Labelling has focused on the carbon footprint (i.e. total GHG emissions) throughout all stages of production and provision of products to consumers and has generally involved the use of a life cycle assessment (LCA) approach.

As the question of the sustainability of future food systems takes root, there is a growing recognition of the need for comparative and standardized indicators to measure the sector's environmental performance and progress towards sustainability. The ability to measure improvements is critically dependent on establishing valid and comparable methods for measuring performance. Metrics, methods and indicators are required not only to measure the environmental performance but also to identify areas where benefits are greatest and also provide information important for the design of more efficient processes, decreasing resource use and environmental impacts. Monitoring the performance is a key element in evaluating and ensuring environmental sustainability of production processes, hence the absence of recognized frameworks for monitoring environmental performance impedes the possibilities for improvements (FAO, 2013a).

THE LIFE CYCLE ASSESSMENT APPROACH

In recent years, the debate about environmental sustainability has broadened to include the impact of livestock production. The increasing worldwide demand for food, feed and renewable energy sources requires new knowledge about production systems to make them acceptable under the sustainability criteria. Among the assessment tools currently available, the LCA is a method for integral assessment of the environmental impact of products, processes and services. The use of LCA to assess food production is becoming more common. This trend is driven by the need of policy-makers, producers and consumers for reliable and comprehensive environmental information to identify environmentally sustainable agricultural products and practices. The LCA approach, which is defined in ISO standards 14040 and 14044 (ISO, 2006), is now widely accepted as a method for evaluating the environmental impact of production, and for identifying the resource and emission-intensive processes within a product's life cycle. The main strength of LCA lies in its ability to provide a holistic assessment of production processes in terms of resource use and environmental impacts, as well as to consider multiple parameters (ISO, 2006). LCA also provides a framework to broadly identify effective approaches to reduce environmental burdens and is recognized for its capacity to evaluate the effect that changes within a production process may have on the overall life-cycle balance of environmental burdens. This enables the identification and exclusion of measures that simply shift environmental problems from one phase of the life cycle to another.

APPLICATION OF THE LCA APPROACH TO LIVESTOCK SUPPLY CHAINS

Life cycle assessments can be used to support a number of initiatives or goals. In order to improve the understanding of livestock's environmental impact, FAO has developed GLEAM, the Global Livestock Environmental Assessment Model that embraces a life-cycle thinking to understand the contribution of the sector to climate change and identify improvement options in different livestock chains (FAO, 2013b).

LCA can guide and inform decisions and choices by providing a more complete picture of food chains that forces actors to look holistically at food chains, helps identify main hotspots in food chains, areas for improvement and possible solutions/mitigation options and is essential for making transparent any potential trade-offs and avoiding any

unintended swapping/shifting of impacts. LCAs provide a detailed breakdown of impacts along each step of the product life cycle and therefore help pinpoint areas where process improvements can yield environmental benefits. Figure 1 illustrates, at global level, that GHG emissions from livestock supply chains are largely driven by emissions from feed

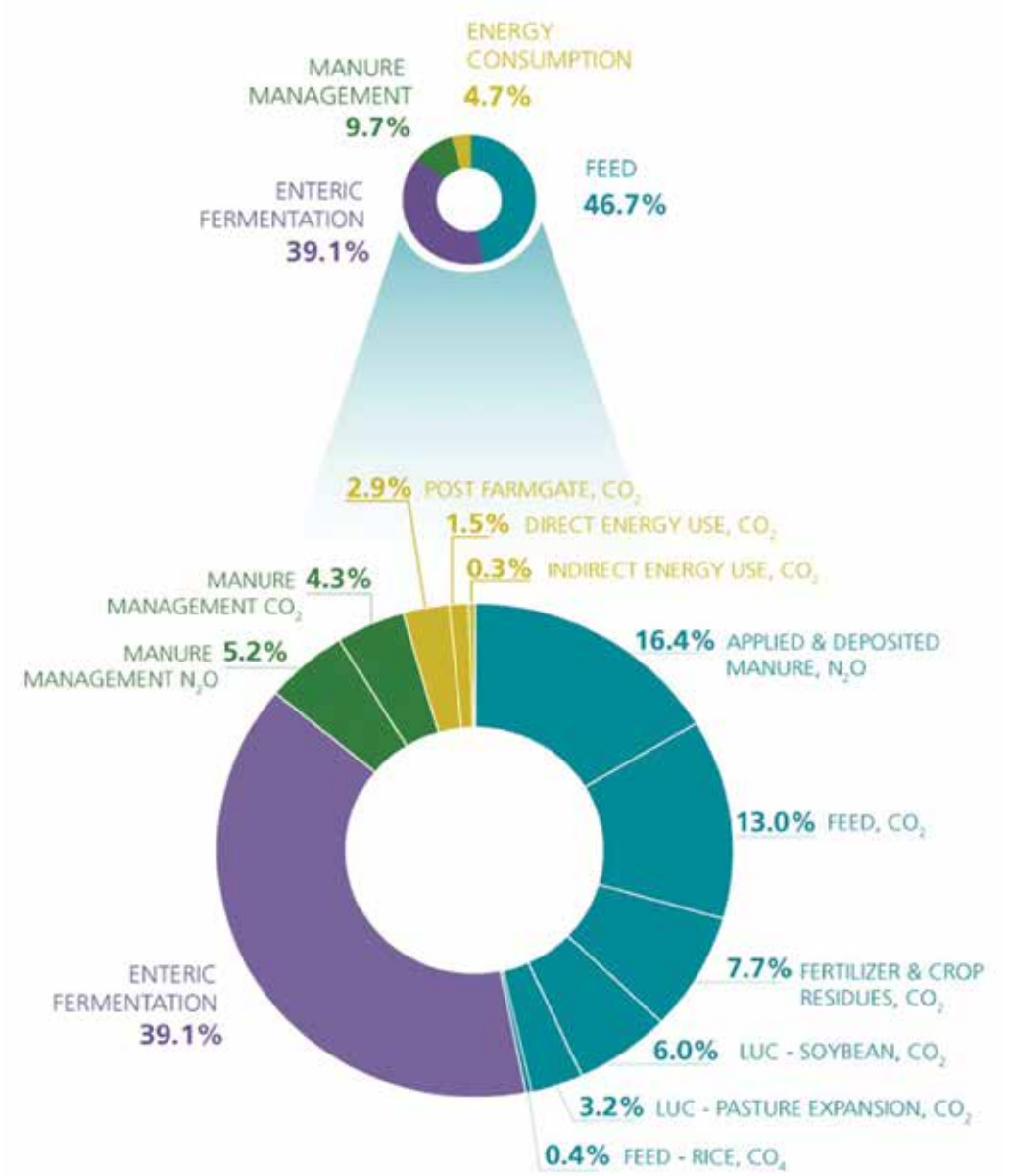

Figure 1. Relative contribution of processes in livestock supply chains to GHG emissions
Source: FAO (2013b).

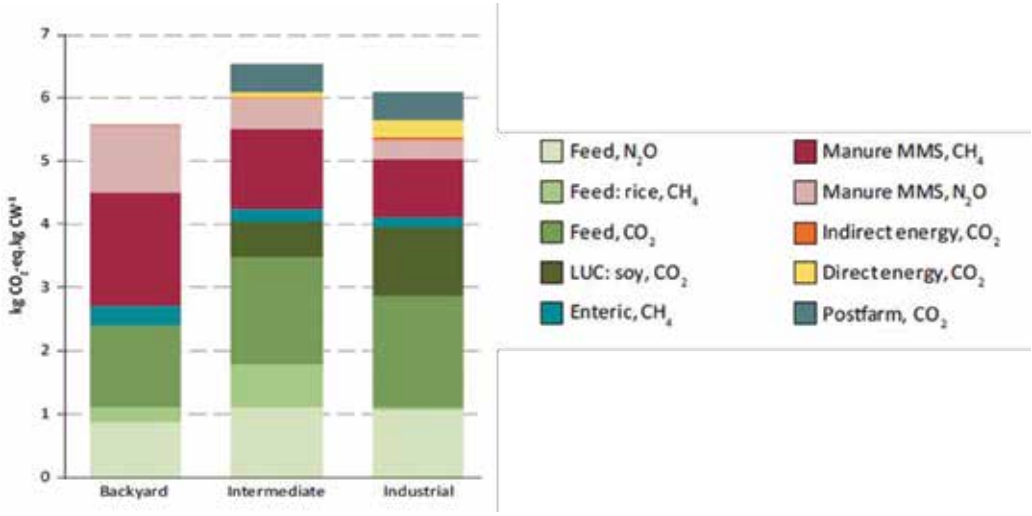

Figure 2. Comparison of emission intensity for pork by production systems
Source: FAO (2013c).

production, transport and processing and methane from enteric fermentation. With this knowledge on which processes contribute towards the impact, stakeholders along the supply chain can target improvements. LCAs can therefore enhance accountability across the supply chain by providing visibility into those stages and processes in the supply chain with high impact.

Livestock production occurs within a myriad of different production systems and species, producing diverse outputs and with varying impacts on the environment. Understanding these differences in production practices is important in assessing the contribution of different systems to environmental impact and unravelling key drivers, as well as explaining key differences between systems. Figure 2 presents a comparison of the emission intensity of pork produced in three systems (backyard, intermediate and intensive systems). It shows that: (i) emissions from feed production and manure management dominate in all three systems (the total manure and feed emissions for backyard systems are 5.3 kg CO_2-eq/kg CW, which compares with 5.8 kg CO_2-eq/kg CW for intermediate systems and 5.2 kg CO_2-eq/kg CW for industrial systems); and (ii) backyard systems are assumed to have negligible emissions arising from post-farm processing, on-farm energy use or manufacture of equipment and buildings, which means that overall they have the lowest emission intensity of the three systems.

It is impossible to drive change and demonstrate that the changes have been effective if there is no standard against which to measure the improved system. This is the basis of benchmarking. Benchmarking the environmental impacts of livestock production systems and comparing the performance of different supply chains against average and top performers within a given region, farming system and agro-ecological zone applying similar production practices can provide insights into their potential for improvement. Figure 3 shows a wide gap in emissions between best performing farmers with lowest emission intensity and those with highest emission intensity, highlighting the room for

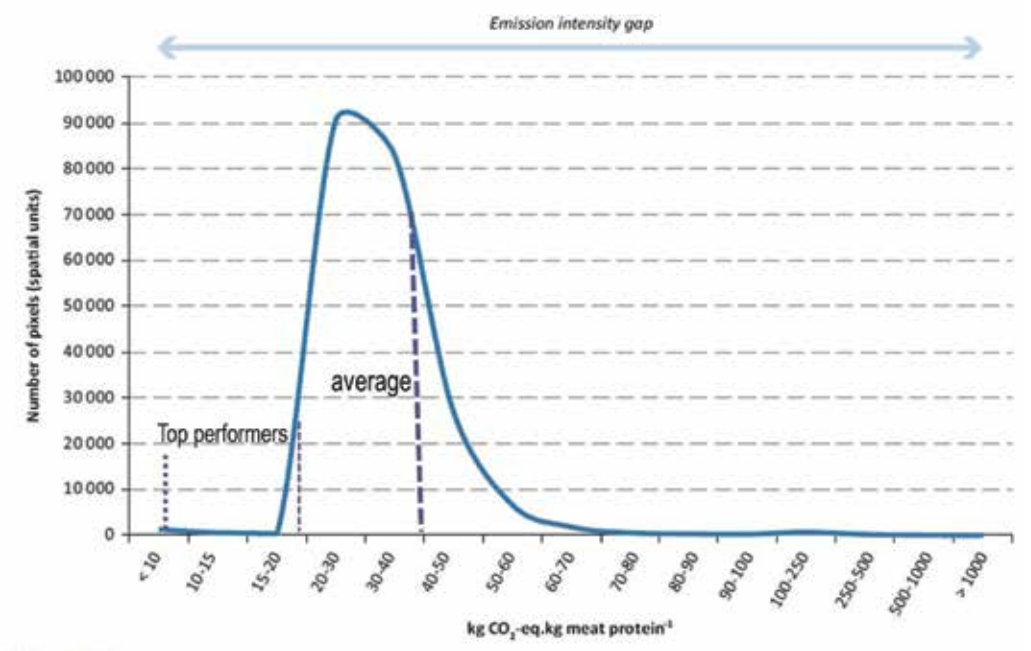

Figure 3. Distribution of intensive broiler supply chains according to their emission intensity in temperate zones of East and Southeast Asia
Source: GLEAM.

mitigating emissions even in the same type of system and the same region, here intensive broiler systems in temperate zones of east and Southern Asia.

CHALLENGES AND WAY FORWARD

In recent years, an increasing number of LCA studies have been carried out for livestock production, mostly in Organisation for Economic Cooperation and Development (OECD) countries (Leip *et al.*, 2010; Ledgard *et al.*, 2011; Beauchemin *et al.*, 2010; de Vries and de Boer, 2010; Verge *et al.*, 2008; Foley *et al.*, 2011). Although LCA methods are well defined, the studies vary considerably in their level of detail, their definition of system boundaries, the emission factors (EFs) they use, and other technical aspects such as the allocation techniques and functional units they employ.

Despite its potential, LCA also presents significant challenges, particularly when applied to agriculture. First, the data-intensive nature of the method places limitations on the comprehensive assessment of complex food chains and biological processes. Limited data availability can force the practitioner to make simplifications, which can lead to losses of accuracy. A second difficulty lies in the fact that methodological choices and assumptions – such as system boundary delineation, functional units and allocation techniques – may be subjective and affect the results. These complications call for methodological harmonization.

Today, the livestock industry is making concrete steps towards sustainability, manifested by the several initiatives on sustainable livestock development such as the IDF Global

Dairy Agenda for Action, the Global Roundtable for Sustainable Beef, the EU Roundtable on Sustainable Production and Consumption and the multistakeholder Global Agenda of Action in support of sustainable livestock sector development. FAO has commenced a programme of work with international groups to develop a harmonized international methodology and guidelines for assessment of the environmental performance of livestock supply chains. This programme is a product of the Livestock Environmental Assessment and Performance (LEAP) Partnership, which is a multistakeholder initiative with the goal of improving the environmental sustainability of the livestock sector through better metrics and data (LEAP, 2014). The LEAP Partnership comprises a range of governments, industry and civil society organizations in a Steering Committee role, and a Technical Advisory Group (TAG) that comprises a range of international experts with experience in LCA and livestock systems supporting the implementation of the project's work programme through the provision of technical and scientific expertise.

When addressing sustainability, it is critical to keep in mind the ultimate needs of society that are met by the system in question: in livestock particularly the roles played by the sector are wide-ranging and beyond just providing food. In addition, the long-term future of livestock production should be assessed in consideration of the consumption patterns and processes that drive production. In other words, a sustainable food system must simultaneously address production and consumption impacts and demands. A life-cycle framework offers a systematic means of linking production and consumption. A life-cycle perspective also assists in identifying areas within the food system where priorities should be placed. Often these areas are not the obvious portions of the system that receive attention.

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The ENVIFOOD Protocol: facilitating consumer choice for greener products

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ABSTRACT
The ENVIFOOD Protocol is a food and drink-specific guidance document created by the European Food Sustainable Consumption and Production Round Table, a multistakeholder initiative co-chaired by the European Commission and business associations from the food and beverage supply chains. The Protocol was published in November 2013 and will be used as a complementary guidance to the Product Environmental Footprint (PEF) and Organizational Environmental Footprint (OEF) guides in the PEF/OEF pilot testing launched by the European Commission. This paper describes the process of creating the ENVIFOOD Protocol as a consensus guidance document from the European food supply chain partners, and describes the key outcomes of the two public testing periods organized in 2013. Finally, how the ENVIFOOD Protocol is expected to be used as part of the PEF/OEF pilot testing and the role it may play outside the application of the PEF/OEF guides are explained.

INTRODUCTION
Lack of consistency in the methodologies for assessing and communicating the environmental performance of food and drink products has the potential to confuse consumers and other stakeholders involved in relevant supply chains. It also poses an unnecessary burden on organizations requested to evaluate their product's environmental footprint on the basis of different guidance leading often to different results. In order to address this issue, business

associations, other food supply chain partners and the European Commission (EC) have established the European Food Sustainable Consumption and Production Round Table (RT).

This paper provides an overview of the process to arrive at the Protocol, describes the process and outcomes of the public consultation and pilot testing and illustrates the next steps for the RT on the development and adoption of Product Category Rules (PCRs) in line with the Protocol and the EC's Product and Organization Environmental Footprint (PEF-OEF) guides. It also provides recommendations on the development of streamlined tools and an adequate database to best support such assessment tools. Finally, it provides insights on the future applications of the Protocol, especially in relation with the EC's PEF. The Protocol and PCRs will allow the development of user-friendly and affordable tools for assessment and communication of the environmental performance of food and drink products in Europe and beyond.

METHODS: THE PROCESS TO CREATE THE ENVIFOOD PROTOCOL

Setup of the Food SCP Round Table

The RT is co-chaired by the EC and food supply chain partners on equal footing and supported by the UN Environment Programme (UNEP) and European Environment Agency. When applying a life-cycle approach, the RT's unique structure based on transparency and dialogue facilitates an open, results-driven and evidence-based dialogue among all players along the food chain, which leads to further harmonization. The RT has delivered on its objectives according to schedule: the publication of the ten *Guiding principles on the voluntary provision of environmental information along the food chain* (European Food SCP Round Table, 2010), the reports on *Communicating environmental performance along the food chain* (European Food SCP Round Table, 2011) and *Continuous environmental improvement* (European Food SCP Round Table, 2012) and the ENVIFOOD Protocol (European Food SCP Round Table, 2013).

Creation of the ENVIFOOD Protocol

Since 2009, RT members have been working together on a commonly-agreed and science-based framework for assessment and communication of the environmental performance of food and drink products in Europe. Based on the above mentioned *Guiding principles*, the RT reached agreement on key methodological aspects at scientific workshops in 2010 and 2011 (Peacock *et al.*, 2011; De Camillis *et al.*, 2012). An analysis of relevant data, methodologies and guidelines for assessing the environmental performance of food and drink was also conducted. The analysis led to a harmonized methodology for environmental assessment, the ENVIFOOD Protocol. The Protocol provides guidance to support environmental assessments of food and drink products conducted in the context of business-to-business and business-to-consumer communication and the identification of improvement options. A public consultation period was organized between 21 November 2012 and 31 March 2013. The consultation was specifically targeted at stakeholders in the food production chain, but open to anyone interested. The feedback from the public consultation was managed through the Round Table Secretariat and addressed by subject matter experts from a technical working group of the Food SCP RT.

Use of the ENVIFOOD Protocol in the PEF/OEF testing

In January 2014 the European Commission launched a second call for volunteers to test the development process of PEF/OEF guides. This second call was dedicated to food, feed and drink products. This call also included a testing of the ENVIFOOD Protocol in the development of the Product Environmental Footprint Category Rules (PEFCRs). The call closed on 28 March, the selected pilots were presented in May, and the testing period started in June 2014. In this testing, the ENVIFOOD Protocol will be used as a complementary guidance to the PEF/OEF guides (European Commission, 2013). The RT will support the PEF/OEF testing as decided in the mandate for Working Group 1 for 2014, mainly on two axes: recommendations on the use of databases, as well as coordination of PCR/PEFCR development.

A first workshop on database development was organized on 11 June 2014 in Brussels, and key database providers for the food sector were invited to present their initiatives to the selected pilot testers as well as to interested stakeholders from the RT.

The Working Group will coordinate the development of product-specific rules (PEFCR/PCR) through the PEF pilot by:

- facilitating coordination and consistency between the pilots, including through participation in PEF pilot consultations and organization of technical workshops;
- providing technical support for the interpretation of the ENVIFOOD Protocol, in relation with the Environmental Footprint (EF) Technical Helpdesk.

As illustrated in Figure 1, the ENVIFOOD Protocol lies between the PEF Guide and the PCRs and PEFCRs. For example, assuming we are to assess the environmental performance of different coffee beverage products we would rely on the general guidance on life-cycle assessment (LCA) provided by the ISO norms 14040 and 14044 (e.g. the different phases of LCA). The methodology to follow would further be specified in the PEF Guide (e.g. which impact assessment model should be used). The ENVIFOOD Protocol then provides additional guidance specific to the food sector – in the example on coffee, this might be related to functional unit and the calculation of land-use change associated to the development of coffee plantations. Finally, PCRs and PEFCRs would specify further details of how the assessment should be conducted at product level, including for

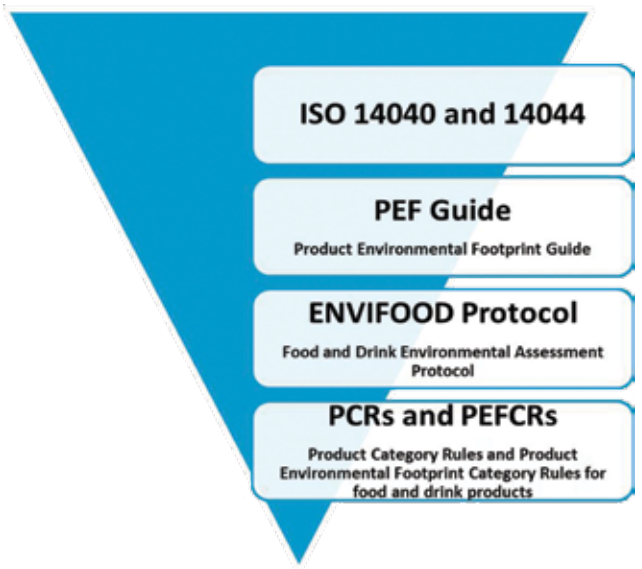

Figure 1. The intermediate position of the ENVIFOOD Protocol as a sectoral guidance in the context of the PEF/OEF pilot phase

instance on the consumer use phase (e.g. heating of water to prepare the beverage). Based on all documents, calculation tools to assess environmental impacts of coffee beverages could be developed. Such tools would be sufficiently simple to use without the need of a deep understanding of all available guidance.

RESULTS

Outcomes of the public consultation

A total of 11 stakeholders of different affiliations (industry, consulting, government agencies and research institutes) submitted feedback during the public consultation period. The feedback highlighted contradictions within the Protocol, misalignments with guidance provided by other institutions, further need for clarifications, as well as highlighting guidance with which certain stakeholders could not agree. Altogether, 144 comments have been received and have been analysed by the members of Working Group 1 of the RT to be included in the updated version of the ENVIFOOD Protocol. Many of the comments received could be used to improve the clarity of the guidance provided. However, a certain number of requests could not be followed because, among other reasons, a consensus on certain questions could not be achieved in the RT or because the points raised were considered more relevant for PCR than for the ENVIFOOD Protocol itself.

Outcomes of the pilot testing

A call for volunteers to evaluate the draft version of the ENVIFOOD Protocol was made by the RT at the end of 2012. The pilot testing period lasted from 27 March 2013 to 15 October 2013 and actors of the food supply chain were invited to test the ENVIFOOD Protocol in their organizations on case studies of new product developments or comparisons of existing products with product alternatives or competing products. The participants were free to choose the product to test. Also, the participants could choose whether or not to also communicate environmental performance based on the outcomes of the testing (the RT did not, at that time, recommend specific communication tools).

Overall, 18 organizations participated in the pilot testing. The participants included a wide range of manufacturers from the food and drink sector, research institutes and trade associations. Written feedback was gathered from the 18 pilot projects and a workshop with pilot testers and RT members took place in February 2014 in order to reach consensus among the pilot testers on the modifications to include in the ENVIFOOD Protocol. The comments have been assessed by technical working group of the RT and classified into three categories:

1. Comments for immediate change, mainly editorial comments or clarification needs. These comments have been incorporated into version 1.0 of the ENVIFOOD Protocol (published on 20 November 2013).
2. Medium-term changes: some comments requested further guidance that could not be incorporated into the ENVIFOOD Protocol in the small amount of time available between the pilot testing and the publication of the Protocol. Therefore, these comments have been addressed in a separate guidance document that is available on the RT's Website. In this document there is a clear focus on land-use change (LUC)

as the need for clarification on this topic was often mentioned (although the technical recommendations from the ENVIFOOD Protocol were not challenged).

3. Long-term comments: some comments on fundamental questions could not be addressed, either because they would have required significant changes to the document, or because no consensus could be reached on them in Working Group 1. They will be kept in a separate list and addressed during the next major revision of the ENVIFOOD Protocol.

Example: specific results from the testing of the feed sector

The main outcomes of the pilot test of the ENVIFOOD Protocol undertaken by the EU feed industry, represented through the European Feed Manufacturers Federation (FEFAC), are given as an illustrative example of feedback from the pilot testing.

As an active member of the EU Food SCP, FEFAC contributed to the development of the ENVIFOOD Protocol. It was then a logical step to participate in the pilot test of the ENVIFOOD Protocol in order to practically evaluate its relevance and applicability for the compound feed industry. This pilot test was undertaken by a consortium of feed associations and feed companies from the EU but also from outside EU. Testing the recommendations of the ENVIFOOD by undertaking a concrete cradle to gate assessment for 21 feed compositions for feed for land animals as well as fish enabled the following conclusions to be drawn:

- It is currently necessary to be an experienced LCA practitioner in order to be able to deal with the requirements of the ENVIFOOD Protocol. Further work remains necessary so that these recommendations can be implemented by feed companies on a regular basis.
- The development of a comprehensive database, aligned with the requirements of the ENVIFOOD Protocol, would be useful to facilitate the implementations of the requirements of the ENVIFOOD Protocol.
- For impact assessment, going through all the impact categories mentioned in the ENVIFOOD Protocol was not considered as something feasible. The selection criteria recommended in the ENVIFOOD Protocol were particularly useful to reduce the list to a manageable level.
- The recommendations regarding assessment of data quality were difficult to implement and considered as a way to try to quantify a subjective interpretation of data quality, which can often be just as well (or even better) discussed in a qualitative way. Moreover, there is no easy way to combine these types of quality indicators for a wide range of data points (such as in compound feed production) and end up in a meaningful cumulative assessment.
- The ENVIFOOD Protocol, however, provides added value when it comes to the environmental assessment of feed and constitutes a very relevant starting point for a feed PCR.

DISCUSSION

The ENVIFOOD Protocol is also intended to be used outside the context of PEF/OEF. The main reason for this is that many actors in the food sector are interested in applying one single LCA methodology throughout their organization, which may be located in more

than one country and even beyond the EU. Therefore, if the ENVIFOOD guidance is implemented as part of the PEF/OEF approach in these organizations, they would also like to use the same guidance outside the context of PEF/OEF. The RT therefore is in contact with organizations inside and outside Europe that work on sustainability in the food sector, and is interested in promoting the guidance developed in the RT also in other organizations.

CONCLUSION

The RT as a large European stakeholder initiative has successfully established scientifically solid and harmonized guidance on life-cycle assessment for the food and drink sector. A number of guidance documents have been published (ENVIFOOD Protocol, but also related documents on communication, databases, PEFCR/PCR development, etc.) over the past years. While the ENVIFOOD Protocol and associated documents do not solve all challenges in assessing the environmental impacts in the food sector, the RT has created a platform for exchange of views between stakeholders, and has managed to establish a methodology that can further evolve as consensus forms and scientific methods improve.

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Food loss and waste: scenario of India

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ABSTRACT
The issues of food losses and waste are of high importance for India in its efforts to combat hunger, raise income and improve food security in the country. Food losses take place at production, post-harvest and processing stages in the food supply chain. Food losses occurring at the end of food supply chain are rather called "food waste", as it basically relates to the behaviour of retailers and consumers. Total food losses globally have been estimated at 1.3 billion tonnes per annum. Food losses and their prevention have an impact on the use of scarce resources (water, land and energy), the environment, food security for poor people, food quality and safety, and the economy. Irrespective of the level of economic development and maturity of systems in a country, food losses and waste should be kept to a minimum. The food losses occur at different stages of the supply chain such as harvesting, collection, threshing, cleaning and grading, handling and packaging, transportation, storage, and retailer level. In a study conducted by the Indian Council of Agricultural Research (ICAR), India during 2005–07, the overall food losses in different farm operations and the supply chain from farm gate to retailer level in cereals, pulses and oilseeds have been reported as 3.9 to 6 percent, 4.3 to 6.1 percent and 2.8 to 10 percent, respectively. The losses in fruits and vegetables have been reported as 5.8 to 18 percent and 6.8 to 12.5 percent, respectively. The total monetary loss was estimated as Rs. 44 000 crores (USD7 330 million), which is a huge amount. The reasons for food losses are lack of technological support, poor awareness among rural masses, lack of facilities and infrastructure, lack of government policy support, lack of processing facilities in the production catchments, sudden glut of certain commodities and natural calamities, etc. The strategies and existing tools for prevention of food losses are presented in the paper. The issue of food wastage is a matter of great concern in India. Some of the major sources of food wastage are marriage parties, hotels and restaurants, university/college messes, canteens, domestic level, etc. A huge amount of food is wasted at marriages, and therefore a systematic study on food wastage in Banglore city was conducted in 2011 in order to collect data on registered marriage halls and marriages held in Bangalore city. The study revealed that 943 tonnes of quality high-calorie food is wasted in Banglore city annually, which is enough to serve about 26 million people a normal Indian meal. About 246 calories of food per meal are wasted, which amounts to about 20 percent. Food wastage has been found to be more in the buffet system than in served systems. Food wastage in monetary terms has been estimated at Rs. 3 390 million among only 531 marriage halls in Bangalore city. In Jaipur in 2010, a non-governmental organization (NGO), Annakshetra

Foundation developed a network of 500 hotels and marriage halls. The NGO collects the unused food, stores it, checks for quality and finally distributes to the poor, slums or orphanages. This model is being replicated in Delhi, Mumbai and Vadodara. The paper also presents mitigation strategies to prevent food wastage from different sources.

INTRODUCTION

Food losses are defined as "the decrease in quantity or quality of food" and are the agricultural or livestock products intended for human consumption that are ultimately not consumed by people. There is a scarcity of information on accurate estimates of the magnitude of loss and waste, particularly in developing countries. However, according to FAO estimates, the quantity of food loss and waste globally is about 30 percent of cereals, 40–50 percent of root crops, fruits and vegetables, 20 percent of oilseeds, meat and dairy products, and 35 percent of fish (FAO, 2011). Total food losses globally have been estimated at 1.3 billion tonnes per annum (FAO, 2011).

The issues of food loss and waste are of high importance for India in its efforts to combat hunger, raise income and improve food security in the country. Food loss and waste mainly depend upon the specific conditions and local situation of the country. Food loss takes place at production, post-harvest and processing stages in the food supply chain. Food loss occurring at the end of food supply chain is rather called "food waste", as it basically relates to the behaviour of retailers and consumers. Food losses and their prevention have an impact on the use of scarce resources (water, land and energy), the environment, food security for poor people, food quality and safety, and the economy. Irrespective of the level of economic development and maturity of systems in a country, food loss and waste should be kept to a minimum.

FOOD LOSSES

Food losses occur at different stages of supply chain such as harvesting, collection, threshing, cleaning and grading, handling and packaging, transportation, storage, and at retailer level (HLPE, 2014). Food losses for 46 major crops and livestock produce contributing to the food basket of India have been estimated by the Indian Council of Agricultural Research (ICAR) during 2005–07 on an all-India basis (Nanda *et al.,* 2012). The food losses comprise essentially on-farm losses and those in transport and storage in different marketing channels. The salient points of the study are as follows:

- The losses for selected cereals, constituting 94 percent of the national cereal production, are in the range of 3.9–6.0 percent.
- The losses in pulses are in the range of 4.3–6.1 percent. Among all the selected pulses, black gram indicates the highest losses in harvesting (1.1 percent), collection (1.0 percent) and threshing (1.6 percent) operations.
- In the case of oilseeds, the losses are in the range of 2.8–10.1 percent, with the highest percentage in groundnut and mustard.
- For cereals, pulses and oilseeds, the losses in farm operations constitute about two-thirds of the total losses. Therefore, efficient technologies for these operations are required for reduction of losses.
- The losses in selected fruits and vegetables are in the range of 5.8–18 percent.

- The losses in inland and marine fisheries are 6.9 and 2.9 percent, respectively. The losses of marine fish do not include on-board loss.
- The losses in meat and poultry sectors are 2.3 and 3.7 percent, respectively.

The total monetary loss was estimated as Rs 44 000 crores (USD7 330 million), which is a huge amount. The reasons for food loss may be described as lack of technological support, poor awareness among rural masses, lack of facilities and infrastructure, lack of government policy support, lack of processing facilities in the production catchments, sudden glut of certain commodities natural calamities, etc.

REASONS FOR FOOD LOSS

Food loss mainly depends upon specific conditions and local conditions in a given country; some of the reasons for food loss in India are described below:

- Existing supply chain is quite fragmented, and hence inefficient.
- Handling of raw produce through many stages of middlemen.
- Processing is mostly controlled by urban rather than rural entrepreneurs.
- Non-availability of adequate and efficient on-farm equipment and machinery.
- Cold chain in India is presently available for milk, meat and pharmaceuticals only but not for other perishable commodities.
- Existing surface cold storage capacity is inadequate (only 11 percent of production) which is largely dedicated to potato (75.4 percent of available cold stores).
- Low availability of multicommodity cold stores (23.1 percent of cold stores).
- Non-availability of refrigerated transport from point of harvest to point of sale.

MITIGATION OF FOOD LOSS

Approaches

Food loss is a matter of concern for all the stakeholders in the supply chain, including producers and government organizations. Therefore, a holistic approach may be adopted involving public organizations and the private sector through:

- providing technological backstopping;
- organization of roundtables, workshops, seminars and conferences at regional and national levels (policy-makers, civil society, NGOs, the private sectors, farmers, etc.);
- government policy support and creation of an enabling institutional environment;
- addressing production to consumption value;
- creation of awareness among farmers and training;
- creation of infrastructure and facilities for processing in the production catchments;
- creation of storage and transportation in supply chain facilities;
- improvement of supply chain management;
- financial tools and initiatives (government support, public–private partnerships, bank support, private sector, etc.).

Existing tools

A number of government organizations are providing financial, technical and policy support in order to mitigate food loss. Some of them are listed below:

- Technology Mission for Integrated Development of Horticulture in North-East States of Sikkim
- National Horticulture Mission
- National Horticulture Board
- Ministry of Agriculture & Cooperation: **Central Sector Scheme** to develop infrastructure, e-trading, market intelligence, mobile infrastructure for post-harvest operations
- **Rural Storage Scheme (Gramin Bhandaran Yojana)** to support rural storage

FOOD WASTE

The issue of food waste is a matter of great concern in India. Some of the major sources of food waste are marriage parties, hotels and restaurants, university/college mess, canteens, domestic level, etc. In India, a huge amount of food is wasted at marriages, therefore, a systematic study on food waste was conducted by the University of Agricultural Sciences (UAS), Banglore, during 2011 (Gowda *et al.,* 2011). It was reported that on an average annually 80 marriages were held in the 531 marriage halls and usually two days were booked for the marriage. On average 1 000 people attended the function, where two meals are served per function. Meals served during the function were wedding reception, wedding lunch and breakfast. It was estimated that on average 641 grams of food were served per plate, of which 112 grams were wasted, which accounts for 18 percent in physical quantity. Generally, 10–20 items are served during the wedding ceremony. About 1 000 people attend marriage parties and on average 943 tonnes of high-quality, high-calorie food are wasted annually, which is enough to serve around 26 million people with a normal Indian meal.

From the survey, it was reported that on average a typical meal served is very rich in energy. It was observed that each meal may have 1 239 calories of food served, enough to meet an entire day's requirement of a child. Of this, around 20 percent was wasted, amounting to 246 calories.

Buffet and served are the two methods followed in the marriage halls. It was also reported that food waste is more in the buffet system (22 percent) than served (20 percent). The rice and cereal waste is about 20 percent in the served system. The rice and cereal wastage is around 35 percent in high budget marriages. Food waste in monetary terms has been estimated at Rs 3 390 million (USD56.5 million) only among 531 marriage halls in Bangalore city.

MITIGATION OF FOOD WASTE

Food waste can be mitigated to a great extent by creating awareness through mass media and other channels and campaigning in schools in order to create awareness among school children. Efforts may also be made to reduce food waste in kitchens and on plates. A mechanism may be developed under a public–private partnership mode to supply unused food to needy people.

An NGO, the *Annakshetra Foundation*, during 2010 in Jaipur, developed a network of 500 hotels and marriage halls. The NGO collects the unused food, stores, checks for quality and finally distributes to the poor, slums or orphanages. This model is being replicated in Delhi, Mumbai and Vadodara.

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Recovery and redistribution of safe and nutritious food for human consumption and food waste prevention and reduction

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ABSTRACT

The Committee on World Food Security (CFS) addressed food loss and waste (FLW) prevention and reduction in the context of sustainable food systems based on a report by its High Level Panel of Experts (HLPE, 2014a). It recommended an enabling environment facilitated through the "food use-not-waste" hierarchy (i.e. prevention, recovery and redistribution of safe and nutritious food to people).

The paper explores first the global and regional policy settings. It then provides a conceptual framework of food recovery and redistribution and food waste (FW) prevention and reduction. Recovery and redistribution of safe and nutritious food for human consumption is performed by food banks, among others. Subsequently, the paper describes the roles that food banks may have in the food system, with questionnaire-based evidence from 44 countries from the Federation of European Food Banks (FEBA) and food banks in the Global FoodBanking Network (GFN) on: (i) number of people assisted (societal dimension); (ii) institutional/policy/regulatory frameworks of reference; and (iii) options for operational implementation. It concludes with identifying food banks' needs such as: public–private partnerships; implementation capacity to address an increasing social demand; and tools for monitoring and evaluation, including food safety, quality and nutrition.

POLICY BACKGROUND

Food loss (FL) is the decrease in quantity or quality of food in the production and distribution segments of the food supply chains and is mainly caused by the functioning of production and supply systems or their institutional and legal frameworks. Food waste (FW) is part of FL and refers to the removal from the food supply chain of food that is fit for human consumption, by choice, or that has been left to spoil or expire as a result of negligence. (FAO, 2014).

FAO (2011) estimated that nearly 1.3 billion tonnes of food are lost or wasted per year. Yet, approximately 805 million people were estimated to be chronically undernourished between 2012 and 2014 worldwide. In particular, slow progress has been registered in

improving access to food due to limited income growth, high poverty rates and poor infrastructure that has made physical and distributional access a significant challenge to overcome. (FAO/IFAD/WFP, 2014).

At global level, the Zero Hunger Challenge[1] includes as objectives the sustainability of all food systems and zero food loss and waste. Furthermore, the Post-2015 Development Agenda current negotiations are considering FLW reduction and monitoring within the potential Goal No. 12 on ensuring sustainable consumption and production patterns.

In October 2014, the Committee on World Food Security (CFS), the world's foremost inclusive intergovernmental and multistakeholder platform for food security and nutrition, held its Forty-first Session on "Making a difference in food security and nutrition" (CFS, 2014). It addressed food losses and waste (FLW) in the context of sustainable food systems based on a report of its High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014a). It was acknowledged that food security and nutrition are central objectives of sustainable food systems and that FLW impact their sustainability, resilience and ability to ensure food security and nutrition for all for this generation and for future generations.

FLW are a consequence of how food systems function and have underlying causes and solutions at "micro", "meso" and "macro" level (HLPE, 2014a). States and, as appropriate, subnational and local authorities as well as intergovernmental mechanisms were invited, by the Policy Round Table recommendations, to measure improvement over time, set targets as appropriate, and introduce an enabling environment to reduce FLW based on a "food use-not-waste" hierarchy (i.e. prevention, food recovery and redistribution of safe and nutritious food to people).

Consequently, all concerned stakeholders should undertake cost-effective, practicable and natural resources sustainable use actions, according to their priorities and means, while coordination of policies and strategies on prevention and reduction should be improved (CFS, 2014). FLW prevention and reduction guidelines were also highlighted in the HLPE report on *Sustainable Fisheries and Aquaculture for Food Security and Nutrition* (HLPE, 2014b) (i.e. minimize fish discards and post-harvest losses and waste at all steps of the fish value chain) and the relevant discussions in CFS, as well as in the *Principles for Responsible Investment in Agriculture and Food Systems* (i.e. reduce food loss and waste in production and post-harvest operations, while enhancing the efficiency of production, the sustainability of consumption, and the productive use of waste and/or by-products). (CFS, 2014).

Furthermore, it has been argued that a major cause of FLW is related to the interpretation of date marking both by the concerned private sector actors and by the end consumer. Box 1 provides a summary of current discussions on the revision of date marking provisions in the Codex Alimentarius.

At regional level, in July 2014 the European Commission (EC) communicated, through the Circular Economy package, the target to reduce food waste by at least 30 percent between 1 January 2017 and 31 December 2025 in the manufacturing, retail/distribution,

[1] United Nations. Zero Hunger Challenge (available at http://www.un.org/en/zerohunger/challenge.shtml).

Box 1: Date marking in Codex Alimentarius

1. Date marking provisions in Codex standards

Food labelling provisions are included in each commodity standard. The provisions were developed in the relevant Commodity Committee based on the recommendation sent from Codex Committee on Food Labelling (CCFL).

Regarding date marking, the Commodity Committee is recommended to choose the date from the following five different types.

- Date of Manufacture
- Date of Packaging
- Sell-by Date
- Date of Minimum Durability
- Use-by-Date

In addition, for the pre-packaged foods "the General Standard for the Labelling of Pre-packaged Foods (CODEX STAN 1-1985)" (GSLPF) also applies. In provision 4.7.1 of GSLPF it says that if not otherwise determined in an individual Codex Standard (i.e. commodity standard) "the date of minimum durability" shall be declared with the exception of products listed in (vi) of provision 4.7.1. Currently there is no commodity standard using "Date of Manufacture" as a type of date marking for final products and almost all the commodity standards refer to GSLPF for pre-packaged commodities.

2. New work on date marking

At the Fortieth Session of CCFL, New Zealand proposed new work on date marking. It has been suggested that current Codex guidelines do not provide adequate guidance on date marking with definitions being identified as being ambiguous and with no clear guidance on how and when to use the date markings that are defined. Therefore, its proposal is to review the relevant provisions of GSLPF in order to give more clear guidance on date marking to Members, especially the Members that do not have national regulations for date marking and depend heavily on imported food.

In 2014 (at the Forty-second Session) the CCFL discussed date marking with the conclusion that revisions (e.g. "best before" and "use by") are extensive and agreed to return to the proposed draft revision for comments and further consideration at the following session in 2016.

food service/hospitality sectors and at households level. Member States of the European Union (EU) were required to establish frameworks to collect and report levels of food waste across all sectors in a comparable way and develop national food waste prevention plans, aimed to reach the objective to reduce food waste to the set targets. The EC was to adopt implementing acts by 31 December 2017 in order to establish uniform conditions for monitoring the implementation of food waste prevention measures taken at Member State level. On 16 December 2014, the EC announced the withdrawal of the Circular Economy package (proposed in July 2014) from the European Commission's new work programme. The package addressed policy and regulatory areas such as waste (including food waste), recycling, incineration, and landfill. A new proposal is targeted by end of 2015.

In 2014 the African Union Heads of State and Government, through the *Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods*, committed to end hunger by 2025 and, as a contribution to achieving this objective, further specified the target of halving current levels of post-harvest losses by 2025.

FOOD RECOVERY AND REDISTRIBUTION AND FOOD WASTE PREVENTION AND REDUCTION - CONCEPTUAL FRAMEWORK

The conceptual framework (Figure 1) allows food systems' actors to identify current status and potential scenarios for effective and efficient interventions. The figure identifies the area of maximum impact as the sum of the intersections between *interpretation and implementation; prevention and reduction drivers as well as their expression for food recovery and redistribution* and *FW prevention and reduction*; as well as *data available* and the level at which it can inform decision-making processes as well as perform monitoring and evaluation.

OVERVIEW OF AVAILABLE DATA FROM THE FEDERATION OF EUROPEAN FOOD BANKS (FEBA) AND FROM FOOD BANKS IN THE GLOBAL FOOD BANKING NETWORK (GFN)

Recovery and redistribution of safe and nutritious food for human consumption is performed, among others, by food banks. We describe here the roles that food banks may have in the food system with evidence from data collected in 2013 and 2014 by FAO in collaboration with FEBA and through two surveys with the food banks in GFN in order to identify key constituent elements of food recovery and redistribution such as: (i) number of people assisted (societal dimension); (ii) institutional/policy/regulatory frameworks of reference; and (iii) options for operational implementation. The questionnaire-based data cover a total of 44 counties. Information (rural, peri-urban and urban levels) is fragmented at local, national, regional and international levels.

It is acknowledged that other networks[2] perform activities for recovery and redistribution of safe and nutritious food for human consumption and food waste reduction and that these may operate through food banks and/or other models (e.g. social supermarkets).

FOOD BANKS

The food bank systems within their core function are connecting surplus and unsalable food with food insecure people and could provide community support through their potential auxiliary functions that support, for instance, job training programmes, child and youth food assistance, and supplemental educational programmes. This system of safe food recovery and redistribution is motivated by, for instance, public awareness and optimization of efficiency in supply chains of business systems that undertake efforts towards ensuring sustainability. Specifically, the food banking infrastructure establishes

[2] For instance: Feeding America, the Middle East North Africa FoodBanking Regional Network, Second Harvest Asia, Food Banks Canada. For a more detailed overview on global activities and networks on food loss and waste reduction please consult the Global Initiative on Food Loss and Waste Reduction (SAVE FOOD) online data base at http://www.fao.org/save-food/partners/en/

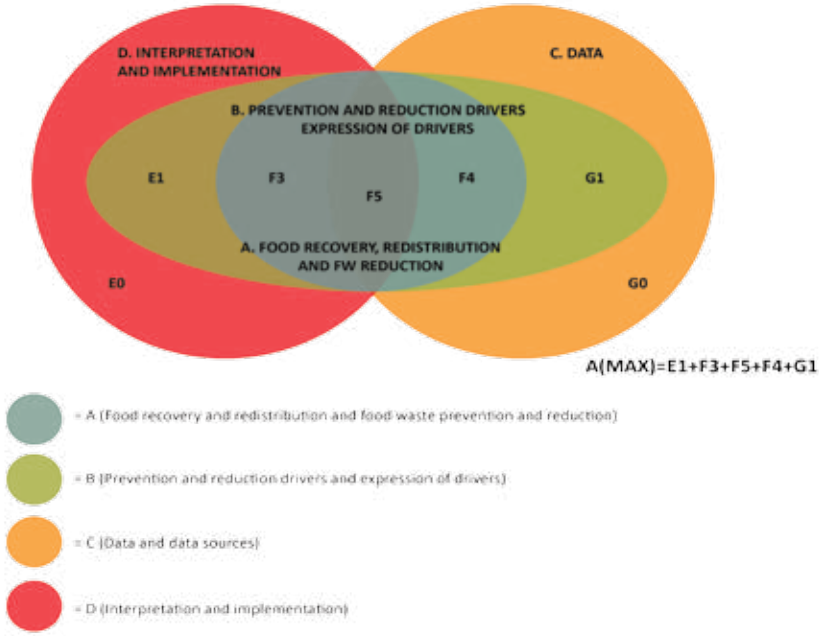

Figure 1. Recovery and redistribution of safe and nutritious food for human consumption and food waste prevention and reduction – conceptual framework (Version 1.0)

Multistakeholder processes in urban, peri-urban and rural areas, at local, national, regional and global level with short, medium and long-term perspectives in order to concurrently address social, natural resources and economic dimensions:

A. Recovery and redistribution of safe and nutritious food for human consumption and food waste prevention and reduction from: primary production, processing operations, supply/stock management optimization, hotels–restaurants–hospitality (HORECA sector), consumer level; within the food use hierarchy ensuring human, plant and animal health, (natural) resources use efficiency; environmental impact minimization.

B. Prevention and reduction drivers: social (including e.g. education and awareness), economic, natural resources, infrastructural, technological, policy/regulatory; expression of drivers through the level of capacity (social, economic, technical, policy/regulatory) for recovery and redistribution and food waste prevention and reduction; coherence and coordination behaviour of food system stakeholders e.g. public–private partnerships; food systems multistakeholders (policy/regulatory, the private sector, civil society [including consumers' organizations]) networks and their functionality and efficiency; existence and functionality of communities of practice for food waste reduction.

C. Data and data sources for: recovery and redistribution and food waste and reduction and prevention; food waste as quantity (mass and/or volume) and quality (food safety, calories and/or micro/macronutrients, economic); data sourced and/or available from food recovery and redistribution entities (e.g. food banks, social supermarkets), local authorities, the private sector, governments, international organizations; for monitoring, evaluation and revision; level of harmonization of quantification methodologies; transparency.

D. Interpretation and implementation: policy and regulatory frameworks, vertical and horizontal coordination mechanisms that enable coherent food systems governance; private strategies and standards, civil society strategies and activities and accountability.

Source: author's elaboration.

access to supply chains extending from primary production through processing, retail and the services sector and captures food that has reached the end of its commercial value.

All relevant safeguards such as food safety and quality management, traceability and inventory controls are retained and exercised by the food banking system at the same level as required on the commercial side of the food supply chains.

The food bank system restricts distribution to vetted, qualified institutions that deliver relevant services to the low and/or no-income community and that incorporate food assistance as a component of those services (e.g. homeless or domestic abuse shelters, orphanages, soup/community kitchens, drug and alcohol rehabilitation facilities, medical clinics, food pantries).

EUROPEAN FEDERATION OF FOOD BANKS

The European Federation of Food Banks (FEBA)[3] was founded in 1986. It brings together 256 food banks in 21 countries[4] in Europe.

Supplying management and food distribution are handled by 12 934 volunteers and 924 employees who work in the European food banks.[5] When organizing public food collections additional hundreds of volunteers are mobilized (FEBA, 2014, personal communication).

FEBA food banks recover food from the food industry and retail stores, European and national food aid programmes or from individual donations of retail prepackaged foodstuffs. Nearly half (44 percent) of the food collected in Europe comes from the European programme of food aid for the most deprived, 22 percent comes from the food industry, 17 percent comes from the retail stores, 14 percent from individuals through national and local collections, and 3 percent from withdrawals from national markets. The total distribution in thousand tonnes was 401 in 2011, 388 in 2012 and 402 in 2013 (FEBA, 2014, personal communication).

In 2013, the European food banks distributed 402 000 tonnes of food, equivalent to 804 million meals, to 5.7 million people in partnership with 31 000 charitable organizations and social services. From 2012 to 2013, there was an increase of 3.7 percent in total quantity distributed, and an increase of 6.4 percent in the number of beneficiaries, representing a range from 0.01 percent to 3.2 percent of total population in their respective countries (FEBA, 2014, personal communication).

The 2014 European Economic and Social Committee (EESC) Comparative Study on EU Member States' legislation and practices on food donation provides an overview of current legislation and practices concerning food donation by investigating five legislative areas impacting food donation (product liability, food safety and hygiene, food durability and date marking, tax legislation, waste) in 12 Member States (the United Kingdom, France, Belgium, Germany, Italy, Spain, Portugal, Greece, Poland, Hungary, Denmark and

[3] http://www.eurofoodbank.eu/portail/index.php?lang=en

[4] FEBA Members: Belgium, Bulgaria, Czech Republic, Denmark, Estonia, France, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Serbia, Slovakia, Spain, Switzerland, Ukraine, United Kingdom. FEBA Projects: Albania, The former Yugoslav Republic of Macedonia, Malta, Norway, Slovenia. FEBA Partners: Germany. (http://www.eurofoodbank.eu/portail/index.php?option=com_content&view=category&layout=blog&id=7&Itemid=26&lang=en).

[5] http://www.eurofoodbank.eu/portail/index.php?option=com_content&view=category&layout=blog&id=4&Itemid=10&lang=en

Sweden). The study recommends clarification around VAT liability on donated food and EU guidelines for food donations. Furthermore, the European Commission (EC) provides[6] on the Web site of the Directorate General Health and Consumers[7] a list of guidance documents for food donation from Member States data sources.

FOOD BANKS IN THE GLOBAL FOODBANKING NETWORK

The Global FoodBanking Network (GFN)[8] was founded[9] in 2006 and currently supports a network of over 250 operational food banks around the world (GFN, 2014). It currently works in more than 30 countries on six continents.

Food banks in the GFN have replied in 2013 from 21 countries and in 2014 from 23 countries. These[10] have distributed in 2012 more than 450 000 tonnes of food to more than 19 000 institutions that support communities directly. In 2013, more than 550 000 tonnes of food were distributed to approximately 25 500 social service agencies. The total number of people that are annually accessing the food bank services ranges from 1 000 to 1 500 000 in their respective countries.

Recovery and redistribution differs highly in quantity across food banks for: cereals; roots and tubers; oil crops and pulses; fruits and vegetables; meat; fish and seafood; dairy and eggs; beverages. Similar to FEBA, GFN's network of food banks recover from the food industry, the retail sector, including groceries, individual donations, farms, produce markets, restaurants and the hospitality industry, among others. Examples of implementation options are available in Box 2.

From the data (2012) gathered in 2013, liability laws enabling donations were implemented in five countries of the 21 countries that have replied. Moreover, in 2014 legislative shifts (from 2013) towards facilitating donations and food recovery and redistribution were registered in three countries. The food banks in GFN are actively involved in national processes that currently consider revisions of legislations and policies related to food donors' liability.

Out of 21 replies in 2013, tax incentives for financial donations were indicated in 16 countries while tax incentives for goods/food donations were indicated in 17 countries. Moreover, food date marking information for the supplies managed across food banks in GFN is highly diversified, reflecting the current unharmonized approach, thus results are heterogeneous and inconclusive. Collaboration with nutritionists was identified in seven replies.

A total of 11 replies indicated a strategic business plan in 2013. Additionally, five have indicated an established collaboration with primary producers (e.g. gleaning, assigning part

[6] Alongside the EC, the European Parliament has also contributed to the European Union knowledge base, and political and institutional development on food waste prevention and reduction (http://www.europarl.europa.eu/news/en/news-room/content/20120118IPR35648/html/Parliament-calls-for-urgent-measures-to-halve-food-wastage-in-the-EU).

[7] http://ec.europa.eu/food/safety/food_waste/library/index_en.htm

[8] The Global FoodBanking Network is a 501(c)3 charitable organization registered with the Internal Revenue Service in the United States of America (http://foodbanking.wpengine.com/gfn/frequently-asked-questions/, accessed 3 December 2014).

[9] GFN Founders: Argentina, Canada, Mexico, United States of America.

[10] GFN Member Food Bank Systems: Australia, Brazil, Bulgaria, Chile, Colombia, Guatemala, Hong Kong, India, Israel, Paraguay, Republic of Korea, Russian Federation, Singapore, South Africa, Taiwan, United Kingdom; GFN is Engaged in: Africa (Namibia, Nigeria, Sierra Leone), Asia (Turkey), South America (Ecuador, Peru, Uruguay) Central America (Costa Rica, Dominican Republic, El Salvador, Honduras, Nicaragua, Panama) (http://www.foodbanking.org/work/where/).

Box 2: Examples of food bank implementation models

Argentina – engages the domestic operating units of global companies to conduct projects aimed at enhancing the operational capacity of the food banks and strengthening their IT capabilities to elevate the operating sophistication of the member food banks and enhance capacity to serve the food insecure population.

Australia – captures from the supply chain hundreds of tonnes of agricultural raw materials that are difficult to use in their stand-alone form, but which, when processed and combined with other ingredients, represent critically needed staple food items to the beneficiary base. Their project includes voluntary engagement of support industries that provide cans, labels and cartons.

Egypt – the Egyptian Food Bank (EFB) collects more than 17 million meals per month from 400 hotels and resorts and redistributes them through programmes across the country while it also produces and processes. EFB also engaged stakeholders to facilitate the development and implementation of a project targeted toward the comprehensive economic development of whole villages across Egypt.

An example of national level complementarities from Australia

Since 2004 **OzHarvest** is a not-for-profit organization that recovers surplus food and delivers it, directly and free of charge, to close to 500 charities. Food is sourced from farmers, wholesalers, fruit and vegetable markets, supermarkets, hotels, catering companies and restaurants. OzHarvest makes reference to *Civil Liability Amendment (Food Donations) Act 2005 No 16* for the liabilities related to the food donations. (Information available at www.ozharvest.org/) .

The **SecondBite** NGO delivers food to over 1 200 food programmes across Australia with the national headquarters, the Kensington warehouse, operating with five vans, one truck, 23 staff and over 600 volunteers. Since 2005 it recovered over 12.6 million kg of fresh food, built community capacity in food management skills and nutrition and advocated for an end to food insecurity. (Information available at http://secondbite.org/).

of the primary production directly to food banks) of which one has indicated that it made its own investments in land for primary agricultural production, two have also developed capacity for farmers that deliver to the food banks, and one is exploring the potential of urban and peri-urban agriculture (e.g. rooftop gardens).

Food banks in GFN support, through social services, organizations that, for instance, are working to prevent women trafficking, and women and children domestic violence, as well as organizations assisting with refugees and women affected by drug abuse.

"Our food banks look for the most efficient, economical, and environmentally friendly ways to connect surplus with need. For instance: moving a food bank closer to a produce market to take advantage of nutritious perfectly edible food that does not meet the criteria for retail sales; organizing volunteer teams who are on call to glean excess crops from fields, and engaging global partners in the restaurant and hospitality industry to safely pack and deliver surplus food to food banks instead of throwing it away" said Jeff Klein President and CEO The Global FoodBanking Network.

Box 3: Global initiative on food loss and waste reduction (also called Save Food)

Since 2011, the FAO Global Initiative on Food Loss and Waste Reduction (also called SAVE FOOD), together with the private sector trade fair organizer Messe Düsseldorf GmbH (Germany), works in partnership with donors, bi- and multilateral agencies, public entities, the private sector and civil society for: (i) awareness raising; (ii) collaboration and coordination of worldwide initiatives; (iii) evidence-based policy, strategy and programme development; and (iv) technical support to programmes and projects.

FAO is collaborating with the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP) for the *Global Community of Practice for Reduction of Food Losses*. The Organization will compile the Global Food Loss Index to estimate loss ratios in countries (dynamic predictions are supported, i.e. estimates can be continuously updated) and has designed the food supply chain case study methodology for the food subsectors in developing countries. The methodology, covering (i) screening, (ii) sampling and survey, (iii) synthesis and final report, has been tested in 2013 in Kenya.

In October 2013, the World Resources Institute (WRI) launched the design of the Food Loss and Waste Measurement Protocol. FAO is a member of the Steering Committee and facilitates technical support and a harmonized approach. In January 2013, FAO and UNEP launched the Think.Eat.Save (TES) Campaign (as part of SAVE FOOD and of the FAO-UNEP Sustainable Food Systems Programme) and in May 2014 published the *Prevention and reduction of food and drink waste in businesses and households – Guidance for governments, local authorities, businesses and other organizations Version 1.0*. focused on designing effective food waste prevention programmes with governments, local authorities, private companies, institutions and civil society for the retail, hospitality and food service supply chains.

For more information and to join SAVE FOOD, see http://www.fao.org/save-food/en/

CONCLUSIONS

Among the food banks' needs identified are: (i) multistakeholder dialogue platforms to enable food recovery and redistribution potential assessment, ownership and knowledge/capacity transfer; (ii) prioritization and coordination criteria for interventions of governments, the private sector and civil society; (iii) resource mobilization, infrastructure and public–private partnerships; and (iv) implementation capacity to address an increasing social demand. Moreover, tools for monitoring and evaluation are needed that could provide guidance also on food safety and quality (including human nutrition) and further data on the four dimensions (availability, access, utilization and stability) of food and nutrition security.

The largest costs for food banks relate to personnel and volunteer management along with hard assets (warehouse, rolling stock, equipment, etc.) and logistics management (collection and distribution of food and grocery products). Globally, access to adequate funding and surplus food are ongoing challenges. Despite the staggering scale of global food waste, it is challenging to overcome logistics, the cold chain and attitudinal issues related to capturing the food resources before they are wasted. Farmers, manufacturers,

distributors, retailers, food services providers and others in the supply chain who own the products that the food bank system targets for their programmes are often reluctant to donate due to concerns over liability exposure (e.g. lack of Good Samaritan Law) or because of economic disincentive (e.g. unfavourable, or interpreted as such, tax laws).

The former UN Special Rapporteur on the Right to Food, Olivier De Schutter, has indicated in 2013 that food banks, that are donation-dependent, can help identify flaws in social protection for the most vulnerable members of the communities (De Schutter, 2013). Nevertheless, food banks cannot be used as a substitute for social protection measures that address the underlying poverty and inequality, and subsequently generated food insecurity.

Information (rural, peri-urban and urban levels) is fragmented at local, national, regional and international levels. At global level, FAO is undertaking collaborative and coordinative actions - within the SAVE FOOD Initiative framework (Box 3) - in order to improve data and facilitate recovery and redistribution of safe and nutritious food for human consumption and food waste prevention and reduction.

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Food losses: methodologies for appraisal

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ABSTRACT

The importance of measuring food losses has been reaffirmed in current international development processes and fora, for example the zero food losses and waste element of the Zero Hunger Challenge, Global Green Growth Forum (3GF) and post-2015 process as well as by the High Level Panel of Experts on food security (HLPE, 2014). This paper aims to present several initiatives launched by FAO and its partners to improve knowledge on FLW and its causes and to provide actors with methodologies and tools adapted to their needs.

These initiatives include a definitional framework of FLW; a food supply chain case studies methodology; FAO work on compilation of a Global Food Loss Index; the FLW Measuring Protocol (a multistakeholder effort to develop a standard for measuring of food loss and waste); the Guidance on the Prevention and Reduction of Food and Drink Waste (a product of the Think.Eat.Save campaign and the FAO/UNEP Sustainable Food Systems Programme, as well as of the SAVE FOOD Initiative).

INTRODUCTION

The importance of measuring food losses has been reaffirmed in current international development processes and fora, for example the *zero food losses and waste* element of the Zero Hunger Challenge, Global Green Growth Forum (3GF) and post-2015 process as well as by the High Level Panel of Experts on food security (HLPE, 2014).

An estimated one-third of food produced for human consumption is lost or wasted globally each year (FAO, 2011), causing unnecessary pressure on natural resources, food and nutrition security, and economic value for the actors in the food supply chain and consumers. In 2011, FAO estimated yearly global quantitative food loss and waste (FLW) at roughly 30 percent for cereals, 40–50 percent root crops, fruits and vegetables, 20 percent oilseeds, meat and dairy products, and 30 percent for fish (FAO, 2011). However, accurate estimates of the magnitude of losses and waste are still lacking, particularly in developing countries and, as a consequence, *evidence* is missing in *evidence-based policy-making*.

During recent decades, numerous studies were conducted at national level, based on literature reviews, statistical data, and stakeholder interviews. The studies have revealed that we do not know yet which causes of food losses are most important, what is the impact

of the solutions implemented and which solutions are most viable and cost-effective, in economic, environmental, and food and nutrition security terms.

Improving knowledge and data collection has been identified as a major issue to reduce FLW (FAO, 2011; HLPE, 2014). FAO along with its partners has launched several initiatives to improve knowledge on FLW. It starts by a definitional framework of FLW.

The SAVE FOOD Initiative[1] has designed the *food supply chain case studies methodology* for the most important f*ood subsectors in developing countries* in order to generate primary and empirical data for different causes of FL and feasibility analysis of solutions (technical, economic and social).

FAO has also prioritized FLW in its new Strategic Framework (Strategic Objective 4[2]) and identified the need to *improve assessment of the magnitude and causes of FLW*. FAO Statistics Division will compile a *Global Food Loss Index* using data available, including those from existing surveys (e.g. APHLIS[3]) and official data from FAOSTAT questionnaires.

The FLW Measuring Protocol is a multistakeholder effort to develop a standard for measuring of food loss and waste. The following hypotheses will guide development of the Protocol: (i) *Series of versions* – the FLW Protocol is targeting to evolve over time reflecting advances in methods, data, and user needs; (ii) *Tiered methods* – the FLW Protocol may propose "tiers" of recommended methods and data sources for quantifying food loss and waste; and (iii) Modular coverage – Modular elements could be selected, based on the necessities for appraisal.

The *Guidance on the Prevention and Reduction of Food and Drink Waste* is a product of the Think.Eat.Save campaign and the FAO/UNEP Sustainable Food Systems Programme, as well as of the SAVE FOOD Initiative (UNEP, 2014). It provides clear and comprehensive steps for governments, businesses and other organizations to develop strategies, programmes and activities to prevent and reduce food and drink waste, and to achieve the associated financial savings and reductions in environmental impacts.

DEFINITIONAL FRAMEWORK OF FOOD LOSS

In recent years, the topic of food loss and waste (FLW) has been gaining importance, both in the public and private sectors of the global food systems. Many initiatives are being undertaken worldwide to reduce FLW. Many definitions and terminologies are being used by various actors and stakeholders in the global food systems. Sometimes definitions are the same, but different terms are being used; sometimes the terms are the same, but their meanings can be a little different.

Therefore, FAO's Global Initiative on Food Loss and Waste Reduction has taken a coordinating role, to enhance information exchange, collaboration, synergy and harmonization of strategies and methodologies. In this respect, it is important to agree on, and accept, a common definition of FLW. It will provide an opportunity towards achieving

[1] http://www.save-food.org/
[2] http://www.fao.org/docrep/meeting/027/mf490e.pdf
[3] http://www.aphlis.net/

a globally harmonized approach to improving data collection, data comparability, and evidence-based regulatory and policy decisions for FLW prevention and reduction.

FLW has an impact on food security, on local and national economies, on the natural resource base, on waste streams and the environment. FAO's main focus in formulating the definition of FLW is the food security dimension.

One thing has become very apparent in the process: a definition on FLW is not a mathematical or physical law, it has many different logics that are equally good, and therefore it is just a matter of choice on what to accept as the definition. FAO offers this definition[4] as a global reference for any stakeholder dealing with FLW, and to use it within the context of their operations. It is not cast in stone, and after one year of feedback the functionality of the definition will be evaluated and adjusted if necessary.

Essential terms and concepts in this definition are:

- Food waste is a *part of food loss*, however not sharply distinguished; the term "food loss and waste" is nevertheless maintained in regular communication.
- "Intended for human consumption" (already embedded in the Codex definition of "Food").[5]
- Plants and animals produced for food contain "non-food parts" that are not included in FLW.
- Food redirected to non-food chains (including animal feed) is food loss or waste.
- Quantitative FLW = the mass (kg) reduction.
- Qualitative FLW = reduction of nutritional value, economic value, food safety and/or consumer appreciation.

DEFINITIONS

Food loss (FL): The decrease in quantity or quality of food.

Quantitative food loss: The decrease in mass of food.

Qualitative food loss: The decrease of quality attributes of food.

Food: Any substance, whether processed, semi-processed or raw, that is intended for human consumption, and includes drink, chewing gum and any substance that has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substances used only as drugs (Codex Alimentarius Commission, Procedural Manual, 2013).

Food plants and animals (FPA): Plants, animals and their derived products for food.

Non-food parts of food plants and animals: The parts of food plants and animals that are not intended to be consumed by humans.

Food supply chain (FSC): The connected series of activities to produce, process, distribute and consume food.

[4] For a definition and scope of losses see http://www.fao.org/fileadmin/user_upload/save-food/PDF/FLW_Definition_and_Scope_2014.pdf

[5] "Food means any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance that has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substances used only as drugs" (FAO/WHO, 2013).

CASE STUDIES ON THE EXTENT, CAUSES AND SOLUTIONS TO FOOD LOSSES IN THE SMALL-SCALE AGRICULTURE AND FISHERIES SUBSECTORS – DEVELOPMENT OF A FOOD LOSS REDUCTION STRATEGY

Food losses refer to the decrease in edible food mass throughout the different segments of the food supply chains – production, post-harvest handling, agro-processing, distribution (wholesale and retail) and consumption. Food losses and their prevention have an impact on the environment, food security for poor people, food quality and safety, and economic development. The exact causes of food losses vary throughout the world and are very much dependent on the specific conditions and local situation in a given country.

During the recent decades numerous studies have been undertaken to assess the quantities of food losses and food waste in many countries of the world. Most of these studies were conducted at national level, and based on literature review, statistical data and stakeholder interviews.

The research revealed the knowledge gap: we have quantitative estimations of food losses, we know the causes of food losses, and we know that food loss reduction will be of great benefit to all actors in the food production and supply chains, to food security for poor people, and to the environment. However, we do not know yet which causes of food losses are the most important, what is the impact of solutions and which solutions are viable and cost-effective, in economic, environmental and food security terms – meaning, the solution to food loss should not be more expensive than the food loss itself, should not place a higher burden on the environment and greenhouse gas emission, should make more food available to the people that need it most, and should be socially and culturally acceptable.

Therefore, the Save Food Initiative has designed the "food supply chain" case studies, for the most important food subsectors in developing countries. In these case studies, primary and empirical data will be generated for the different causes of food losses, and solutions for food losses will be analysed for their feasibility.

A case study is just a one-moment recording of what is happening in a specific food supply chain in a specific season; next season and in a different location the situation can be very different again. Therefore it is important that the Save Food Initiative can undertake many case studies in many different locations, so that the multitude of study results provide significant trends and solutions. Further, the strategy aims at using the results of the case studies to target opportunities for investment programmes and interventions, during which formulation a wider geographical scope and the seasonality will be analysed.

The objective of this study is the identification and quantification of the main causes of food losses in the selected food supply chains, and the analysis of the measures to reduce food losses on their technical and economic feasibility, social acceptability and environment-friendliness, leading to concrete proposals to implement a food loss reduction programme.

IMPLEMENTATION OF THE FIELD STUDY

Selection of countries and subsectors

Countries and subsectors are based on existing and ongoing programmes to work with, and collaboration with partners in the field. Subsectors are chosen from the important food

commodities in the country: cereals, roots and tubers, fruits and vegetables, oilseeds and pulses, animal products (meat, milk, eggs), and fish and seafood.

Identification of consultants

The field work will be done by a team of two or three national consultants: one subsector specialist, who could be an actor in the food supply chain, one agricultural economist, and one rural sociologist.

Selection of food supply chains

This is based on smallholder producers, at a significant scale of food production, preferably including agro-processing and urban markets, and if possible, included in an ongoing support programme for the subsector.

Uniform methodology

The methodology of the case studies needs to be uniform for all countries, so that the results are comparable and extrapolation is possible. The methodology has been developed specifically for this purpose and will be published and promoted among other Save Food partners. It involves the collection of data and their analysis with assessments carried out using qualitative and quantitative field methods. The methods applied are (i) *Preliminary Screening of Food Losses ('Screening')* – based on secondary data, documentation and reports, and expert consultations (by phone, e-mail, in person) without travel to the field; (ii) *Survey Food Loss Assessment ('Survey')* – a questionnaire exercise differentiated for either producers, processors or handlers/sellers (i.e. warehouse manager, distributor, wholesaler, retailer), complemented with ample and accurate observations; (iii) *Load Tracking and Sampling Assessment ('Sampling')* – for quantitative and qualitative analyses at any step in the supply chain; and (iv) *Solution Finding ('Synthesis')* – used to develop an intervention programme for food losses, based on the previous assessment methods. The sequence in the 4-S approach should be: 1) screening, 2) sampling and survey, 3) synthesis, and concluding with the elaboration of a final report.

The consultants will physically follow the product for four weeks, from production site to final retail outlet, make direct observations and measurements, and discuss with supply chain actors the causes and solutions for food losses. The consultants draft a proposal for a food loss reduction strategy or plan.

Stakeholder validation

In a one-day workshop with stakeholders from the public and private sectors the study results and proposed food loss reduction strategy are discussed and endorsed. A concept for a programme to finalize and implement the food loss reduction strategy or plan is prepared.

The methodology has been tested in 2013 in Kenya and FAO is currently revising it for a second case study (FAO, 2014).

GLOBAL FOOD LOSS AND WASTE MEASUREMENT PROTOCOL

The Food Loss and Waste Measuring Protocol is a multistakeholder effort to develop a global standard for measuring FLW. It will enable countries, companies and other organizations to estimate, in a credible, practical and consistent manner, how much food is lost and wasted and identify where the loss and waste occur. With this information, users will be better equipped to address food loss and waste.

Guiding the FLW Protocol is a vision that wide use of the measurement standards will empower the world to minimize food loss and waste, thereby enhancing food security, economic growth and environmental health.

Although the adage "what gets measured, gets managed" applies to food loss and waste, several challenges exist. For instance, there are varying definitions of what constitutes FLW. In addition, different methods for quantifying FLW are emerging, a development that risks creating confusion among users, lack of comparability and consistency among methods, and multiple "reinventions of the wheel". Furthermore, data availability remains a challenge; quantifiable data on food loss and waste are often sparse or inconsistently gathered.

The FLW Protocol seeks to address these challenges. Developed via an expert and stakeholder engagement process, the Protocol will provide a globally consistent approach and guidance for countries, companies and others to measure and monitor the FLW that occur within their boundaries and value chains. It seeks to define best practice methods and data sources, harmonize measurement approaches, enable comparability between areas and entities, and facilitate transparency across users.

Users of the FLW Protocol will likely have varying motivations for measuring food loss and/or waste. The FLW Protocol design will reflect these distinctions and meet multiple purposes. It will provide written guidance on various aspects of measuring food loss and food waste including, but not limited to:

- definitions of food loss and waste (e.g. across different parts of the food value chain, by destination, and by type of material);
- boundaries or "scopes" for what to measure;
- unit(s) of measure;
- data collection, quantification and extrapolation methods;
- types of data sources;
- evaluating trade-offs between accuracy, completeness, relevance and cost;
- setting targets;
- reporting results.

The FLW Protocol will take the form of a publication, which may be complemented by an online component that points to tools and other forms of assistance for entities that want to conduct a food loss and waste audit in accordance with the FLW Protocol.

The FLW Protocol development process may go beyond developing guidance for measuring FLW. For instance, it may recommend new methods for gathering and/or generating data on FLW. And it may conduct outreach and make recommendations to decision-makers about policies and investments (e.g. in data collection) needed to facilitate the ability of governments, companies and others to measure their food loss and waste.

The FLW Protocol is designed to generate a number of benefits to countries, companies and other organizations. Most importantly, it will guide users on how to measure food loss and waste, providing:

- confidence that the methods used are robust, credible and globally accepted;
- consistency and comparability;
- alignment to prevent "reinvention of the wheel";
- accelerated transfer of best measurement practices.

In turn, measuring FLW in accordance with the FLW Protocol will enable users to answer questions such as:

- How much food is being lost and/or wasted:
  - provides methods for users to quantify the amount of loss and waste;
  - links to guidance on how to set baselines, formulate targets, benchmark, measure, and report;
  - supports the development of relevant prevention and reduction strategies.
- Where is the loss and/or waste happening:
  - identifies where loss and waste is occurring;
  - highlights who to engage;
  - enables the development of practical action plans.

In light of these guiding principles, the following hypotheses will guide development of the FLW Protocol:

- *Series of versions*. The FLW Protocol will evolve over time reflecting advances in methods, data and user needs. Therefore, there will be multiple versions of the FLW Protocol over the course of a decade (e.g. version 1.0, version 2.0).
- *Tiered methods*. In order to be amenable to differences between regions regarding current data availability and measurement capacity, the FLW Protocol may propose "tiers" of recommended methods and data sources for quantifying food loss and waste. The level of accuracy and comprehensiveness increases the higher the tier. This feature is important because some countries (e.g. the United Kingdom) and companies today may be able to measure their food loss and waste in accordance to the highest tier while others (e.g. Burkina Faso) may not. Having lower tiers available enables the latter to still start the process of quantification. Yet having higher tiers available sets aspirations and establishes "the bar" that can guide investment decisions around what data need to be collected.
- *Modular coverage*. Guidance will be provided in a modular manner so that a user can select the suite of elements most relevant to its specific objectives. This may include, for example, recommendations that users measure and record separately the different paths food may take if not consumed by humans (e.g. donation, animal feed, energy, compost, disposal).

GLOBAL FOOD LOSS INDEX – CONCEPT

Much has been discussed about policy interventions that target food loss reduction. However, there is little existing data about where and when these losses occur, for which commodities and their extent. As a consequence, "evidence" is missing in "evidence-based policy-making".

A major reason for the lack of data on food losses is that costs of direct measurement are prohibitive, typically involving tracking quantities of a commodity and recording weights/biomass at each stage of long and complex value chains. Accordingly, there are no global comprehensive and coordinated efforts to collect data. Nevertheless, some efforts have been started at the regional level, e.g. the African Postharvest Losses Information System (APHLIS) funded by the EU Commission's JRC, initiatives of the Alliance for a Green Revolution in Africa (AGRA) and the Bill and Melinda Gates Foundation. That said, there is emerging consensus about the need to equip countries with a common framework for measuring food losses and waste.

FAO has prioritized the subject of food losses and waste in its new Strategic Framework (under Strategic Objective 4), identifying the need to i*mprove assessment of the magnitude and causes of losses and waste*. A key deliverable of Strategic Objective 4, which also constitutes an indicator of FAO's corporate monitoring and evaluation framework, is to compile a **Global Food Loss Index**. Emphasis is on post-harvest losses given their magnitude relative to household waste in developing countries.

Using data, including those from existing surveys (e.g. APHLIS, AGRA) and official data collected from FAOSTAT questionnaires:

- A model is constructed to estimate loss ratios in countries and for commodities for which no hard data are available. As a first step, the model designed with predictive power (i.e. ability to predict collected data), which incorporates observed variables that conceivably influence food losses on a commodity basis. These include countries' infrastructure, for example: inadequate storage facilities; quality of roads in a country influences losses during transportation; in the case of bumper harvests, insufficient infrastructure to store, or no price incentive to distribute to markets; climate zone, country's share of small farms, rainfall at harvest, pests, etc.
- Accordingly, attention is paid to whether the commodity is perishable or storable. The model is then used to predict loss ratios for any commodity given knowledge on the causal factors. As these factors are subject to trends, dynamic predictions are supported, i.e. estimates can be continuously updated.
- Most importantly, when hard data on losses are received, the model is subsequently updated to improve estimates for other countries and commodities. Through standardizing on *calories*, aggregation is made possible, and loss indices at the country, regional and global level may be compiled – by commodity or in totality. The index will employ a percentage scale, indicating the degree of loss incurred in total or in the particular commodity.

The Index is a model that estimates loss ratios in countries (dynamic predictions are supported, i.e. estimates can be continuously updated). Food loss indices at country, regional and global may be compiled – by commodity or in totality. The Index will employ a percentage scale, indicating the degree of loss incurred in total or in the particular commodity and it constitutes also an indicator of FAO's corporate monitoring and evaluation framework and has been proposed by the Rome-based agencies as an indicator for post-2015.

PREVENTION AND REDUCTION OF FOOD AND DRINK WASTE IN BUSINESSES AND HOUSEHOLDS – GUIDANCE FOR GOVERNMENTS, LOCAL AUTHORITIES, BUSINESSES AND OTHER ORGANIZATIONS

The objective of the *Guidance* is to catalyse action around the world by sharing proven methodologies for food waste prevention. The scope of this *Guidance* is food waste prevention in the retail, hospitality (restaurants, hotels) and food service (schools, hospitals) supply chains, and household food waste. Waste and loss in the agricultural stages of production are not covered.

The document is organized in four modules, which together provide extensive guidance on how action can be taken at a country, region or business level to prevent food waste – measured in tonnes. Food waste has a range of complex causes, and it arises in a dispersed nature – both geographically, across the globe, and at all stages of the supply chain and at consumption level. In order to address this food waste, there are simple actions that every individual or business can take, but there is even greater opportunity to achieve larger reductions if targeted programmes are developed and delivered. It is scoping, planning, delivering and measuring food waste prevention programmes and activities that are the focus of the guidance. The guidance seeks to address the complex problem of food waste, by providing a framework for action that can be used flexibly, as required by the user.

The *Guidance* is based on the proven experiences of developing and delivering food waste programmes that have achieved significant measureable impact. One of these is the experiences in the United Kingdom, where household food waste has been reduced by 21 percent overall between 2007 and 2012, and food retailers, restaurants, food service providers and food and drink manufacturers are signed up to voluntary targets to reduce food waste. A wide range of experiences from across the globe have also been used, both in developing the guidance and to illustrate examples of food waste prevention in action.
The *Guidance* has been developed by using these proven experiences, in order to facilitate knowledge transfer – allowing others to develop and deliver programmes to prevent and reduce food waste more easily and effectively than might otherwise have been the case. There are currently a limited number of examples of such programmes, so it is likely that the guidance can be further developed over time, drawing on new experiences from around the world. In the first instance, elements of the guidance will be piloted in a range of countries.

The experiences drawn upon are largely from examples in the industrialized world and some emerging economies. In developing countries, it is documented that food losses and waste are more likely to be at the primary production stages and from farm gate to market including storage.

However, as food consumption patterns become more similar across the world, the food waste prevention actions included in the guidance will become increasingly applicable to developing countries. Learning from food waste prevention programmes in a developing country and emerging economy context can be added to the guidance over time.

There is potential to reduce the amount of food waste that is disposed of to landfill, by recycling more through anaerobic digestion and composting, for example. These opportunities are set in context in this document, using a food material hierarchy, but the

guidance focuses solely on reduction and prevention of food waste, not on different waste management options.

The audience for the Guidance document is government departments, businesses and other organizations that have the capacity to influence food waste at a country, regional or business-sector level, by developing and implementing strategies and programmes. This could also be within business operations and supply chains, and tools and information are provided in the guidance, but the key focus is around developing regional and country-level strategies and implementing these strategies by developing and delivering food waste prevention programmes targeted at consumers and businesses.

Because of this strategy and programme focus, the Guidance document is extensive and comprehensive – providing a full journey for the reader. Different organizations and countries may be at different stages of developing strategies for food waste and may therefore have different areas of focus, so the guidance can be used flexibly.

The *Guidance* document is structured into four modules:

Module 1: Mapping and measuring food and drink waste.

Module 2: Options for developing national or regional policies and measures for food and drink waste prevention and reduction.

Module 3: Developing and implementing programmes to prevent and reduce household food and drink waste.

Module 4: Preventing and reducing food waste in the food and drink business supply chain (retail and manufacturing, and hospitality and food service).

CONCLUSION

A better understanding of the causes of FLW is key to devise strategies to address them and identify priorities of action (HLPE, 2014). The methodologies and tools presented above aim to enable each category of actors, international organizations, governments, the private sector and consumers, to assess FLW, identify causes and priorities of action, and ultimately monitor results. As such they can play a key role to facilitate individual and collective action.

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Knowledge management for sustainable food value chain development: the FAO perspective

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ABSTRACT

Over the last decade, the value chain (VC) has established itself as one of the main paradigms in development thinking and practice. In recent years, the triple-bottom-line approach to sustainability – combining economic, social and environmental aspects – has emerged as a key theme in this area. This has been accompanied by an at times bewildering increase in the literature, tools, case studies and training materials dedicated to the various aspects of sustainable food VC development. Against this background, reflecting its role as a global knowledge broker, FAO is developing a new global platform to provide user-friendly guidance to this vast and ever-growing collection of materials. The library and discussion forum of the platform will allow practitioners and policy-makers to quickly find the most suitable items for their particular needs. The realization of the knowledge platform will be accompanied by parallel efforts such as practitioner handbooks, training materials and e-newsletters. It is expected that this new knowledge platform will facilitate the spread of new ideas and knowledge related to the development of sustainable food value chains.

INTRODUCTION

Over the last decade, the value chain (VC) has established itself as one of the main paradigms in development thinking and practice. In recent years, the triple-bottom-line approach to sustainability – combining economic, social and environmental aspects – has emerged as a key theme in this area (Neven, 2014). This has been accompanied by an at times bewildering increase in the literature, tools, case-studies and training materials dedicated to the various aspects of sustainable food VC development. Against this background, reflecting its role as a global knowledge broker, the Food and Agriculture Organization of the United Nations (FAO) is developing a new global platform to provide user-friendly guidance to this vast and ever-growing collection of materials. The library and discussion forum of the platform will allow practitioners and policy-makers to quickly find the most suitable items for their particular needs. The realization of the knowledge platform will be accompanied by parallel efforts such as practitioner handbooks, training materials and

e-newsletters. It is expected that this new knowledge platform will facilitate the spread of new ideas and knowledge related to the development of sustainable food value chains.

DEFINING THE CONCEPT

When discussing management in a particular field of knowledge, the first step is to demarcate clearly what it includes. This starts with a definition. What is a sustainable food value chain? There are two parts to this. First, a food value chain consists of all the stakeholders that participate in the coordinated production and value-adding activities that are needed to make food products. A sustainable food value chain then is a food value chain that:

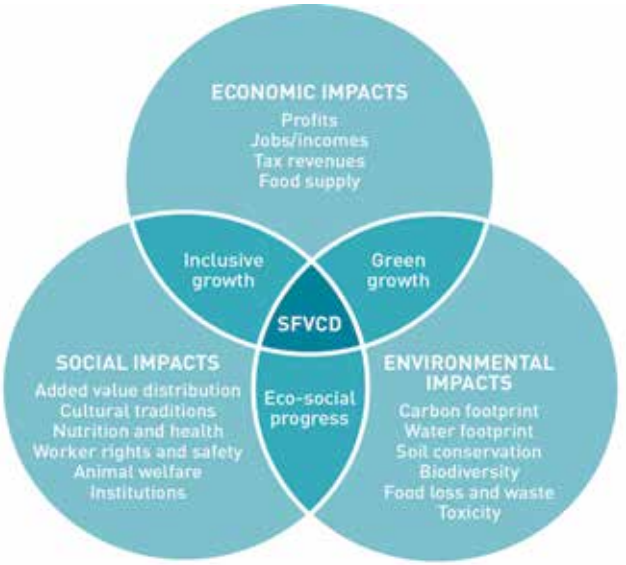

Figure 1. The triple bottom line of sustainability
Source: Neven, 2014.

- is profitable throughout (economic sustainability);
- has broad-based benefits for society (social sustainability); and
- shows a positive or neutral impact on the natural environment environmental sustainability).

THE CONCEPT OF SUSTAINABILITY

Figure 1 depicts the triple bottom line of sustainability: economic, social, environmental. The elements under each of these three dimensions are intended to list exhaustively what falls under this dimension (a process that is not yet completed in FAO – for example water health and animal health are elements that need to be added under environmental sustainability). Assessing the performance of a value chain, or the impact of an upgrading activity, implies that each of the elements under these three dimensions needs to be taken into account simultaneously (although rarely all will be relevant for a given value chain). The immediate implication in such a holistic approach is that there are usually various trade-offs that need to be considered. For example, one upgrade may be better in terms of increasing profitability, but have an inferior impact in terms of carbon emissions or gender equality. Making these trade-offs is largely a decision of a political nature, but even so one that stresses the importance of knowledge-based decision support systems.

FRAMEWORK AND GUIDING PRINCIPLES

The analytical framework applied at FAO for analysing food value chains is holistic, systems-based and market-driven (Figure 2). Beyond the actors in the core value chain

(from farmer to consumer) are various environmental layers that are critical in terms of understanding the performance of the chain. It is often in one of these layers, rather than in the core value chain itself, that an upgrade can have the biggest impact on improving the impact on sustainability. This reflects the systems-nature of the value chain. The first of these layers are the various actors that provide inputs (e.g. fertilizer, packaging material), non-financial services (e.g. spraying, transport) and financial services (e.g. working capital, insurance). Financial services are separated out from other services in reflection of their fundamental and ubiquitous importance as the "oil in the value chain-machine". Along with the core value chain actors, the input and service providers form the extended value chain.

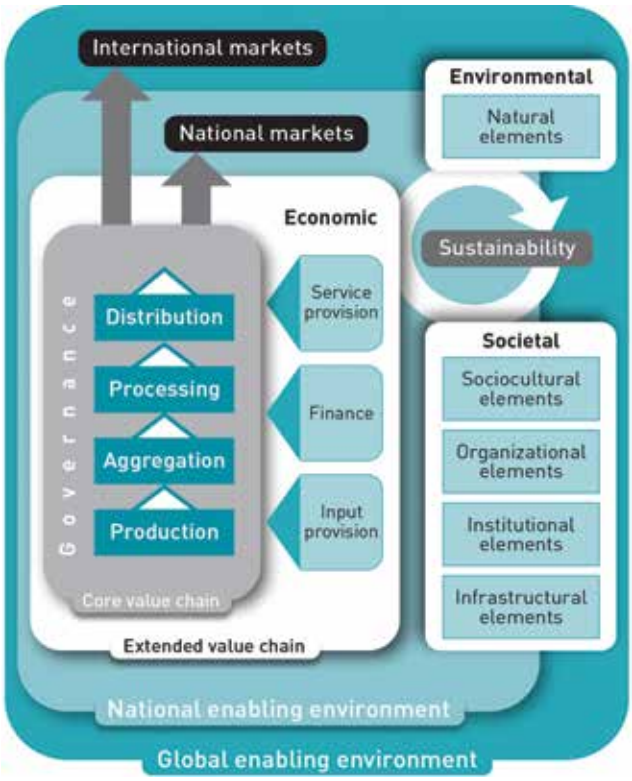

Figure 2. The SFVC analytical framework
Source: Neven, 2014.

The latter ends in end-markets where the consumers make their "dollar-votes": they decide what food products represent the greatest value to them by spending their income on these products. Value here increasingly includes not just the product itself, but also how it was produced and delivered to them (i.e. with what ecological or social impacts are associated with it). As such, opportunities in end-markets are the starting point in the upgrading of any value chain. The extended value chain is further embedded in "enabling environments" at the national and international levels. These include the ecological environment (e.g. soils, climate, water availability, biodiversity) and the social (or human-made) environment (e.g. electrical grids, policies, research institutions, cultural traditions).

Reflecting best-practices, ten guiding principles can be distinguished in sustainable food value chain development (Figure 3). Failure to abide by these can easily lead to small, no or negative impacts of efforts. These ten principles are grouped into three cyclical steps. Under measuring performance, three principles stress the importance of simultaneously assessing the three dimensions of sustainability as described above. Under understanding performance, the systems- and market-driven nature of the approach is stressed, as well as the importance of so-called "governance" structures (i.e. how stakeholders interact with each other, what drives their behaviour). Under improving performance, four principles

describe four critical aspects: developing a joined vision, carefully assessing and selecting upgrading options, assuring impact at scale, and combining the complementary strengths of various stakeholders in multilateral efforts.

Figure 3. Ten guiding principles for SFVC development
Source: Neven, 2014.

KNOWLEDGE MANAGEMENT ISSUES IN SFVC DEVELOPMENT

Both globally and inside FAO, there are some issues in terms of SFVC development. Globally, three main challenges can be distinguished. First, such a vast literature on the topic has emerged that it has become difficult to find the best references in that sea of options. Second, many practitioner experiences, both on what works and what does not, are not well-disseminated as practitioners often do not have the resources (time, funds, networks) to do so. Third, the use of VC approaches is continuously broadened across disciplines, creating the need for an integrated framework. For example, VC approaches are used to tackle issues as wide-ranging as nutrition, gender and animal health. The risk is that the application in these fields becomes myopic in terms of its impact assessment (e.g. maximizing nutritional outcomes at the expense of competitiveness).

At FAO, two issues related to the application of VC approaches have emerged. The first is that while they are widely used at FAO (e.g. in agribusiness, nutrition, livestock, fisheries, trade), there is little commonality in the approach and there are no systematic tools for knowledge sharing beyond inefficient one-on-one efforts. The second is that the Organization does not have sufficient or sufficiently adapted VC development capacity building tools that focus on FAO's needs.

THE DEVELOPMENT OF A SET OF INTERRELATED PRODUCTS TO ADDRESS THE ISSUES

To address the issues, and reflecting its role as a global knowledge broker, FAO has embarked on the development of a set of new products related to SFVC development that are highly complementary and synergistic in nature. In terms of new tools, FAO is developing a set of practitioner handbooks and a training package. The practitioner handbooks take a case-study based approach to capturing, packaging and distributing the solutions to SFVC development problems. In other words, they stimulate the spread of

ideas, best practices and effective solutions emerging from the field, whether in FAO or non-FAO projects, in government programmes or in private sector efforts. The training package will combine a careful selection of existing tools inside and outside FAO, build on the framework and principles presented above, and be adapted (and adaptable) to the specific needs of FAO and its partners (e.g. the use of food VC-based examples, triple-bottom-line sustainability, field-based and e-learning-based modules).

Connecting FAO's VC work internally and externally, three products are in various stages of development. These include a theme page, an FAO Technical Network (internal) and an online knowledge platform. The use of theme pages and internal technical networks are two new developments at FAO, both aimed at reducing the risk of stove piping along disciplinary or commodity-based boundaries. Theme pages are part of FAO's Web site and provide a quick overview of key facts, recent outputs and further links related to the theme. FAO technical networks link staff from both headquarters and field offices who use the VC approach in their daily work through various tools, such as newsletters, webinars, and a joint workspace on the Organization's intranet. For the theme of SFVC development, these tools allow FAO staff a platform for an effective knowledge sharing within the Organization and to present the Organization's wide-ranging VC development activities in an integrated way to outside users (e.g. development practitioners, policy-makers).

The online knowledge platform on SFVC development is the main development around the theme at FAO. Intended to become part of the FAO public Web site, the platform will consist of four core elements: a library; a training and learning centre; a news and events section; and a member zone. The key structural element throughout is a thesaurus of technical tags on SFVC that has been developed specifically for the site. The library consists of both FAO and non-FAO materials, carefully selected and extensively tagged. This set of materials includes discussion papers, case studies, briefs, media and data-sets among others, and can be searched using a variety of search options that will allow users to quickly find the best items for their specific needs. The training and learning centre will also contain FAO and non-FAO materials, including the specific training materials described above. The news and events section and member zone are extensions of the FAO technical work, linking FAO staff to experts around the world working on SFVC development. The member zone includes yellow pages for the membership and tools to communicate and establish discussion groups around subthemes.

CONCLUSION

Knowledge management is a critical driver of organizational performance. At the same time, improving it is challenging task. Developments in information and communication technology offer important, even essential, tools for accomplishing this task and, around themes such as SFVC development, FAO is eagerly applying them. Even so, results will be limited if technology promotion is not accompanied by fundamental changes in organizational culture that create a willingness to work across disciplines and to take the effort to share with peers. Such changes take time and require a sustained effort supported by sufficient resources and commitment at all layers of the Organization.

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Project EcodEX: Nestlé Product Ecodesign Tool

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ABSTRACT
Nestlé has introduced a simplified ecodesign tool (EcodEX) to evaluate the environmental performance of its products during the new product development process. The tool is based on the life cycle assessment (LCA) methodology. EcodEX guides the user along the typical modules of the life cycle of a packaged food product. For each ingredient and processing step of the recipe, the user selects life cycle invento-ry data from a predefined list. The tool has been rolled out to the Nestlé R&D community and is now systematically used when new products are developed. The use of EcodEX has also driven the development of further life cycle inventory data, as well as the harmonization of LCA methodology for the agri-food sector.

INTRODUCTION
Nestlé, the world's leading nutrition, health and wellness company, is using environmental life cycle assessments (LCA) to set priorities and make comparisons between projects to improve product environmental performance throughout its value chain. An LCA approach has been introduced into the Nestlé product development process and is used to assess and compare the environmental performance of product alternatives. Comprehensive life cycle assessments with external LCA consultants have been performed in all Nestlé business-units over the past years. Selected studies have been critically reviewed, some of them published in the scientific literature.

Conventional LCA with external consultants reaches its limitations in the fast moving consumer goods sector because of the speed of the new product development process: conventional LCA usually takes several months to complete. By the time results are available, and recommendations on product improvements can be made, the product development is usually considerably advanced: the design freedom is limited, the cost for change very high. Furthermore, a company as large and diverse as Nestlé (over 2 000 brands worldwide, with many more different products) would need to dedicate a considerable amount of resources to systematically assess its entire product portfolio with external LCA consultants.

Nestlé has therefore introduced a series of simplified ecodesign tools throughout its organization to facilitate and accelerate taking into account environmental considerations

during the new product development process. The most advanced of these tools, EcodEX, has been developed in collaboration with Selerant, an IT company specialized in product life cycle management, and has been rolled out to all Nestlé R&D centres during 2013 and 2014.

CHARACTERISTICS OF ECODEX

EcodEX is a simplified ecodesign tool specifically developed to assess the environmental performance of packaged food products. Given its limited scope and the simplifications implemented, it is capable of guiding non-expert users through the relevant phases of the typical life cycle of a packaged food product. The tool asks specific key questions to calculate a reliable estimate of the environmental performance of a packaged food product.

The tool is based on the serving size as the functional unit, and therefore capable of comparing the environmental performance of different product systems with similar functions (such as soluble coffee with roast-and-ground coffee capsules). The tool is linked to the company recipe system and takes product composition and processing information directly from the existing product database, which further facilitates ease of usage. The tool user will have to select life cycle inventory (LCI) profiles that match ingredient specifications from an LCI database. In the case of Nestlé specific operations (such as in-house production), default parameters may be overwritten with specific measured values.

Results can be displayed in a number of ways, allowing non-expert users to understand the details of an assessment, while at the same time providing decision-makers with a simple-to-understand graphical il-lustration of complex scientific results.

METHODOLOGICAL ALIGNMENT WITH EXTERNAL INITIATIVES

The choice of environmental impact assessment methods has also been guided by the PEF and the Envifood Protocol. However, the number of indicators to be used has been further restricted to simplify decision-making. The retained indicators are: land use and water consumption at the inventory level, greenhouse gas emissions (according to the Intergovernmental Panel on Climate Change [IPCC]) and non-renewable minerals and fuels (according to the Institute of Environmental Sciences, Leiden CML), as well as ecosystems quality (at endpoint) based on the IMPACT 2002+ methodology. These indicators will be updated as new methods in better alignment with international guidance become available: for instance, an updated water consumption indicator that takes scarcity into account should be available shortly (ongoing development as part of the Water Use in LCA [WULCA] working group of the UN Environment Programme/Society for Environmental Toxicology and Chemistry [UNEP/SETAC] Life Cycle Initiative). Similarly, a land use indicator that takes actual biodiversity losses into account is expected to be available in several upcoming regionalized impact assessment methods (IMPACT World +, LC IMPACT).

The LCI database in EcodEX is based, as much as possible, on data that have been independently published and critically reviewed. The Ecoinvent database is used for most of the background processes such as electricity mix, transportation and fuels, as well as for

packaging materials and conversion processes. Ecoinvent also contains a number of food ingredients, but has to be complemented with further databases, as describedbelow.

RESULTS

The direct benefits of EcodEX include products with better environmental performance, as well as con-scious decision-making where a design alternative with worse environmental performance is retained (e.g. for reasons other than the environment, such as legal compliance, nutritional value, quality). More important, however, are the indirect benefits, which include the increased understanding of environmental issues by the EcodEX users. As the users calculate the results of environmental performance of their products themselves, they develop a much deeper understanding of the environmental performance of their product than if they were confronted with the results that have been developed by someone else.

NEED FOR MORE COMPREHENSIVE LCI DATABASES

Given the lack of LCI datasets for food ingredients, Nestlé has contributed to establishing the World Food LCA Database Project. This joint initiative is financed by private companies in the agri-food sector and government agencies and aims to establish a large number of reliable LCI datasets for key crops used globally in the agri-food sector. The data will be made available publicly through the Ecoinvent database. The data from the World Food LCA database are currently being used in the EcodEX database.

Several other initiatives have developed (or aim to develop) LCI databases in the food sector: Agribalyse and Agri-Footprint are both publicly available databases, focused on the French and Dutch context, respectively. Further databases are expected to be developed in the near future. For those different LCI database initiatives to be successful, a consolidation process needs to happen, whereby the different database initiatives need to make sure they become interoperable. A detailed methodological alignment on life cycle inventory modelling is therefore required.

OUTLOOK

The experience with EcodEX shows that such a tool helps to improve the environmental performance of the products of a large food company in the new product development process. Further LCI data contribute to improve the accuracy of assessments, and a better methodological alignment will help increase the credibility of the assessments. Nestlé would also like to extend the tool towards other sustainability aspects such as the nutritional performance of food products, as well as social aspects along the product supply chain. Science in these areas is still evolving and needs to be further developed to be sufficiently mature for use in simplified tools.

Building Smallholder's Capacity through the Sustainability Assessment of Food and Agriculture systems (SAFA)

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ABSTRACT

Since the 1992 Earth Summit, there has been a proliferation of different sustainability frameworks, standards and metrics. To avoid the risk of fragmentation, there is a need to define what sustainability means in practice. Building on existing initiatives, the *Sustainability Assessment of Food and Agriculture systems (SAFA) Guidelines* provides an international reference point by describing the essential elements of sustainable food and agriculture systems, including the dimensions of environmental integrity, economic resilience, social well-being and good governance. By defining universal sustainability themes and key performance indicators, SAFA provides a common language for sustainability. Yet SAFA is also a flexible, multipurpose framework. SAFA's vision of sustainability can be achieved through different pathways, depending on local circumstances. For instance, the open access SAFA Tool offers a practical way to undertake macro-assessments of supply chains. SAFA Small App is designed to address the specific requirements of smallholders; a sustainability assessment consists of an hour-long survey that collects information on a set of indicators that are most relevant to smallholders, while results are communicated through SMS or voice mail. The primary objective of the SAFA Small App is outreach to illiterate farmers in order to raise awareness of sustainability issues, build capacity amongst smallholders and trigger a continuous process of sustainability improvements.

SUSTAINABILITY ASSESSMENT OF FOOD AND AGRICULTURE SYSTEMS (SAFA)

At the 1992 Earth Summit, the principle of sustainable development was established with widespread support. However, agreeing upon a universal definition of what sustainability means in practice has proven to be more difficult. In the past two decades, there has been a proliferation of different sustainability frameworks, standards and reporting procedures. Over 100 countries have developed national sustainability strategies and produced national reports to the Commission on Sustainable Development. Furthermore, over 150 voluntary sustainability standards, ecolabels, codes of conduct and audit protocols are referenced on

the Standards Map of the International Trade Centre (ITC). There is an increasing demand for practical decision-support tools to help enterprises operate sustainably.

Among the expanding landscape of sustainability standards, there is a risk of fragmentation. The number of different tools and sustainability claims places an extra burden on producers and can confuse and frustrate consumers. In this context, the SAFA Guidelines (FAO, 2013a) have been developed to support harmonization and provide an international reference point. Rather than competing with other standards, SAFA builds on existing initiatives to provide a holistic definition of sustainability in food and agriculture systems.

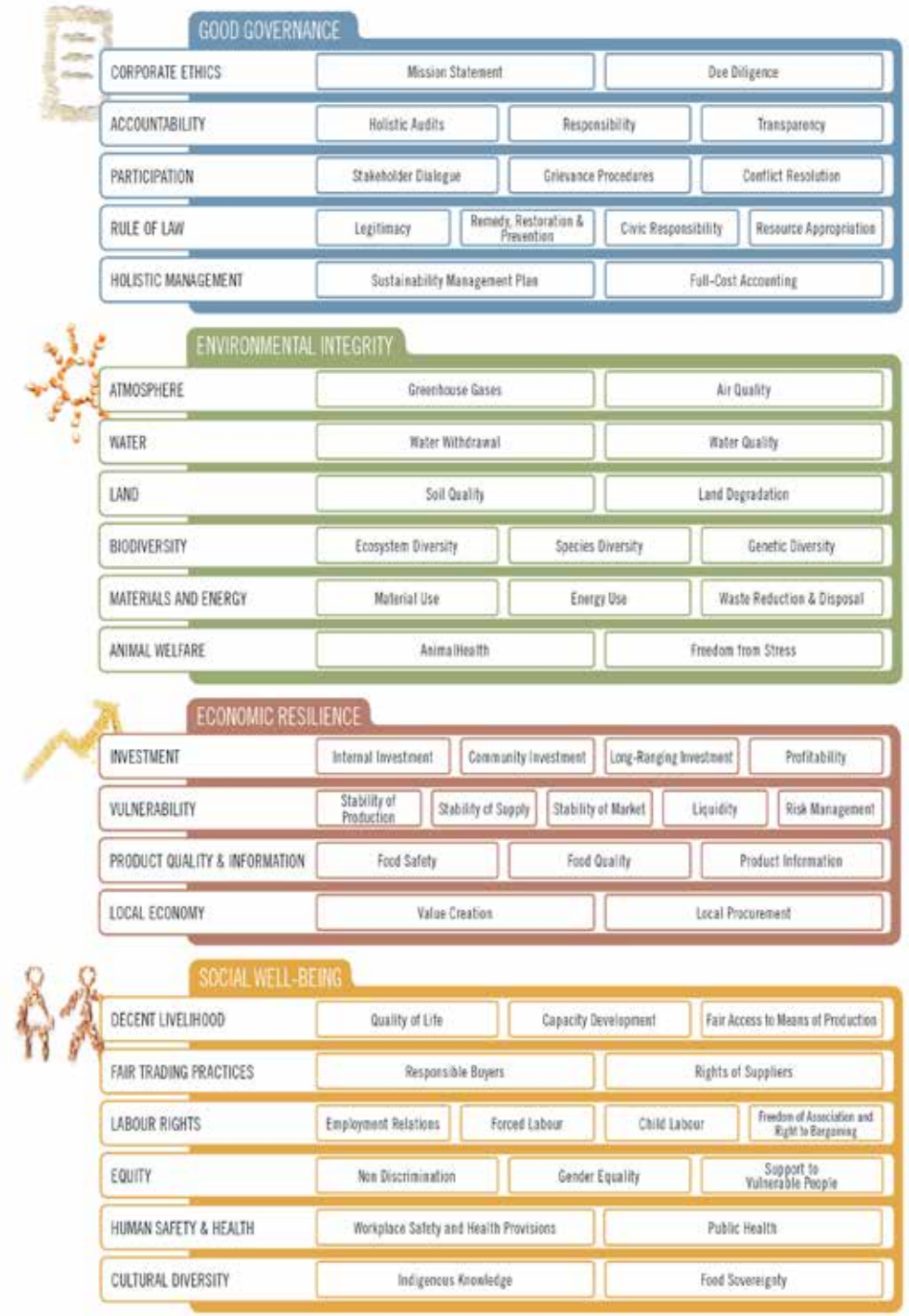
SAFA defines 21 themes that are crucial to four sustainability dimensions: environmental integrity, economic resilience, social well-being, and good governance. Further subthemes and default indicators are also described. Moreover, SAFA outlines a procedure for users to conduct a sustainability self-assessment of their activities. Running a SAFA produces a "sustainability polygon" that highlights the areas where sustainability performance is "best" (dark green), "good" (green), "moderate" (yellow), "limited" (orange) or "unacceptable" (red). This "traffic light" system allows users to quickly and clearly identify sustainability hotspots, in order to target improvements in these areas. Also, the sustainability polygon allows a quick overview of the different trade-offs and synergies that can be achieved among the different sustainability themes and hence informed decision on where to focus efforts.

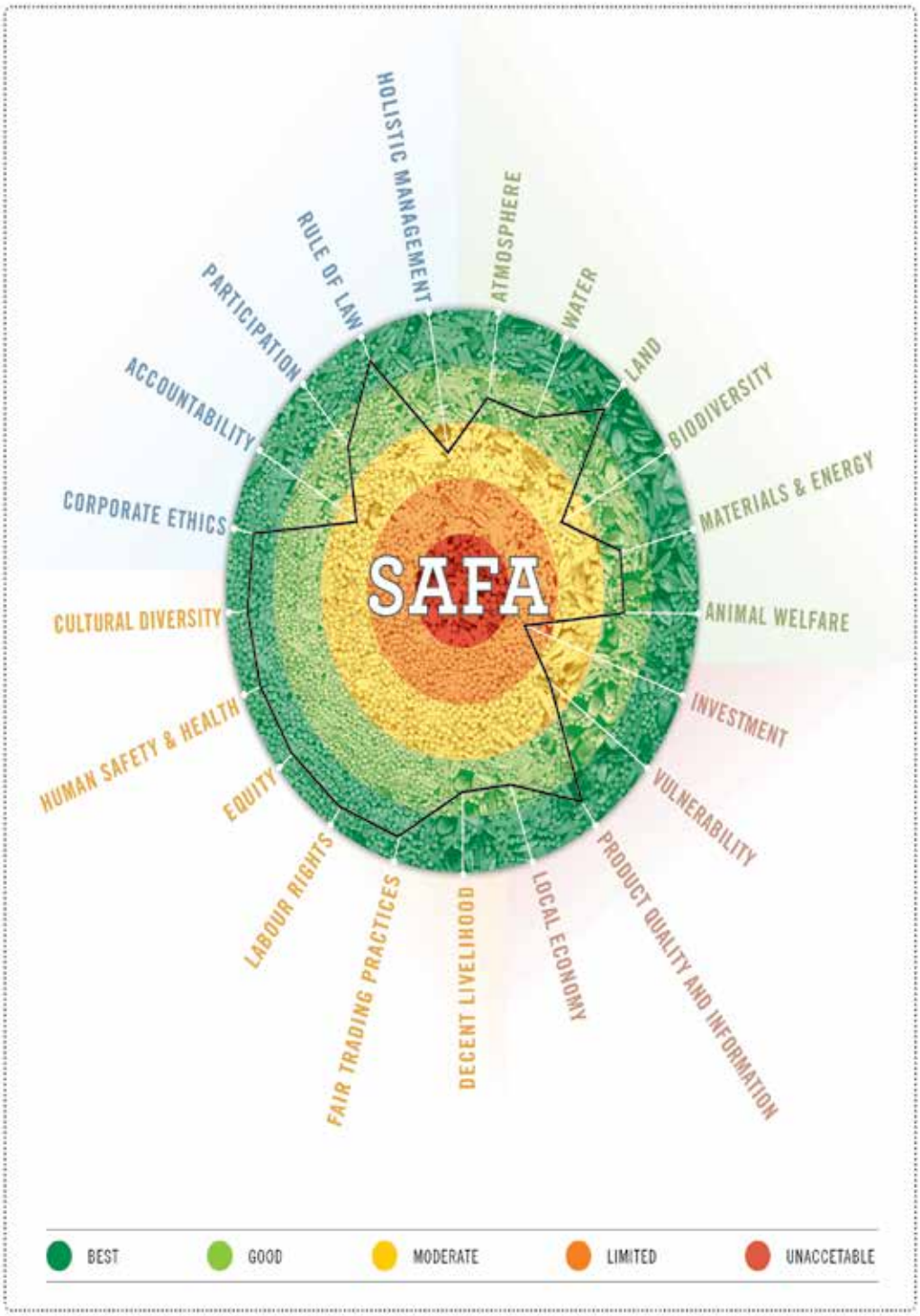
One of the major strengths of SAFA is its flexibility. The definition of common sustainability themes ensures equivalency among different enterprises, while specific indicators can be customized to reflect local contexts and different scales of production in different subsectors' (i.e. agriculture, livestock, forestry, fisheries and agri-food processing) operations. SAFA can be applied at all stages of the supply chain and it is possible to overlay and compare the performance of different entities, production years or phases of the supply chain. It should be emphasized that SAFA is not an index, standard or labelling tool; SAFA is an approach that can be tailored to suit different users' needs, promoting sustainability through a range of applications.

DEVELOPMENT OF SAFA

SAFA has evolved through a process of participatory development starting in 2009. The initial conceptual framework was established through a partnership between FAO's Natural Resource Management and Environment Department and the ISEAL Alliance – the global membership association for sustainability standards. Following a thorough review of corporate responsibility, social and environmental standards, and sustainability reports of food chain actors, the draft framework evolved through targeted stakeholders' interviews, expert meetings, electronic public consultations and, finally, a partners' and practitioners' workshop. The draft SAFA Guidelines were pilot tested in 23 different settings across 19 countries and the SAFA software was beta tested in seven countries.

Throughout the development process, SAFA received substantial insights from multistakeholder organizations, the private sector, civil society, research institutes and colleagues within the UN system involved in sustainability schemes. The finalized,


GOOD GOVERNANCE
CORPORATE ETHICS
Mission Statement
Due Diligence
ACCOUNTABILITY
Holistic Audits
Responsibility
Transparency
PARTICIPATION
Stakeholder Dialogue
Grievance Procedures
Conflict Resolution
RULE OF LAW
Legitimacy
Remedy, Restoration & Prevention
Civic Responsibility
Resource Appropriation
HOLISTIC MANAGEMENT
Sustainability Management Plan
Full-Cost Accounting
ENVIRONMENTAL INTEGRITY
ATMOSPHERE
Greenhouse Gases
Air Quality
WATER
Water Withdrawal
Water Quality
LAND
Soil Quality
Land Degradation
BIODIVERSITY
Ecosystem Diversity
Species Diversity
Genetic Diversity
MATERIALS AND ENERGY
Material Use
Energy Use
Waste Reduction & Disposal
ANIMAL WELFARE
Animal Health
Freedom from Stress
ECONOMIC RESILIENCE
INVESTMENT
Internal Investment
Community Investment
Long-Ranging Investment
Profitability
VULNERABILITY
Stability of Production
Stability of Supply
Stability of Market
Liquidity
Risk Management
PRODUCT QUALITY & INFORMATION
Food Safety
Food Quality
Product Information
LOCAL ECONOMY
Value Creation
Local Procurement
SOCIAL WELL-BEING
DECENT LIVELIHOOD
Quality of Life
Capacity Development
Fair Access to Means of Production
FAIR TRADING PRACTICES
Responsible Buyers
Rights of Suppliers
LABOUR RIGHTS
Employment Relations
Forced Labour
Child Labour
Freedom of Association and Right to Bargaining
EQUITY
Non Discrimination
Gender Equality
Support to Vulnerable People
HUMAN SAFETY & HEALTH
Workplace Safety and Health Provisions
Public Health
CULTURAL DIVERSITY
Indigenous Knowledge
Food Sovereignty


HOLISTIC MANAGEMENT
ATMOSPHERE
WATER
LAND
BIODIVERSITY
MATERIALS & ENERGY
ANIMAL WELFARE
INVESTMENT
VULNERABILITY
PRODUCT QUALITY AND INFORMATION
LOCAL ECONOMY
DECENT LIVELIHOOD
FAIR TRADING PRACTICES
LABOUR RIGHTS
EQUITY
HUMAN SAFETY & HEALTH
CULTURAL DIVERSITY
CORPORATE ETHICS
ACCOUNTABILITY
PARTICIPATION
RULE OF LAW
SAFA
BEST
GOOD
MODERATE
LIMITED
UNACCETABLE

tested and peer-reviewed *SAFA Guidelines* (FAO, 2014a)were presented to member countries in October 2013. The *SAFA Guidelines* are accompanied by the *SAFA Tool* (FAO, 2014b) (free open-access software for Windows and Mac for conducting SAFA impact assessments) and the *SAFA Indicators* (FAO, 2013b) (a detailed reference guide to the SAFA default indicators).

SUSTAINABILITY SELF-ASSESSMENT: BUILDING CAPACITY AMONG SMALLHOLDERS

In striving to define and measure progress towards sustainable development in food and agriculture systems, SAFA also seeks to develop actors' capacities to improve their own sustainability performance. This is the goal of the SAFA Small App – the latest SAFA product that is being developed in partnership with the Committee on Sustainability Assessments (COSA), the Grameen Foundation, and the Soil & More Foundation.

The definition of what constitutes a smallholder depends on context and differs according to sector, country and production system. Three important characteristics to consider are:

- size: smallholders manage areas considered small for their production and region;
- mechanization: smallholders use no or little mechanization; and
- labour: smallholders mainly use family labour for production.

Smallholders face many unique challenges in terms of sustainability assessments, including limited existing data, limited relevance of global indicators and lack of capacity to complete the assessment independently. Smallholders may lack the time or resources to conduct testing or other expensive means of collecting primary data for certain performance indicators (e.g. greenhouse gas (GHG) balance), or may be located in regions where this kind of data collection is not feasible. To address these challenges, practitioners have requested a tool that is specifically designed to meet smallholders' needs.

The SAFA Small App will operate through smart phones and tablets, allowing farmers to conduct a sustainability self-assessment, either independently or with the assistance of extension or other agents. The assessment involves a survey that examines up to 39 indicators (while the SAFA Tool counts 116 Default Indicators), covering all 21 SAFA themes. This specific set of indicators focuses on the sustainability issues that are most relevant to smallholder farmers. The survey questions are designed to be brief and easily understandable, taking less than one hour to complete. The final version of the App will be available in 26 languages and will send farmers SMS or voice mail feedback, identifying sustainability strengths and weaknesses based on their results. The App offers the opportunity to add as many local languages as needed, while voice mail feedback allows reaching illiterate farmers.

The structure of the survey addresses sustainability issues theme by theme, encouraging farmers to think about the different aspects of their sustainability performance and how these may be affected by various practices. For example, questions relating to the environmental dimension ask about practices that influence GHG mitigation, soil fertility, species conservation, water quantity and quality, pest and disease management, and land

conservation and rehabilitation – these questions provide hints towards practical options for improving management practices.

The survey also includes pop-up descriptions with additional information relating to each sustainability theme's objective that the indicator intends to measure. The descriptions are designed to assist survey respondents by outlining key concepts and explaining how each issue contributes to sustainability. For example, the following description appears before questions relating to the indicator "safety nets":

> *Safety nets include access to credit, savings, crop-related insurance and having a risk management plan. Safety nets are important at the smallholder level because they help minimize vulnerability to economic, environmental, and social risks during emergencies, such as when producers face a lack of cash flow and are unable to meet short-term financial obligations.*

By providing some context to support the survey questions, farmers are better equipped to relate the sustainability assessment to their own local/traditional knowledge and experiences.

Some questions are deliberately intended to raise the bar for sustainability. In the questions relating to 'Sustainability Management Plan', farmers are asked if they are working on, or executing, a plan to improve the sustainability of their production; how successful their plan has been, and which elements are part of their plan. To achieve the green rating, a producer must have a sustainability management plan that touches on each of the environmental (e.g. soil fertility management), social (e.g. health and safety) and economic dimensions (e.g. marketing).

Rating performance requires measuring what matters and comparing with peers, a process that inherently raises awareness and builds capacity to trigger sustainability improvements. In the SAFA Small App, the initial baseline assessment is based on the previous five production years. After baseline scores have been established, annual SAFA assessments are recommended, allowing smallholders to track their progress and alerting them if their sustainability performance decreases in any area. The App provides feedback on performance according to three thresholds (green, yellow and red), helping farmers to easily spot areas where they need to improve their practices.

SAFA Small App has been field tested in Colombia and Kenya, with the participation of 439 smallholders, including a range of subsistence, semi-commercial and commercial farmers. Surveys were undertaken by agricultural technicians, professional surveyors and community knowledge workers; they interviewed smallholders, validated surveys and held focus groups. Lessons from the field test are being considered before the App is released at the end of 2014.

SAFA DATABASE: AN INCREMENTAL KNOWLEDGE HUB

In parallel to the development of the SAFA Small App, the SAFA Database is being constructed. The SAFA Database will collect and store the results of SAFA assessments from the desktop-based SAFA Tool, as well as survey results from the SAFA Small App,

to form an incremental knowledge hub. As users will upload their results, information will build-up and grow into a worldwide sustainability performance repository. This will allow users to query the Database on information related to enterprises similar to them, thus better benchmarking of performance in different contexts.

In addition, the SAFA Database will be linked to other FAO statistical databases (e.g. FAOSTAT, AQUASTAT, GAEZ). In the enormous FAO repository, data and indicators do not reflect in a direct way the links between particular agricultural outputs and the associated environmental or social pressures. To help cross this gap, information related to SAFA indicators will be organized and linked as a basis for measuring comparable indicators. The connectivity of information is indeed a challenge but providing a basis on which to collectively construct is the current aim.

By providing access to a wide range of statistical data, the SAFA Database will allow enterprises to benchmark their sustainability performance, place individual estimates in context - in relation to other enterprises from the same region, sector and production system – and hence relay internally consistent description of trends. As such, SAFA intends to bring substance to the System of Environmental Economic Accounting for Agriculture (SEEA-AGRI) (FAO, 2013c) currently under development in FAO and the wider UN system.

THE WAY FORWARD

In 2015, further SAFA products are planned. The SAFA Safeguards will provide an integrated impact assessment of development projects across the environmental, economic, social and governance dimensions of sustainability.

Other applications of SAFA are being spontaneously adapted by users for their own requirements. As an example, the Cacique Guaymallén water management programme in Mendoza, Argentina, is using SAFA to assess the sustainability of the local hydrological system across each sustainability dimension. During the planning phase of the project, sustainability polygons were created for the current situation, the future situation without the programme and for each alternative intervention. Comparing the different polygons, it was possible to select the most sustainable alternative in each area of work, using SAFA to provide technical support to decision-making.

Like the SAFA Small App, these projects are applying the SAFA framework in different ways, tailored to suit their users' needs and local circumstances, to promote a common vision of sustainability. In this way, SAFA is able to support a range of different stakeholders, guiding them to self-assess their operations, and building capacity to implement and monitor improvements in sustainability performance.

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Connecting the dots: incentives and challenges to use food safety and sustainability information at farm level in the entire supply chain – learning from GLOBALG.A.P.

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ABSTRACT

After introducing GLOBALG.A.P., the paper identifies a number of knowledge needs for players in the entire supply chain – needs that are believed to bring incentives to farmers to adopt safer and more sustainable practices. We will focus on on-farm food safety and sustainability information that should be made available to the entire supply chain. Large buyers and brands need to demonstrate sustainable sourcing practices to consumers, stakeholders and shareholders, and this is where the GLOBALG.A.P. system comes into play.

Each identified knowledge need is referenced to the tools that are provided by GLOBALG.A.P. and that are used by GLOBALG.A.P. member retailers.

The question is then what data are available beyond the reach of GLOBALG.A.P., to the extent to be beneficial for enabling more incentives to farmers and, thus, to further mainstream sustainability.

Finally the paper suggests a set of actions to connect the dots of different information sources, referenced to the relevant services and collaboration offers of GLOBALG.A.P.

ABOUT GLOBALG.A.P.

G.A.P. stands for good agricultural practice – and GLOBALG.A.P. is the worldwide standard that assures it. We are a global organization with a crucial objective: safe, sustainable agriculture worldwide. We set voluntary standards for the certification of agricultural products around the globe – and more and more producers, suppliers and buyers are harmonizing their certification standards to match.

The purpose of GLOBALG.A.P. is for members to create private sector incentives for agricultural producers worldwide to adopt safe and sustainable practices to make this world a better place to live in for our children.

Our mission is to globally connect farmers and brand owners in the production and marketing of safe food to provide reassurance for consumers. We lay the foundation for the protection of scarce resources by the implementation of good agricultural practices with a promise for a sustainable future.

GLOBALG.A.P. CERTIFICATION WORLDWIDE AT A GLANCE

GLOBALG.A.P. has **23** standards and programmes, **140 000** producers under certification in more than **115** countries, **42** National Technical Working Groups, **35** accreditation bodies, **138** certification bodies, **900** inspectors and **690** auditors.

Our vision interprets sustainable agricultural practices as *"doing everything on the farm today so that your grandchildren will be able to make a good living growing food on that same piece of land".*

KNOWLEDGE NEEDS

Type of product – meeting market specifications

To identify a certified product in the supply chain, the type of the product must first be identified – be it apple or pear or salmon. GLOBALG.A.P. has published a product list that defines the certificate scope and is printed on each certificate. A specific code makes this machine-readable. What is not known or recorded with GLOBALG.A.P.'s certificate information is the individual buying specification, e.g. quality, variety or size. A possible approach to include this would be to develop electronic interfaces to buying platforms of retailers or auctions.

For the alignment of international trade data and statistics, there are specific trade specifications and customs numbers. A synchronization of such product lists with trade commodity numbers would enable the use of government trade statistics and data sources and compare with the flow of certified products.

Product availability

Often, buyers wish to find more certified products, but do not have readily available access to information about markets that are not currently certified, but are open to doing so if demand called for it.

Currently, GLOBALG.A.P. is working to create a global network of qualified consultants and trainers that could bring more producers to adopt GLOBALG.A.P. standards. This Farm Assurer Program for Capacity Building (mid-term) is not yet linked to suppliers (platforms) that aggregate supply and would have market information available.

However, using a database interface between these consultants, the GLOBALG.A.P. Database and supplier platforms or connecting farm management software providers such as FarmForce (Syngenta) have the potential to help buyers better plan and incorporate sustainability practices into their buying plans.

Product traceability

Maintaining traceability of the product to the farm or group of farms it comes from once on the shelf is still a challenge. However, GLOBALG.A.P. has been able to achieve

this using a GLOBALG.A.P. Number (GGN) on packaging, which allows a product to be traced back to its farm. A special GLOBALG.A.P. Bookmarking Service also allows the continuous tracking of such information by mapping the supply chain in the GLOBALG.A.P. Database. The limitation, however, is that the GLOBALG.A.P. Database is only compatible with GGNs, not the Farm IDs of other standards and systems. Establishing a single farm ID would make it much easier to program database interfaces with other standards and systems.

Geographic location of production

On-farm certification looks at the impact farming practices have on the product itself and the farm site. But for a broader environmental and social risk assessment, the physical location of the farm site is of importance. Knowing this, information on what lies next to or around the farm(s) can be collected and assessed.

There is already a field to input GPS locations of farms and fields in the GLOBALG.A.P. Database, but inputting this is not enforced. Once technology can be used to connect existing electronic maps and satellite images containing protected areas and other risk factors, not only current but also historic information can be recorded and used for assessing production risks.

In particular, a number of local and regional risk factors could be discussed within GLOBALG.A.P. National Technical Working Groups, and serve as a basis for improving partnerships with the public sector.

Label and claim of product

The number of labels and sustainability claims is still increasing, and one can expect a drive for more differentiation over time. For buyers in the supply chain, it is becoming more and more difficult to carve a consistent marketing message from the different labels, in particular when confronted with a mix of different labels and systems, but no clear way of knowing which standards were actually applied.

GLOBALG.A.P., like many other standards, maintains an up-to-date internal catalogue with information on the version, scope and identification of recognized standards that prove a level of equivalency to GLOBALG.A.P. through the benchmarking process. On top of that, there are a growing number of so-called GLOBALG.A.P. add-on standards or modules that allow further differentiation for specific markets, such as the GRASP module for social risk assessment, or for companies, such as the Albert Heijn Protocol.

But this system has its limitations to cover other standards that are applied on the same farm. There is a need to reduce duplication with other labels and standards, and, to do this, all standard items need to be mapped down to auditable checklists. Once finished with such a mapping exercise, it would be possible to generate customized combined audit protocols depending on the particular mix of required standards one wants to certify against.

Another tool to capture national legislation and customs in countries are the "National Interpretation Guidelines" from GLOBALG.A.P. These guidelines reference national legislation in individual countries and add particular compliance criteria for farms to adhere to when operating in the legal environment. At this point, not all applicable standards

and public claims have been incorporated into such guidelines, but this is something that GLOBALG.A.P. is striving to do as part of its efforts to reduce duplication. The main constraint to incorporating more standards is the willingness of other standard owners, and the available resources.

Established rules for public–private information exchange, access to public controls and surveillance information, e.g. feedback on public residue monitoring data or environmental reporting, would build the trust needed for national sectors to define more sustainable policies.

Supply chain integrity

Any certification system needs to build a trustful infrastructure to ensure that the plausibility of claims – e.g. how much can a farm sell of a certified product? – is controlled and there is no incentive to cheat.

GLOBALG.A.P. records the farm size to reference the potential of total production under certification by product. Yet, there is no link to the legal size and public registration. If a country would enable public sector registration numbers to be linked with private sector farm IDs, a better opportunity for occasional cross-checks would be given.

In addition, traceability certification should be enforced more. The GLOBALG.A.P. Chain of Custody certification of supply chains has recently been launched. It would be important to encourage other standards like ASC and MSC to link their Chain of Custody with standards like GLOBALG.A.P. through a collaboration agreement.

The next challenge will be infrastructure that can facilitate full traceability through the entire system (mass balance, hard and soft IP). This next step would require even more collaboration and an open interface with full systems and standards.

Currently, GLOBALG.A.P. runs its own Certification Integrity Program, but has begun to share integrity issues with other standards. This exchange of integrity relevant information is still in its infancy, and further collaboration with other standards is needed.

Social and gender issues

More and more impact analyses refer to changes in social and gender-related issues on farms. Certification programmes should begin to log more data on such aspects. Today, GLOBALG.A.P. identifies whether a farm is owned by an independent farmer or belongs to a group structure; however, details of that dependency structure among market participants are not yet captured. We should define and record more common indicators and their evolution.

For farms conducting the GRASP assessment, GLOBALG.A.P. knows the number of employees, but no further details. We still lack, for example, gender or family farm criteria, which would also be worthwhile for use according to common indicators. The same applies to the buyer–farmer relationship: which contracts and what contact levels with a farm have been established to demonstrate chain integration. While GLOBALG.A.P. has the sublicense agreement between Certification Bodies and certified farmers, it would be beneficial to enter into direct two-way communication with farmers, e.g. establish social media platforms to strengthen farmers' position in the supply chain.

Continuous improvement

Many certification programmes only capture the annual status of a farm with respect to the standard. Often, there is more emphasis on continuous improvements implemented on a number of farms and the associated timelines of reporting.

GRASP assessments are reported online with a full checklist, and GLOBALG.A.P. reviews the development over time. GLOBALG.A.P. has not yet established a fully electronic checklist that could be compared from year to year or make use of self-assessment reports or other inputs. With the development and utilization of a globally applicable checklist tool, a farmer's annual certification status could be stored from the beginning of engagement, and easily linked to other sustainability standards over time via an interface to demonstrate the continuous improvements of farms and entire regions.

A first example of this is the Localg.a.p. Program, GLOBALG.A.P.'s stepping stone to certification. If we could link this to other private and public sector capacity building programmes via an interface, and exchange information, information on the improvement in developing countries could be collected at early stages and assist in policy-making.

Metrics

Next to good agricultural practices, the role of measuring specific metrics and performance indicators to assess the impact of certification and capacity building programmes becomes increasingly important. It is not a question of "either/or", rather "and", which assists certification programmes to add metrics based on sustainability modules. GLOBALG.A.P. introduced such an add-on with REWE International in Austria three years ago. The successful implementation has resulted in a system where certification body-validated and farmer-reported metrics find their way into an independent non-governmental organization and research body. The research body assesses the data with defined algorithms, and provides consultancy feedback to the farmers. The thresholds are used by the retailer to allow successful farmers to participate in a special label programme. At this stage, it would be beneficial to gain additional access to other metrics and performance indicators, to collaborate internationally to define and record common metrics and performance indicators, and to program an interface to enable easier exchange of information with other standards.

CONCLUSION

What is needed to enable legal systems and institutional environments, in particular in capacity building, to connect the dots and increase incentives of farmers to adopt safe and sustainable practices? – an enabling horizontal and vertical COLLABORATION.

One foundation is laid down by the founding signatories of the Declaration of Abu Dhabi for Global Food Security through Good Agricultural Practices:

- A common set of good agricultural practices criteria:
  - We need to ensure higher productivity and more efficient resource use, so that we can continue to feed a growing population, without compromising biodiversity and ecosystems. This includes food safety, animal, plant, human, community and ecosystem health, human rights and animal welfare.

- A system for uniquely identifying every farm that is recognized by all stakeholders:
  - With one common identification system, we can reduce the burden of duplication on the entire supply chain, and ensure that a farmer in one part of the world is identified using the same means as a farmer on a different continent.
- A mechanism for securing commitment and reporting by supply chains:
  - In order to really make an impact, the entire supply chain must be committed to working together.

We hope that all partners joining the Declaration and participating in the working groups recognize the potential we have when we collaborate and build trust to exchange information. It is in our hands, as we have the data and can design the rules for exchange.

How to assess the sustainability of diets – the example of the Mediterranean diet

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ABSTRACT

There is rising evidence of the cost of diets on the environment, society and public health nutrition. Food consumption and production trends and patterns are among the most important drivers of environmental pressures. Food systems around the world are changing rapidly, with profound implications for diets and nutritional outcomes. The sustainable diet concept highlights the role of sustainable *consumption* as a driver of sustainable *production*, aiming for food systems' transformation towards more sustainable food consumption and production patterns.

To consider together the various sustainability dimensions and scales, and their complex interactions, requires working across disciplines to develop and strengthen studies on diets and food consumption patterns, with particular regard to: the need to develop and test methodological approaches addressed to specific contexts; the need to define the scales of priorities for development of methodological approaches; the centrality of the individual, the consumer (of paramount importance for assessing sustainable diets), in spite of lack of data availability on individuals; and the need to agree on the most appropriate nutrition and health indicators for sustainable diets.

Current progress for assessing the sustainability of the Mediterranean diet as a case study for sustainable diets will be presented. It builds upon the work on sustainable diets, as an objective and driver of sustainable food consumption and production, which has been developed over the last years by FAO in collaboration with CIHEAM-Bari.

INTRODUCTION

The concept or notion of the Mediterranean diet began to be studied in the 1950s as a model of a healthy diet (Keys, 1970) that reduced morbidity and mortality. The notion of "sustainable diets" started to be explored in the early 1980s (Gussow and Clancy, 1986) to designate diets that would be healthier for the consumers as well as for the environment. This developed in the 2000s to a model of sustainable diet (Gussow, 1995), which also considers the overall impact on the ecosystem (Burlingame and Dernini, 2011).

In 2010, in Rome, at FAO headquarters, participants at the international symposium on "Biodiversity and sustainable diets: united against hunger", organized by FAO and Bioversity International, reached an agreement on the following definition of sustainable

diets: *Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources* (FAO/Bioversity, 2012).

In the last decade, the interest in sustainable diets has been further raised by a growing body of scientific evidence of the non-sustainability of current dietary trends (Van Dooren *et al.*, 2014; Masset *et al.*, 2014; Macdiarmid, 2013; Saxe, Larsen and Mogensen, 2013; Wilson *et al.*, 2013; Macdiarmid *et al.*, 2012; Smith and Gregory, 2012; Berners-Lee *et al.*, 2012; Vieux *et al.*, 2013; WWF, 2013; Scarborough *et al.*, 2012; Pluimers and Blonk, 2011; Guyomard *et al.*, 2011; Garnett, 2013; SDC, 2009, 2011; American Dietetic Association/American Nurse Association/American Planning Association/ American Health Association, 2010; Marlow *et al.*, 2009; Stehfest *et al.*, 2009). However, there is no evidence that high nutritional quality is always associated with low greenhouse gas emissions (Vieux *et al.*, 2012).

SUSTAINABLE DIETS AS THE OBJECTIVE AND DRIVER OF SUSTAINABLE FOOD CONSUMPTION AND PRODUCTION

When discussing management in a particular field of knowledge, the first step is to demarcate clearly what it includes. This starts with a definition. What is a sustainable food value chain? There are two parts to this. First, a food value chain consists of all the stakeholders that participate in the coordinated production and value-adding activities that are needed to make food products. A sustainable food value chain then is a food value chain that:

- is profitable throughout (economic sustainability);
- has broad-based benefits for society (social sustainability); and
- shows a positive or neutral impact on the natural environment (environmental sustainability).

THE CONCEPT OF SUSTAINABILITY

The sustainable diets concept highlights the role of sustainable *consumption* as a driver of sustainable *production*. This relationship was at the basis of the 10-year Framework Programme (10YFP) on Sustainable Consumption and Production adopted at the Rio+20 Conference (UNCSD, 2012).

The challenge of feeding the growing world population, which is expected to reach 9 billion people in 2050, requires new strategies to ensure global sustainable food security (FAO, 2009, 2011; Godfray *et al.*, 2010). Today, the main challenge for the food and agriculture sector is to provide simultaneously enough food, in quantity and quality, to meet nutritional needs and to conserve the natural resources for present and future generations (UNCSD, 2012).

Food consumption and production trends and patterns are among the most important drivers of environmental pressures (Vanham, Mekonnen and Hoekstra, 2013; Kastner *et al.*, 2012; Tukker *et al.*, 2011; EC, 2011; Garnett, 2013; Popp, Lotze-Campen and Bodirsky, 2010; Earthscan, 2010a; Friel *et al.*, 2009; Carlsson-Kanyama and Gonzalez, 2009;

EC/JRC, 2009; Lundqvist, de Fraiture and Molden, 2008). Food systems around the world are changing rapidly, with profound implications for diets and nutritional outcomes.

There is rising evidence of the cost of diets on the environment, society and public health nutrition (Heller, Keoleian and Willet, 2013; O'Kane, 2012; Burke Delaney, 2012; Clonan and Holdsworth, 2012; Haines *et al.*, 2009; Holdsworth, 2010; Hawkesworth *et al.*, 2010; Lock *et al.*, 2010).

Within the objective of the food systems transformation towards more sustainable food consumption and production patterns (HLPE, 2014a; FCRN, 2014; Garnett, 2013), the interest in sustainable diets is markedly increasing as an emerging issue, bridging agriculture, nutrition, food security and sustainability (IOM, 2014; ODI, 2014; Johnston, Fanzo and Cogill, 2014; Capone *et al.*, 2014a; WRI, 2013; Lang and Barling, 2013; Buttriss and Riley, 2013; Esnouf, Russel and Bricas, 2013; FAO, 2012a, 2013; UNEP, 2012; CGIAR, 2012; Dangour *et al.*, 2012, Earthscan, 2010b; Pinstrup-Andersen and Herforth, 2008).

Food consumption is variably affected by a wide range of factors including food availability, food accessibility and food choice, which in turn may be influenced by geography, demography, disposable income, socio-economic status, urbanization, globalization, religion, culture, marketing and consumer attitude (Kesse-Guyot *et al.*, 2013a; FAO, 2012a; Kearney, 2010; de Boer, Hooglan and Boersema, 2007). It will require a better understanding of the drivers of food consumption changes (HLPE, 2014b).

It requires an intersectoral effort to reverse the simplification of diets, the degradation of ecosystems and the erosion of biodiversity. This can be achieved through sustainable food consumption and production linked to sustainable diets, acknowledging the interdependencies of food production and food consumption with food requirements and nutrient recommendations (FAO/Bioversity, 2012).

This further requires reshaping food systems towards sustainable diets (UN, 2014). The world is producing enough food to feed all of its population. Yet almost one billion people go hungry and two billion are malnourished, lacking the essential micronutrients they need to lead healthy lives. Globally, the number of overweight/obese people has reached more than 1.4 billion adults. These figures show profound imbalances in consumption and diets (FAO, 2013).

There is a large geographic variation in patterns of food consumption and production, which influences their environmental impacts and requires solutions and guidelines tailored to these different geographic conditions, with local, national, regional and international levels of application. There are still many challenges towards the development of guidelines for assessing the diets' sustainability (Van Dooren *et al.*, 2014; Heller *et al.*, 2013; Swedish National Food Agency, 2013; WWF, 2013; Esnouf, Russel and Bricas, 2013; Health Council of the Netherlands, 2011). Developing methodologies that describe and characterize diets at various levels, identifying types of diets and assessment of their impacts, would provide a more holistic understanding of food consumption. This would increase the value given to food and food choices highlighting nutritional, economic, social and cultural dimensions.

THE MEDITERRANEAN DIET AS A CASE STUDY FOR SUSTAINABLE DIETS

The Mediterranean diet has nutritional, economic, environmental and socio-cultural characteristics and, because of these characteristics and because it concerns a large number

of countries, the Mediterranean diet has been selected by FAO as a pilot case study on which to develop and validate methods and indicators for sustainable diets (Burlingame and Dernini, 2011; FAO, 2012b). The study of the Mediterranean diet as a sustainable diet model should contribute to clarify what is required for an environmentally sustainable food system and more eco-friendly food-based dietary guidelines.

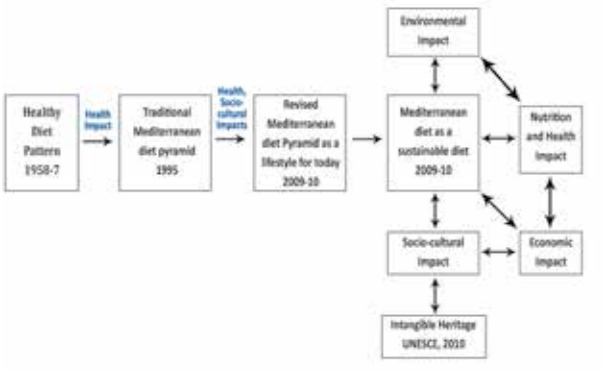

Figure 1. The evolution of concepts surrounding the Mediterranean diet
Source: Berry and Dernini, 2015.

The Mediterranean diet has been well scientifically characterized, since the pioneer *Seven Countries Study* by Ancel Keys (Keys, 1970), as a healthier dietary pattern (Estruch *et al.*, 2013; Trichopoulou *et al.*, 2014; Gotsis *et al.*, 2014; Kesse-Guyot *et al.*, 2013b; Maillot *et al.*, 2011; Kastorini *et al.*, 2011; Vernele *et al.*, 2010; Sofi *et al.*, 2010; Trichopoulou, Bamia and Trichopoulos, 2009; Bosetti, Pelucchi and La Vecchia, 2009; Babio *et al.*, 2009; Serra-Majem *et al.*, 2009; Serra-Majem, Roman and Estruch, 2006; Martínez-González *et al.*, 2009; Trichopoulou *et al.*, 1995; Willett *et al.*, 1995; Nestle, 1995). It has further started to be analysed in many studies and appreciated for its lower environmental impact (Van Dooren *et al.*, 2014; Pairotti *et al.*, 2014; Capone et *al.*, 2014b; Almendros *et al.*, 2013; Tukker *et al.*, 2011; Pluimers and Blonk, 2011; EC/JRC, 2009; Baroni *et al.*, 2007; Duchin, 2005; Gussow, 1995).

The Mediterranean diet is more than just a diet; it represents a lifestyle, a social and cultural expression of the different Mediterranean food cultures that has been acknowledged in 2010 by UNESCO as an intangible cultural heritage of humankind (UNESCO, 2010). The Mediterranean diet is closely related to the Mediterranean lifestyles, and has been deeply influenced by cultural and economic modifications during the last decades.

The Mediterranean diet results from a highly diversified heritage, which makes it diverse in various countries. Food traditions vary from country to country in the Mediterranean area and as a consequence it is necessary to take into consideration different local realities with specific environmental, economic, social and cultural traits. As a result, the Mediterranean diet should be considered in continuous evolution, related closely to the particular historical and environmental mosaic that is the Mediterranean region.

There is not one single Mediterranean diet, but rather a number of variations on a basic dietary pattern adapted to diverse country's cultures. The term "*Mediterranean diet*" implies the existence of some common dietary characteristics in Mediterranean countries such as: high amounts of olive oil and olives, fruits, vegetables, cereals (mostly unrefined), legumes, nuts and fish, moderate amounts of dairy products (preferably cheese and yoghurt), and low quantities of meat and meat products. Wine in moderation is acceptable when it is not contradictory to religious and social norms (Willet *et al.*, 1995; Trichopoulou and Lagiou, 1997; Bach-Faig *et al.*, 2011).

But despite the well-documented health and environmental benefits of the Mediterranean diet, current data show a decline in adherence to it in Northern, Southern and Eastern Mediterranean countries, because of multifactorial influences – lifestyle changes, globalization of food markets, economic and socio-cultural factors (León-Muñoz, 2012; Da Silva *et al.*, 2009; Vareiro *et al.*, 2009; Padilla, 2008; Garcia-Closas, Berenguer and Gonzalez, 2006; Alexandratos, 2006; Belahsen and Rguibi, 2006; IOTF, 2005). This decline has caused an increasing process of erosion of the Mediterranean diet heritage that needs to be counteracted through promoting its adherence and enhancement as a practical, sustainable cultural resource (Dernini, 2011; Medina, 2011).

Various dietary scores of adherence to the Mediterranean diet have been published (Trichopoulou *et al.*, 1995, Trichopoulou, Bamia and Trichopoulos, 2009; Fidanza *et al.*, 2004; Martínez-González *et al.*, 2002; Sanchez-Villegas *et al*., 2002; Serra-Majem *et al*., 2004; Gerber, 2006) and extensively reviewed (Bach *et al.,* 2006; Koularba and Panagiotakos, 2009; Sofi *et al.*, 2008, 2010, 2013; Milà-Villarroel *et al*., 2011; Issa *et al*., 2011). Several dietary guidelines for specific Mediterranean populations have been developed and associated with pyramidal graphic representation, such as for the Spanish population (Aranceta and Serra-Majem, 2001); for the Greek population (Supreme Scientific Health Council, Ministry of Health and Welfare of Greece, 1999); and for the Italian population (Ministero della Salute, 2004; del Balzo *et al.*, 2012).

The first traditional Mediterranean diet pyramid was presented in 1993 at the international conference on Mediterranean diets held at the Harvard School of Public Health in Boston (Willett *et al.*, 1995), and it was compared with the 1992 food guide pyramid issued by the US Department of Agriculture in preparation for the 1995 Dietary Guidelines for Americans.

In 2009 and 2010, the Mediterranean diet pyramid was revised, through a participatory process in which the pyramid was presented as a simplified mainframe to be adapted to different country-specific variations related to various geographical, socio-economic and cultural contexts of contemporary Mediterranean lifestyles (Bach-Faig *et al.*, 2011; Dernini *et al.*, 2012). This new revised Mediterranean diet pattern was presented as an example of a sustainable diet, in which nutrition, local food production, biodiversity, culture and sustainability are strongly interconnected, with a lower impact on the environment. The concepts of seasonality, fresh and locally grown products, culinary activities, biodiversity, traditional, local and eco-friendly products, of variety of colours for fruits and vegetables were introduced together with the concepts of main meals, frugality, moderation, conviviality and physical activity.

METHODOLOGICAL APPROACH FOR THE ASSESSMENT OF THE SUSTAINABILITY OF THE MEDITERRANEAN DIET

The assessment of the sustainability of the diets requires considering together the different sustainability dimensions (nutrition and health, environment, economic, social and cultural factors), and their interactions. It requires working across disciplines, with particular regard to: the need to develop and test methodological approaches addressed to specific contexts; the need to define the scales of priorities for development of methodological approaches;

the centrality of the individual, the consumer, of paramount importance for assessing sustainable diets, in spite of lack of data availability on individuals.

Much evidence is available on the constituents of healthy diets (WHO, 2003), and many countries have adopted dietary recommendations to encourage healthy consumption patterns (WHO, 2004). Food-based dietary guidelines from different countries contain similar broad messages based on principles of nutrition science. National dietary guidelines, however, often contain unique features that were designed by national experts to address the priorities of each individual country. Nevertheless, evidence to assess whether national agricultural and food systems are providing the correct balance of foods, or whether populations are consuming recommended dietary patterns, is extremely limited (Hawkesworth *et al.*, 2010).

Recent trends and projections in the Mediterranean area (FAO, 2012c; UNEP/MAP/Plan Bleu, 2006, 2008, 2010, 2011; Plan Bleu, 2012; UNEP/MAP, 2005) were taken into consideration to identify priority challenges to be addressed for improving the sustainability of the diets and food consumption patterns in the Mediterranean area.

Considering together the various sustainability dimensions and scales, and their complex interactions, in the context of the Mediterranean area, joint collaboration across disciplines are required to develop and strengthen studies on diets and food consumption patterns.

The development of a first methodological approach for the assessment of the sustainability of the Mediterranean diet was initiated in 2010 by FAO (FAO, 2010), and further developed in 2011 and 2012, through a collaboration with CIHEAM-Bari (FAO, 2012b), which allowed finalizing a methodological framework (Dernini *et al.*, 2013), as follows:

1. Identification of four priority areas for assessing sustainability of diets:
    a. nutrition and health;
    b. environment;
    c. economy;
    d. socio-cultural factors.
2. Identification of an ensemble or suite of appropriate indicators for the above four priority areas and related selection criteria, to be applied at individual, household and country level.
3. Selection of one or more Mediterranean countries in which to test and further refine this methodological approach for assessing, at individual, household and country levels, the sustainability of the diet and its conformity to the Mediterranean diet model.
4. Identification of food groups and serving sizes in the selected countries, using recent food consumption surveys, supplemented from food balance sheet data.
5. Assessment of current food consumption patterns in selected Mediterranean countries by using available food consumption surveys and food balance sheets/supply utilization account. Assessment of their adherence (Bach *et al.*, 2006; Koularba and Panagiotakos, 2009; Sofi *et al.*, 2008, 2010, 2013; Milà-Villarroel *et al.*, 2011) to the new revised Mediterranean diet pyramid (Bach-Faig *et al.*, 2011) as areference framework to be adapted to each country.
6. Calculation of a value/score using the data gathered for each indicator.

7. Combination of all scores into a scale and analysis of trends over relevant time series. Assessment from this set of indicators/scores of the relationship between current dietary patterns, adherence to the Mediterranean diet pattern and the sustainability of food consumption at the country level.

According to FAO, *an indicator generally comprises elements (a cut-off value, a frame of reference, a mode of expression, etc.) that allow a relatively universal appreciation of the information it supplies and also facilitates comparison in time and space* (FAO, 2005).

To select the most effective indicators, the following criteria have to be considered: 1. *Relevant to the question being asked* with the objective to select the best indicator currently available to answer the question; 2. *Understandable*, i.e. clear, simple and unambiguous; 3. *Graphically representable*; 4. *Readily interpretable*, i.e. clear which direction the indicator should develop to lead to greater sustainability; 5. *Relevant* in most Mediterranean countries, i.e. not restricted to an element that is limited to a few countries; 6. *Monitorable*, i.e. based on data that are readily available, or could be made available at a reasonable cost–benefit ratio and with regularity/repeatability within the time frame of policy cycle; 7. *Reliable and consistent*, i.e. data collection and analysis methodologies should preferably be consistent between countries and, at the very least, be consistent within a given country from year to year; 8. *Representative*, i.e. can be taken to represent current food consumption and production trends (Watson *et al.*, 2010).

Using the above mentioned criteria and giving consideration to the set of indicators provided by the UK Department for Environment, Food and Rural Affairs for enabling and encouraging people to eat a healthy, sustainable diet (DEFRA, 2009), and by taking into account the four dimensions (health and nutrition, environment, economy and socio-cultural factors) of the sustainable diets (FAO, 2010), a first, preliminary list of 74 potential sustainability indicators was compiled in 2011 (Annex 1). In 2012, from this initial list, a second list of 20 indicators was produced, which was further extended to a list of 24 indicators, considered more feasible considering the availability of data sources (Table 1).

Then, a second list of indicators, Table 2, was extracted in part from the previous larger list (Table 1 and Annex 1) and was more recently brought into discussion, with the purpose to integrate some of them within the final ensemble of nutrition and health indicators.

Because of the lack of time available for preparing this first draft, it was not feasible to integrate the second list of indicators, reported in Table 2. Some of them were considered not a priority or redundant, others difficult to measure. Some of these indicators were instead thought potentially important for incorporation in the ensemble of nutrition and health indicators, despite not being purely nutrition and health indicators but more socio-cultural or environmental or economic ones, because of their close relations with food choices or food consumption – key drivers for the Mediterranean diet as well as for sustainable diets and their assessment. Such integration will require further development and discussion.

CONCLUSION

The complexity of the assessment of the sustainability of diets requires more interdisciplinary cross-cutting studies, to assess not only the nutrition and health dimension, in this case of

Table 1: Proposed indicators to assess the sustainability of the Mediterranean diet

Thematic area	Proposed indicators
A. Nutrition and health	A1. Diet-related morbidity/mortality
	A2. Fruit and vegetable consumption/intake
	A3.Vegetable/animal protein consumption ratio
	A4. Dietary energy supply/intakes
	A5. Dietary diversity score
	A6. Dietary energy density score
	A7. Nutrient density/quality score
	A8. Food biodiversity composition and consumption
	A9. Nutritional anthropometry
	A10. Physical activity prevalence
B. Environment	B1. Water footprint
	B2. Carbon footprint
	B3. Nitrogen footprint
	B4. Biodiversity
C. Economy	C1. Food consumer price index (FCPI): cereals, fruit, vegetables, fish and meat
	C2. Cost of living index (COLI) related to food expenditures: cereals, fruit, vegetables, fish and meat
	C3. Distribution of household expenditure per groups: food
	C4. Food self-sufficiency: cereals, fruit and vegetables
	C5. Intermediate consumption in the agricultural sector: nitrogen fertilizers
	C6. Food losses and waste
D. Society and culture	D1. Proportion of meals consumed outside home
	D2. Proportion of already prepared meals
	D3. Consumption of traditional products (e.g. proportion of product under PDO or similar recognized traditional foods)
	D4. Proportion of mass media initiatives dedicated to the knowledge of food background cultural value

Source: FAO (2012b).

the Mediterranean diet, but also indicators/scores directly and indirectly related to the other dimensions of environment, economic and socio-cultural factors, and, to agree on a methodology of how to aggregate them.

Table 2: Other proposed indicators for nutrition and health

B1	Food composition
B2	Food energy density
B3	Frugality
B4	Household food security
B5	Level of food processing
B6	Local food system and seasonality
B7	Mediterranean diet adherence
B8	Nutrient profile
B9	Organic and eco-friendly consumption
B10	Global Nutritional Index

Source: FAO (2012b).

To consider together the various sustainability dimensions of the Mediterranean diet, by taking into account its differences in the various Mediterranean countries together with their complex interactions, requires more effective intersectoral research across various disciplines.

There is an indispensable need to develop and strengthen intersectoral studies and research on diets and food consumption patterns, by taking into account also that studies of single which, nutrient additions or single foods have proved positive health outcomes, but do not represent the actual adherence to the Mediterranean diet.

There is a need to consider together the various sustainability dimensions of the Mediterranean diet (health and nutrition, environment, economy and socio-cultural factors) also taking into account its differences in the various Mediterranean countries, together with their interactions.

There is also a need to consider the main external drivers and cross-cutting interactions and a need for more effective intersectoral research across specific disciplines to assess its sustainability.

Some points that need to be further developed and finalized:

- to identify an ensemble or suite of the most appropriate nutrition and health indicators;
- to evaluate interactions and correlations, direct and indirect, between nutrition and health indicators and the other three dimensions of sustainability (i.e. environment, economic and socio-cultural factors) at consumer consumption level;
- to develop and test methodological approaches addressed to specific contexts;
- to define the scales of priorities for methodological approaches' development;
- how to weigh the relative importance of these indicators and how to calculate a value/score using the data gathered for each indicator in order to make up a composite index;
- at which scale (individual, household, country, region) should this operational methodological approach be tested; what are the available data;
- how to combine all indicators/scores into a scale and analyse trends over relevant time series and how to assess from this set of indicators/scores the relationship between current dietary patterns, adherence to the Mediterranean diet pattern and the sustainability of food consumption at country level;
- how to further develop the methodological approach development for assessing the sustainability of the Mediterranean diet, in which is also taken into consideration cultural appropriateness and transmission of culinary and traditional eating habits; this will require a composite index of the four dimensions of sustainability and their relating weightings. This will involve both intra- and interdimension evaluations, scalings and prioritizations;
- to consider the centrality of the individual, the consumer, for assessing sustainable diets, in spite of lack of data availability on individuals and of the households.

Moreover, there are also many other points in discussing the Mediterranean diet itself, such as:

- the need to develop a more reliable index to assess adherence to the Mediterranean diet model (Sofi *et al.*, 2013; Milà-Villarroel *et al.*, 2011);
- the need to consider, at least, the adherence to and all items present in the revised Mediterranean diet pyramid (Bach-Faig *et al.*, 2011);
- the need to revise again the Mediterranean diet pyramid, for updating food groupings, taking into consideration the components of the different diet scores (monounsaturated/saturated fat ratio -MS ratio), as well as an indicator for water consumption, by taking into account the revision of the Mediterranean diet pyramid

in which water, as essential for a correct nutrition, is placed inside the pyramid;
- the need to identify the serving sizes/portions in different Mediterranean countries, even in different regions within the same country, and in different physiological states (age, sex, etc.);
- the need, by taking into account its differences in the various Mediterranean countries together with their complex interactions, to consider together the various sustainability dimensions of the Mediterranean diet, which requires funds for more effective intersectoral studies and research across specific disciplines;
- the need to test and revise the methodological approach in one or more Mediterranean countries or specific regions within the country (e.g. Apulia region, Italy; Southeast France);
- the need to revise the Mediterranean diet and to update it as an effective communication tool addressed to revitalize the interest of Mediterranean young generations on the Mediterranean diet as a contemporary, accessible and sustainable, healthy lifestyle model;
- taking into account the increasing erosion of the Mediterranean diet, define which priority indicators/scores should be identified and developed for assessing the dimensions of this erosion.

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Using national dialogue for understanding knowledge and data gaps for transitioning to more sustainable food systems: an African perspective

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ABSTRACT
This paper addresses the strategy and activities for understanding knowledge and data gaps in developing countries to tackle sustainable food systems using dialogue as a platform for cohesion. Strategies and activities include the development of national and regional capacities for sustainable consumption and production (SCP) and promote the effective implementation of the concepts and tools of SCP in African countries. This allows these countries to demonstrate methods of bridging the gaps and creating sustainable food systems.

INTRODUCTION
In the past two years, African countries have convened dialogue on gaps for transitioning to more sustainable food systems or sustainable consumption and production (SCP). The dialogue emanated from the United Nations Conference on Sustainable Development (Rio+20) in June 2012 where countries agreed to adopt the 10-Year Framework of Programmes (10YFP) on Sustainable Consumption and Production (SCP). SCP paves the way to accelerating the transition to an eco-efficient economy, while turning environmental and social challenges into business and employment opportunities.

South Africa is an example of an emerging economy with challenging and diverse socio-economic issues surrounding its sustainable development. Only achieving democracy in 1994, inequalities remain throughout its society. A good indicator of these inequalities is the food and agriculture sector in South Africa. Despite being food self-sufficient or nearly self-sufficient in almost all major food products, with the ability to import shortages when necessary, South Africa has become a net importer of processed food since 2004 (DAFF, 2012). In fact, within the sector as a whole in South Africa, 20 percent of farmers generate 80 percent of agricultural output value (DAFF, 2012). Around 1.3 million hectares are under irrigation, and Irrigated agriculture contributes more than 30 percent of gross value of the

country's crop production. However, this uses approximately 50 percent of South Africa's water. Maize is the most predominant crop in South Africa. Over 2.8 million hectares are dedicated to maize, with annual production of about 12 million tonnes per annum (Grain SA data, 2010–2012). About 8 000 commercial maize growers are responsible for the main part of the South African maize crop, with the balance produced by thousands of small-scale growers. South Africa has emerged as the largest maize producer and exporter in Africa, and shipments rose 20 percent to an estimated 2.4 million tonnes exported in 2012 (GRAIN SA, 2012). Despite these agricultural successes, 11 million South Africans live without the fundamental security of regular meals (GHS, 2011) and 19.4 percent of South African households live with inadequate or severely inadequate access to food in 2011 (GHS, 2011).

Sixty percent of South Africans are urbanized and depend on the agri-food chain and specifically the food processing, distribution and retailing system for their nutritional needs (Kristen, 2012). In South Africa, an estimated 29 percent of men and 57 percent women are overweight or obese (Pouane et al., 2002). Also approximately 9.04 million tonnes of food are wasted in South Africa every year (FoodBank South Africa).

DISCUSSION

In an effort to address these inefficiencies and inequalities within the food and agriculture sector in South Africa, in partnership with the Department of Trade and Industry, UNEP and FAO in April 2013 convened a round table. It was hoped that this round table, the first

Box 1: National roundtables for sustainable food systems: A rationale

The initial focus is on generating discussion amongst the diverse set of stakeholders involved in food systems, bringing them together and often for the first time, to discuss what a sustainable food systems (SFS) approach means for their particular needs and circumstances. From there, the next task is to define clearly what actions are needed to improve sustainable food consumption and production. These actions might range from a list of immediate actions to the development of national strategies or programs on sustainable food systems that help embed the systems approach into food and nutrition policy-making.

Whilst each Round-Table needs to be tailored to the specificities of each community and/or country, some common objectives could include:

- Developing and promoting a business case for sustainable food systems policy;
- Facilitating the uptake of SCP practices amongst food sector stakeholders;
- Creating a dialogue on SFS with financial developmental institutions;
- Supporting development and uptake of SCP at policy development level;
- Supporting the introduction of innovative SCP tools and practice in the food supply chain;
- Identifying and helping to initiate pilot projects;
- Facilitating engagement of stakeholders across the food sector to promote sustainable consumption behaviour.

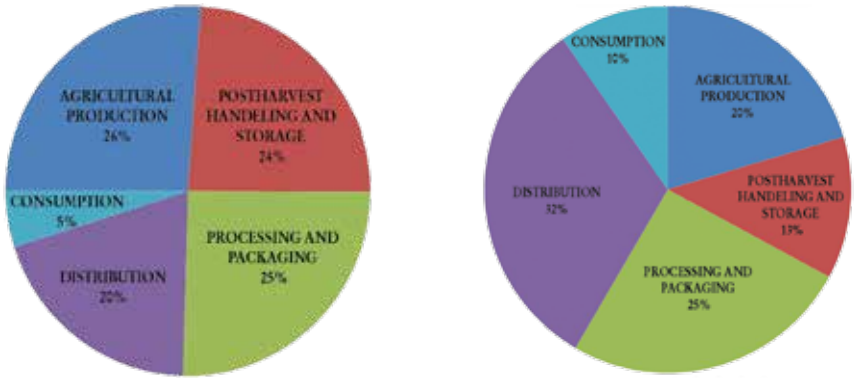

Figure 1. Relative contribution of each stage in the value chain to total food waste generated in South Africa
Source: CSIR, 2013.

of its kind to be held in Africa would increase dialogue at national levels to help catalyse action to significantly improve the sustainability of food systems within South Africa. This effort has allowed South Africa to lead in establishing the first National Policy on Sustainable Consumption and production; secondly to establish methods of curbing food security by preventing food waste and loses.

Since this initial round table, South Africa has convened several meetings to discuss action plans for the South African sustainable consumption production (SA-SCP):

- in developing SCP enabling policy;
- sustainable production;
- food waste and food loss management;
- market incentives; and
- agro-expo events (in collaboration with municipalities and government departments).

Food waste has been and remains a concern. The Foodbank (2012) report for South Africa estimated that between 12 and 14 million people in South Africa are currently food insecure, more especially in rural areas. Environmentally, there are particular concerns about food and organic waste entering landfills, the main problem being that sending organic waste to landfill increases greenhouse gas emissions.

Subsequently, in 2014 the concept was put into broader context to municipalities and the country hosted the second round table on 11 July 2014. Therefore, in the context of South Africa's national activities on SCP, a consensus was reached to pilot the UNEP, FAO and WRAP Think. Eat. Save Guidance and to develop a National Food Waste Prevention Programme.

According to Ramukhwatho, Du Plessis and Oelofse (2014), the relative contribution of each stage in the value chain to total food waste generated in South Africa is reflected in Figure 1.

The pilots with focus on Tshwane and Johannesburg metros follow the Think.Eat. Save Guidance methodology, covering mapping and measurement, policy development and specific activities in households and the supply chain. In its first year, it is defining the

programme framework, mapping and engaging stakeholders in programme development, quantifying baseline food waste volumes and initiating city level projects. A school food waste prevention project has been proposed in Johannesburg, integrating edible education, hands-on food waste prevention activities, cafeteria prevention plans and workshops for parents. A voluntary agreement engaging South African food supply chain businesses in food waste reduction commitments is also being explored.

CONCLUSION

By 2050, the world's population will reach 9 billion people, therefore reducing food waste is critical to global food security strategy. About 805 million people (FAO, 2014) just over 15 percent of the world's population – are undernourished today. At the same time, at least one-third or 1.3 billion tonnes of food is lost or wasted every year (FAO, 2011). UNEP co-leads responsibility for the food waste challenge by implementing it via the Think.Eat. Save Initiative and Guidance document.

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The role of knowledge in transitions to sustainable food systems: examples from institutional innovations

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ABSTRACT

Knowledge is fundamental to our ability to change practices from unsustainable to sustainable ones (Grin, Rotmans and Schot, 2010). However, sustainability has often been described as a "wicked problem", where the knowledge needed to make this transition is often inconclusive and contested (Batie, 2008; Levin *et al.*, 2012; Peters and Pierre, 2014). These "knowledge politics" (Baert and Rubio, 2012) suggest that we should be asking important questions as we develop policy advice, such as what types of knowledge and whose knowledge is taken into consideration in the development of sustainable food systems. If we look at food systems as the value chains and institutional arrangements that connect consumption and production, we see that different actors need different types of information and are willing to trust different types of knowledge about sustainable practices. Drawing upon results from an international survey of 15 institutional innovations in linking sustainable practices with markets that was carried out by FAO and INRA, we reflect upon how these innovations are placing an emphasis on different types of knowledge as the basis for the adoption of sustainable practices. These results shed light on the type of information and knowledge required by different actors in sustainable food systems.

INTRODUCTION

Knowledge is fundamental to our ability to change practices from unsustainable to sustainable ones (Grin, Rotmans and Schot, 2010). As we know, sustainability is often described as a wicked problem (Batie, 2008; Levin *et al.*, 2012; Peters and Pierre, 2014), which means that it is a problem where there is significant uncertainty, not only about how to solve the problem, but actually about what the problem is in the first place. This means that it is a problem to be managed, which requires new knowledge (Peterson, 2013). Put differently, we must be willing to experiment with a number of different approaches to see what works in which context. We also know from some recent research that system

transformations happen when new practices and technologies are taken up as habitual practices (Shove and Walker, 2007, 2010). It is the process of normalization, or rather of making sustainable practices those that we do without really thinking about it. Now how to do that is the challenge, which is recognized by private actors, academics and policy-makers alike (Newson *et al.*, 2013).

As is evident in pubic international debate, sustainability is a multifaceted and highly contested topic, yet simultaneously brings together several different groups in competing regimes of knowledge that provide guidance on what form sustainable agri-food systems should take. The industrial agriculture sector, which relies upon cutting-edge biological, chemical and mechanical technologies, maintains a monopoly on the current agri-food landscape precisely because they have been able to dominate the scientific knowledge production and its resulting technologies (see Vanloqueren and Baret, 2009). The recent discourse on the "new green revolution" for Africa, based on science-driven agricultural research, is indicative of the shifting plates in global discourse around sustainability (Gates, 2012). On the one hand, there is the push by multinational agribusinesses to promote the intensification of agricultural research and experimentation into genetic engineering (GE) and innovations in synthetic inputs as a means to make industrial agriculture more sustainable (see Lyson, 2002). This requires "robust" scientific knowledge that has passed numerous laboratory and field "tests" as part of a process of standardizing the scientific knowledge used to develop these technologies and products.

On the other hand, the predominance of this input intensive paradigm has provided space for numerous alternative approaches to sustainable agriculture (Elzen *et al.*, 2012), many being restricted to socio-technical niches and a number of approaches based on the principles of agro-ecological knowledge to promote agro-ecosystem sustainability (Altieri, 1987; Gliessman, 2001). In these cases, the agro-ecological knowledge has also been standardized through on-farm experimentation, and also through the creation of auditable standards to ensure compliance with the principles of agro-ecology (e.g. Bain, Deaton and Busch, 2005; Bingen and Busch, 2006; Cashore, Auld and Newsom, 2004; Higgins, Dibden and Cocklin, 2008). At both ends of this spectrum of sustainable agriculture practices, we see a clear role for standardizable knowledge. One might characterize this standardization process of sustainable agri-food systems as an expression of a knowledge regime (Pestre, 2003) that fosters certain types of relationships between agronomic science and agricultural technology. As a result, these relationships shape the policy drivers that govern the inclusion or exclusion of certain regimes of sustainable agriculture knowledge and techniques. Therefore, it is important to be aware of the role of knowledge in these processes and how different types of knowledge can contribute to the ongoing transitions to sustainable food systems.

These "knowledge politics" (Baert and Rubio, 2012) described above suggest that we should be asking important questions as we develop policy advice, such as what types of knowledge and whose knowledge is taken into consideration in the development of sustainable food systems. If we look at food systems as the value chains and institutional arrangements that connect consumption and production, we see that different actors need different types of information and are willing to trust different types of knowledge

about sustainable practices. Drawing upon results from an international survey of 15 institutional innovations in linking sustainable practices with markets that was carried out by FAO and INRA, I reflect upon how these innovations are placing an emphasis on different types of knowledge as the basis for the adoption of sustainable practices. These results shed light on the type of information and knowledge required by different actors in sustainable food systems.

DIFFERENT TYPES OF KNOWLEDGE FOR UNDERSTANDING TRANSITIONS TO SUSTAINABLE FOOD SYSTEMS

Modern agri-food systems are highly standardized with multiple layers of rules governing production practices, supplier contracts and distribution networks. For example, each country has baseline standards for health and safety of workers and of food items. On top of this one can find rules that define good agricultural practices (GAPs), good manufacturing practices (GMP), consumer protection laws that lay out the rules that are meant to protect consumers, rules about what can legally be included in contracts, who can hold contracts, and how these can be enforced. Layered above these rules are private standards defining the quantity and quality of food products that meet different market segments. These rule-based systems all rely upon different types of expert knowledge, which are mobilized at different points of the value chain to ensure that the rules are appropriate to the situations in which they are applied, and that they reflect robust "expert" knowledge about the content of the rules (Henson and Humphrey, 2009).

Like all rule-based systems, agri-food systems suffer from the twin problems of embeddedness and embodiment (Schrager, 1990). Embeddedness refers to the tacit social context that contributes to judgment, while embodiment refers to the tacit skills that make human beings able to solve practical problems. These two aspects are important because they influence how new technologies are taken up by users (Nelson, 1998; Rogers, 1962). Understanding how new technologies are adopted is fundamental to understanding how we are able to transition towards more sustainable agri-food systems (see Markard, Raven and Truffer, 2012), as knowledge for sustainability must be able to integrate the tacit knowledge of societal actors (Voß, Bauknecht and Kemp, 2006). This is particularly true in contexts where there are competing technologies, as is the case with sustainable agricultural technologies (Aerni, 2009; Schot and Geels, 2008).

Gorman (2002) combined these two insights with four types of knowledge in order to provide a framework for understanding how technology is transferred, even in the absence of explicit documentation and proposes that this is also why documentation alone is not sufficient for transferring technology and changing practices towards more sustainable ones (Figure 1). In each of these four types of knowledge there are both declarative (recalling facts) and explicit (can be told) and tacit and implicit (that which cannot be easily explained by words but through the way your body knows to do things).

The first type of knowledge is "information" or knowledge about "what". Basically it is the knowing of facts – what exists, what can be done. But increasingly in our society there is so much information out there that it is nearly impossible for individuals to know all of the facts, so it is also about knowing where things are to be found, more than just knowing things.

Figure 1. Four types of knowledge
Source: adapted from Gorman (2002).

The second type of knowledge is procedural. It is about skills and how things are done. This is the hands-on, extended practice of knowing and is often how things can be learned. These are often described as habits, what we do naturally, what works. The third type of knowledge is the judgmental knowledge, which requires knowing when something is appropriate. So basically it involves recognizing that a problem is similar to one whose solution is already known and knowing when to apply a particular procedure. This type of knowledge is commonly used by so-called "experts" and the creation of rules (and standards) can be helpful for developing this type of expertise. The fourth type is referred to as wisdom or knowledge of why we do something. It is related to judgment, but it is a different kind of judgment than the one usually used by experts because it is not necessarily knowledge based on already known facts and procedures. Rather it is the ability to reflect upon what one is doing and to question prevailing procedures, and to sometimes come up with new ones if necessary. Codes of conduct help facilitate wisdom, but it really requires a "moral" imagination or creativity – the ability to think outside the box.

The idea is that these different types of knowledge are important for different activities within food systems and have different roles in enabling change. In this paper this framework is adopted to analyse how different types of knowledge have been fundamental to the emergence of innovations around the promotion of agro-ecological technologies and institutional design that link small farmers with markets in developing countries. These examples come from a joint research project between the French National Institute for Agricultural Research (INRA), the Rural Infrastructures and Agro-industries Division (AGS) and the Plant Production and Protection Division (AGP) of FAO entitled: "Responsible innovation in sustainable agri-food systems: explorations of the intersections between voluntary standards and value chains" (Loconto, Santacoloma and Poisot, in press).[1] This study analyses 15 case studies of institutional innovations that span Latin America and the Caribbean, Africa and Asia.[2] Our main research question of the larger project is: how are voluntary standards encouraging the adoption of sustainable

[1] See the full publication for information about the methods used for data collection and analysis.
[2] The case study countries are Bénin, Bolivia, Colombia, Ecuador, India, Indonesia, Iran, Namibia, Nigeria, the Philippines, the United Republic of Tanzania, Thailand, Trinidad and Tobago, and Uganda (two cases).

practices? Our main thesis is that this happens through the institutional innovations that are constructed at multiple levels, which provide the mechanisms through which information is shared and changes in practices are supported. In this paper, it is suggested that one of the ways in which voluntary standards do this is through the knowledge that is mobilized around their implementation. In the following sections, examples from eight case studies are framed in the form of knowledge challenges that the innovators faced and their responses to this challenge. A brief informative summary of each of these cases is found in a dedicated box. This approach highlights the transformative nature of the role of knowledge in assisting each innovator's transition towards a more sustainable agri-food system.

THE CHALLENGE OF INFORMATION: DEFINING SUSTAINABILITY LOCALLY

The first challenge is about information – or what do we know about sustainable practices? This draws upon the case studies from India and the Philippines to illustrate how information about sustainable practices is translated at a local level.

In the case from India (Box 1), the Participatory Guarantee System Organic Council (PGSOC) is a federation of over 500 local farmer groups who operate participatory guarantee systems that ensure the adoption of organic agricultural practices. The question of "what knowledge" or information was tackled through PGSOC's adaptation of generic organic standards to the particular Indian context – focused on ayurveda and unani medicine and on the need to conserve native seeds on their farms. The public national-level organic standard is the first instance of adaptation, as it integrates these aspects of traditional Indian agriculture into the legal norm. However, the PGSOC has developed its own system of certification and has placed a strong focus on the translation of the organic rules into the numerous local languages and insist that organic is a whole farm concept, not just a "parallel production" system. In this way farmers are able to define sustainable practices based on traditional approaches to agriculture and medicine, and based on locally available inputs.

In our case from the Philippines (Box 2), the local definition of sustainability was tackled through a different approach to defining what organic agriculture means. Here the Quezon Participatory Guarantee System (QPGS) has been promoted through the Farmer Scientist for the Development of Agriculture or MASIPAG. MASIPAG is a network of farmers, scientists and non-governmental organizations (NGOs) working towards sustainable

Box 1: Participatory guarantee system organic council (PGSOC), India

The agricultural practice used in this innovation is **organic agriculture** in order to achieve better health in terms of safe food. The mechanism implemented in the project is a **participatory guarantee system (PGS)**. The characteristic solutions emerging from the project are the native seed marketing and the focus on yields. The project has been developed in a framework of institutional support for organic agriculture and in the country there is a National Organic Law and a public PGS standard. This innovation uses a private PGS standard that is equally recognized by the institutions. Quality products are intended for both **short and long value chains**.

Box 2: Quezon participatory guarantee system (QPGS), Philippines

The agricultural practice used in Quezon Participatory Guarantee System is **organic agriculture** in order to improve local livelihoods. To support this overall objective, the innovation has implemented a **participatory guarantee system (PGS)** that encourages farmer control over genetic and biological resources. In the Philippines, a National Organic Act regulates organic production and labelling, and private PGS standards are recognized by the state institutions. Quality products are marketed to consumers through **local markets** and **media utilization** (radio).

use and management of biodiversity through control of genetic and biological resources, agricultural production and associated knowledge. For example, the University of the Philippines Los Banos is working on developing what they call natural farming methods (NFM), a diversified cropping system and vermiculture production that is adapted to the conditions of the Philippines.

These two cases are illustrative of a broader trend across our 15 case studies. Basically, what we have found in all of our cases is that there is a clear challenge posed by translating international standardized knowledge about sustainability into locally relevant and understandable information. This was evident even within the organic movement, which is considered to have a rather stable definition of sustainability. It was clear that knowledge still requires local adaptation in order to become useful information. These cases also illustrate that there are numerous initiatives between farmers and scientists to further define what sustainability means at a local level, in order to provide more appropriate and understandable information to producers and consumers.

THE CHALLENGE OF SKILLS: "LEARNING BY DOING"

The second knowledge challenge that we have observed in our case studies is based on how different actors know what sustainability means and how they acquire the skills necessary to be more sustainable. We find that in most of our cases there were indeed linkages with universities and the two cases given in Boxes 3 and 4 illustrate how training programmes based on "learning by doing" have become institutionalized.

In Bénin Republic (Box 3), the Songhai Centre is a youth training centre for "agro-entrepreneurs" that was established in 1985 and is based on the teaching of organic agronomic techniques based on an integrated production system. The focus is on increasing yields through simple techniques, without using pesticides or fertilizers, and while cutting production costs and protecting the environment. The main technique is encouraging "good bacteria" – "effective micro-organisms" (EM) present in the soil to maximize production without having to rely on chemicals. But students are also trained in all activities that are necessary for a sustainable food system, such as processing, transport, marketing, agribusiness management and hospitality and cooking. There are 20 000 visitors per year – 3 000 trained. A study carried out by FAO on the sustainability of this model found that the ex-trainees are practising the sustainable agricultural techniques that they learned, but not at the same level of complete integration as the demonstration site – which

Box 3: The Songhai centre, Benin

The innovation focuses on **organic agriculture** in order to promote rural development. The Songhai Centre has created an **innovation platform (IP)** focused on research, training, agro-processing and development services in order to train youth agro-entrepreneurs and to spread sustainable practices. This project emerged from a framework of general principles affirmed by the state institutions but without a specific regulation on sustainable agricultural practices. At the same time, there is a rising consumer demand for quality products with an organic label.

has come about due to a lot of investment. But the key here is actually on the teaching approach that they have taken, which is focused on applied learning during the 18-month residence on the main Porto Novo training site, and additional training of about six months following this on a commercial farm. The philosophy of the training programme is to ensure that the youth gain knowledge of facts, but they also gain competencies and knowledge of how to do things. They must also learn a system of values that is used to discipline them in their work. The case of Bénin is rather interesting because it seems that finally, after almost 30 years of its existence, the Ministry of Education is interested in promoting this model as an accredited training model within the education system and is interested in promoting the creation of this type of training centre in each department of the country in order to increase access.

The Federal University of Agriculture, Abeokuta (FUNAAB) plays a pivotal role in the development of organic agriculture in Nigeria (Box 4). It founded the Organic Agriculture Project in Tertiary Institutions in Nigeria (OAPTIN) in 2004 to build capacities of higher education institutions managers, researchers and farmers in the country. The aim was to develop a more sustainable food production system. OAPTIN's stakeholders include university lecturers, students, scientists, farmers and processors. It developed a curriculum to teach organic agriculture at the bachelor's degree level in higher education institutions in Nigeria (UNAAB, 2008). The approach of FUNAAB is unique because it is working with surrounding communities to use farmers' land for productive experiments, the products from the experiments are sold in an organic kiosk on campus, and they are paying village youth to work on the farms alongside the students. This working together has actually transferred into these community youths having access to university education. In 2011/2012 a total of eight qualified prospective candidates seeking admission to FUNAAB from host communities were admitted for its various undergraduate degree programmes. The number was increased to 16 (100 percent increase) in the 2012/2013 session. This is an approach by FUNAAB to institutionalize the programme. Such candidates pay their school fees from the point they register through the period of their degree programmes. As a Federal Government University, FUNAAB fee of USD100 per session is reasonably low and affordable by the candidates. As FUNAAB students they can compete for their respective state governments' bursary allowances to further assist them.

In sum, these two examples illustrate how these innovations are transferring skills through hands-on training, which takes into consideration both the tacit and the declarative

Box 4: The community based-farming scheme (COBFAS), Nigeria

The Community Based-Farming Scheme promotes **organic agriculture** in order to encourage sustainable farming practices. The project is an **innovation platform (IP)** concentrated on youth training through a system of student farms and community outreach. The state institutions do not provide specific legislation on organic agriculture and international organic standards are utilized. The quality products and services are promoted through the **organic kiosk** on campus and through community engagement.

knowledge that is required to be able to implement sustainable practices. The need for training based on "learning by doing" is a common theme in all of our cases.

THE CHALLENGE OF JUDGMENT: SOCIAL CONTROL

Once one has defined what sustainability is, what information can be used and how one can learn to do it, there is a role for judgment. Basically, judgment means taking a decision about when some knowledge is more important than others and when a certain procedure is more appropriate than another. This concept is illustrated with two examples of "social control" that we have found in our cases.

The first example is in the United Republic of Tanzania where the tea industry is implementing Rainforest Alliance-certified tea (Box 5). In this particular case, we have a farmer group of about 15 000 members, each with about 1–2 hectares of tea. The context here is that Unilever, which is the biggest global buyer of tea, has committed to purchasing only Rainforest Alliance certified tea for its Lipton yellow bag blend. While Unilever is not the biggest buyer of Tanzanian tea, they have plantations in the country and are very influential within the tea industry. Moreover, following Unilever's commitment, Tetley, Sara Lee, Twinings and a number of other smaller UK brands have made similar commitments. What is happening in Tanzania is that the local tea companies have decided to become certified by third-party certifiers, but this is a long process to get all smallholders certified, so they have started with those who were already ready and are moving towards getting all of the smallholders in the country certified within the next five years – which is actually the government commitment. What this particular company came up with was a way to deal with the need for traceability between certified and non-certified tea. Each farmer has an identification number and when the trucks come to pick up the tea at the weight station, the farmer provides his number and the digital scales that the drivers use tell the driver if this farmer is certified or not. The certified farmers receive these new yellow bags and the non-certified receive the other coloured bags. What this company is reporting is that farmers want to have the yellow bags and have been asking the yellow-bagged farmers what they have done to get them – and it is in this way that they have been able to identify those farmers who are ready to be included in the certification system.

The second example comes from Bolivia (Box 6), but the Bolivian case is representative of the six cases of participatory guarantee systems (PGS) in our study. A participatory guarantee system is a group of stakeholders who have decided to work together at the

Box 5: Public-private support for rainforest alliance certification of tea, United Republic of Tanzania

The Tanzania Smallholder Tea Farmers innovation focuses on the **sustainability of a subsector** (tea), with the objective of improving farmers' livelihoods and guaranteeing worker health and safety. The mechanism implemented in the project is an **innovation platform (IP)** to develop new technologies, exchange knowledge and provide financing. The innovation is the institutional collaboration of governmental agencies, NGOs and private companies to support smallholder farmers to implement Rainforest Alliance-certified production practices. Quality products are designed to meet local and international **market requirements** for tea.

level of the farm in order to conduct the audits of the other farmers in the group. These groups are different from internal control systems that are used for group certification because they specifically seek to have consumers, researchers and government officials in the group that takes the decision. Moreover, the farmers themselves are the inspectors and the representatives of these groups. In the case of Bolivia, these groups are authorized in the national standard for organic agriculture as a valid form of certification for the local and domestic markets. The group representative must register the group with the food safety authority and municipal level officials are part of the certification committee. There is also an investment being made now with support from FAO to hire a municipal level extension worker who is trained in organic agricultural practices in each municipality. However, when I spoke with one farmer leader, she explained to me that in general, they do not really need an agronomic extension worker, they have enough experience now that they are resolving their own agronomic problems on their own – what is needed is marketing extension. Indeed, what we are finding is that the creation of these PGS are not only allowing farmers and consumers to judge when practices are or are not sustainable, but they are increasingly being used as collective marketing mechanisms.

These mechanisms for social control illustrate how peer review (or pressure) can work as a mechanism to enable groups of farmers to adopt sustainable practices. In each of these cases we see examples of highly standardized technologies in terms of the sustainable agriculture practices, but possibilities for flexibility of interpretation in how to enforce them. Each technique relies upon farmer judgment and thus farmer knowledge to ensure the adoption of the sustainable technologies.

THE CHALLENGE OF WISDOM: HEALTH AND DIET

The final knowledge challenge that will be discussed is related to wisdom. This refers to the motivation or justification as to why sustainable practices are encouraged by both consumers and producers. From all of our 15 case studies, the most dominant response to this question of "why sustainably produced food" is based on health and diet. By health we refer to both producer health in terms of their status as workers, but also as consumers, because in most of our cases the farmers who are practising sustainable agriculture are consuming what they grow. Additionally, in our case study authors reported that they have

Box 6: Ecofieras and PGS, Bolivia

The agricultural practices used in this innovation are **agro-ecological**, with the objective of achieving food sovereignty and food safety both for consumers and for farmers. To support this overall objective, the project has implemented a **participatory guarantee system (PGS)** in order to ensure farmer compliance and create a local market for certified products. The Ecological Fairs have been developed in a framework of institutional facilitation due to a National Organic Law and PGS standards regulation. Quality products reach consumers mainly through **local fairs**.

Box 7: Familia de la tierra PGS, Colombia

The Familia de la Tierra innovation focuses on agro-ecology to achieve food sovereignty. The mechanism implemented is a **participatory guarantee system (PGS)** through which native seeds and agro-ecological products are cultivated and commercialized. The case has been developed within a framework of **organic agriculture**, in particular thanks to national associations focusing on this topic, but at present only an organic policy proposition exists. Quality products are mainly destined to **gourmet consumers** in the major cities.

been able to gain markets for their products because there are consumers who are looking for products that will improve their health and diet.

In Colombia (Box 7), we have a number of different ways in which we see health concerns as a driver of why sustainable food systems are taking hold. First, they are actually doing something quite similar to what Roberto Azofeifa (2014) explained from Costa Rica. They have linked up with a cooking school and a number of celebrity chefs in Bogota in order to teach them about native crops and the health benefits that they have. It seems that the chefs are quite interested in these crops, not only because of the health benefits, but also because of characteristics such as colour and taste, which enable them to create innovative (and traditional) dishes. Familia de la Tierra is able to provide this information to its buyers because they have been collaborating with the National University and also with the Nazareth Hospital in Sumapaz to do clinical trials on the health benefits of some of their native plants. For example, the hospital has been doing trials and actually treating its patients with *yakón*,[3] in order to slow down the onset of diabetes and to lower cholesterol.

In Uganda proposal (Box 8), we have an example of a PGS that is very consumer-focused and operates a box scheme in Kampala. Their consumers are mostly women who know each other and have been following diet trends. Using Facebook they have organized juicing clubs where they share information about which fruits and vegetables

[3] Yakón (Smallanthus sonchifolius) is a native Andean plant grown for its sweet, crispy, tuberous roots and for its leaves, which are used in infusions. The latter are purported to have prebiotic and antioxidant properties and in Colombia research is being conducted on its use in preventative treatment for diabetes and high cholesterol. See: Valentová and Ulrichová 2003.

Box 8: Freshveggies PGS, UGANDA

The FreshVeggies PGS initiative promotes **organic agriculture** to achieve health and safety for both consumers and farmers. The innovation is a **participatory guarantee system (PGS)** that is used to increase access to local market outlets. FreshVeggies follows a regional organic standard (East African Organic Products Standard) and its PGS standard. Quality products and services reach urban consumers through **Facebook updates** and weekly deliveries.

provide certain vitamins, etc. So they are using the Internet and organizing themselves to gain access to often difficult to find fruits and vegetables. On the side of the farmers in this case, the PGS has built upon an existing savings and credit cooperatives (SACCO) consisting mostly of women, who all have small plots of land that they traditionally use for their kitchen gardens. They have been able to expand these in order to be able to produce extra fruits and vegetables, which they sell through box schemes, and also to supermarkets and other conventional buyers. Here specifically, the PGS has established the rule that each farm must grow three traditional crops, which are medicinal plants and whose leaves provide the basis for the Ugandan diet. In this way they are looking after the health of both the farmers and the consumers.

In all of our cases we find that there is a strong interest from consumers in sustainable food that emerges from a very basic concern over food safety. These customers do not trust the "conventional" food to be safe from the point of view of both the microbial and agro-chemical toxicity. This raising consumer awareness seems to come from increasing availability of information for urban consumers about current agricultural practices in rural areas and recent food scares that have been in the media. Indeed, FAO has noted that the basic food safety infrastructure in many countries needs improvement, particularly in terms of its ability to conduct the tests needed to determine food safety risks and to ensure that food safety standards are enforced (FAO, 2003). These infrastructural changes at the system level (Shove and Walker, 2010) are indeed fundamental to enabling individual consumer behaviour that can be influenced by product advertising (Newson *et al.*, 2013).

CONCLUSION

The purpose of this paper was to illustrate, through examples from case studies of institutional innovations, how knowledge is important for transitions to sustainable food systems and why it is important to pay attention to the different types of knowledge that are needed in different situations. By focusing on how knowledge might be characterized as information, skills, judgment and wisdom, we were able to draw out insights from eight case studies that illustrate how both tacit and declarative knowledge are used by a variety of actors. Moreover, the innovations showed that different actors rely upon different types of knowledge to take decisions or motivate action at different places in the value chain. Finally, these examples show that both consumers and producers are using information that they receive, adapting it to their local contexts. In other words, different types of knowledge

pose different challenges to actors in the food system, but the need for these different types of knowledge also provide opportunities to innovate, particularly by farmers.

Specifically, we may take these challenges as points of departure for public policy interventions. For example, defining sustainability locally democratizes efforts to build up complex agri-food systems by communicating between global standards and local interpretation. Capacity building to change practices is needed that addresses the need to learn tacit knowledge as well as declarative knowledge. Programs that adopt applied training approaches have been effective in mobilizing knowledge for innovation. Traceability and control systems that rely upon farmer knowledge and peer-review illustrate that expert judgment is not always the job of external experts, but local experts who rely upon experiential knowledge also have a role to play in transitioning towards sustainability. Finally, it is clear that there are multiple drivers of knowledge needs, particularly in terms of why people are committed to more sustainable consumption and production. We find that collaboration and networks between farmers, and among farmers, consumers, scientists and other value chain actors, are fundamental to sharing knowledge and changing practices. This collaboration helps to build collective wisdom (at local, subnational, national, regional and international levels) that helps in the normalization process of sustainability transitions.

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Knowledge needs for sustainable food systems

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ABSTRACT

Progressing towards sustainable food systems (SFS), taking into consideration the environmental, economic and social dimensions and the need to ensure food security and nutrition for all without compromising these for future generations, requires the involvement of a multitude of actors along the food chain – from production to consumption – including governments, the private sector and civil society. This requires improved knowledge collection, sharing and use. This paper takes stock of the main findings, on both substance and methods, of the workshop and of the experiences presented, as well as of the discussions and workstreams developed in the FAO/UNEP Sustainable Food Systems (SFS) Programme. It recalls the importance of knowledge in the 10-year framework of programmes on sustainable consumption and production patterns (10-YFP). Starting from the knowledge needs identified in the FAO/UNEP SFS Programme, it proposes a typology of knowledge needs and further questions three of them: common understanding of issues, knowledge tools adapted to the needs of each category of actors and information sharing between different categories of actors. It then identifies some knowledge and data gaps and concludes by proposing a way forward for future work.

INTRODUCTION

Progressing towards sustainable food systems (SFS), taking into consideration the environmental, economic and social dimensions and the need to ensure food security and nutrition for all without compromising these for future generations, requires the involvement of a multitude of actors along the food chain – from production to consumption – including governments, the private sector and civil society. It requires improved knowledge collection, sharing and use by different actors. This explains the key role of knowledge, in various forms, in most of the work of the FAO/UNEP Sustainable Food Systems (SFS) Programme. It also explains the constant tension between the need for collective understanding and orientation and the need for actor-focused approaches and methods to motivate and enable action. The workshop on knowledge needs for sustainable food systems started from these premises in order to identify concrete needs and ways to address them.

This paper takes stock of the main findings, on both substance and methods, of the workshop and of the experiences presented, as well as of the discussions and workstreams developed in the FAO/UNEP SFS Programme. It recalls the importance of knowledge in the 10-year framework of programmes on sustainable consumption and production patterns (10-YFP). Starting from the knowledge needs identified in the FAO/UNEP SFS Programme,

it proposes a typology of knowledge needs and further questions three of them: common understanding of issues, knowledge tools adapted to the needs of each category of actors and information sharing between different categories of actors. It then identifies some knowledge and data gaps and concludes by proposing a way forward for future works

KNOWLEDGE IN THE 10-YFP

The United Nations Conference on Sustainable Development, Rio+20, highlighted the need for all stakeholders to be engaged in decision-making and action, as well as, the importance of science/knowledge for decision-making (UN, 2012a). Inclusiveness and better evidence based processes are in fact mutually reinforcing (Gitz and Meybeck, 2011).

The 10-YFP itself gives prominence to science and knowledge, both as a basis for the programmes and as an instrument. The 10-year framework of programmes on sustainable consumption and production patterns (UN, 2012b) lists criteria for programmes to be included in the 10-YFP. The programmes should "be based on life cycle approaches, [...] as well as science-based and traditional knowledge-based approaches" and "be based on a solid scientific and policy knowledge base". The programmes should "consider the use of a mix of efficient instruments such as education, training and data collection, as well as research activities, in each programme, as appropriate".

This builds upon the activities conducted under the Marrakech process, decided in 2002 in the Johannesburg Conference, that prepared the adoption of the 10-YFP. The Marrakech process progress report prepared by UNEP (2011) notes "a need to strengthen the science base and policy interface" as well as a "need for better methodologies for identifying and measuring resource efficiency". A review of the outputs of the Seven Marrakech Task Forces (Rezaei, 2013) noted that they were mainly related to knowledge and information, policy recommendations and capacity-building tools. It also noted that these activities also seemed to be the ones that have the broadest and more lasting effect.

KNOWLEDGE NEEDS IDENTIFIED IN THE FAO/UNEP SFS PROGRAMME

The FAO/UNEP Programme was designed in 2011 to prepare the inclusion of a programme for sustainable food systems in the 10-YFP established in 2012 at Rio+20. The Programme is supported by an Agri-food Sustainable Consumption and Production (SCP) Task Force (ATF) that brings together representatives of governments, international organizations, the private sector and civil society.

Since the beginning of the Programme there was, often implicit, the need for a common vision of SFS, grounded on a shared understanding of issues and priorities. This was particularly challenging and has long been set aside, given the differences of priorities and perspectives of the various stakeholders.

At the onset of the Programme, stakeholders, gathered in the ATF, identified four key areas to achieve SCP in food systems:

- effective information platforms;
- reliable communication;
- enabling conditions; and
- market-based approaches.

These call for knowledge that is comprehensive and actionable, and adapted to the needs and perspectives of the different actors – from input and service providers to primary producers, transformers, retailers and consumers.

The ATF has further emphasized the need: to better identify the requirements and perspectives of the various actors in terms of data and means to access them; to identify and assess existing data and gaps; and to identify and assess existing knowledge-sharing tools and mechanisms. It also underlined the need for approaches and indicators to measure all impacts of food production and consumption, as otherwise there is a risk of prioritizing the most easily measurable. For instance, biodiversity, gender and social issues, which are much less easily reduced to a single numerical indicator like GHG emissions, are much less addressed.

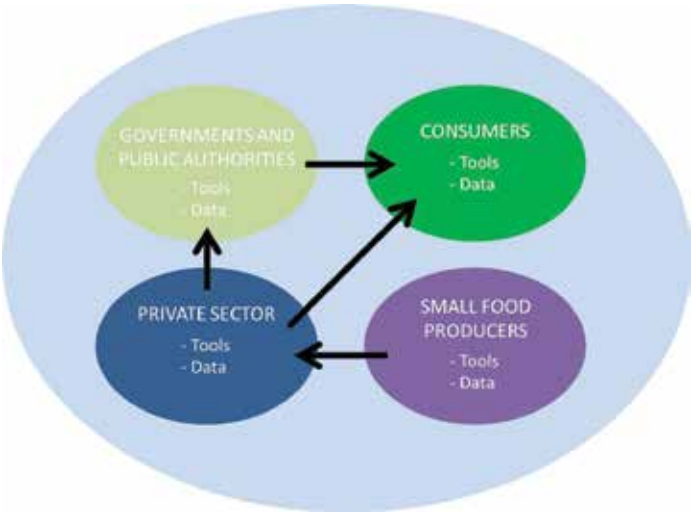

Figure 1. Actors and knowledge in food systems

TOWARDS A TYPOLOGY OF KNOWLEDGE NEEDS

A sustainable consumption and production programme on food systems is particularly challenging for several reasons. It requires considering a vast number of issues, from environment to economics and social issues, as well as the diversity of their interactions, at various levels, from global to local. Improving the sustainability of food systems requires the involvement of a multitude of actors along the food chain – from production to consumption – including governments, the private sector and civil society. Their diversity, in terms of interests, size, capacity and their sheer number, is in itself a major challenge. Most actors have a very specific entry point to sustainable food systems, determined by their role, priorities and scope of intervention. Therefore, given these diversities of capacities, scope and priorities, this creates several types of knowledge needs:

- a common understanding of issues, and of different perspectives, to be able to discuss, and agree on common orientations;
- knowledge "tools" adapted to the needs of each category of actors;
- data collection and sharing mechanisms adapted to each category of actors;
- information-sharing systems between categories of actors (see Figure 1).

SHARED UNDERSTANDING FOR COLLECTIVE ENGAGEMENT

To work together towards sustainable food systems requires first of all a shared understanding of the global objective, of the issues and of what needs to be collectively

achieved. A common vision is an indispensible requisite to ensure that any single action contributes to the objective pursued (Faurès, 2015). It requires taking into account different issues, to mobilize different disciplines and types of knowledge, to consider different spatial and time scales. It also, and critically, requires involving and engaging all concerned categories of actors. This is often particularly challenging as all actors have their own perspectives, points of view and interests, thus putting emphasis on different issues and ways to address them.

This very workshop, as well as some of the results presented, provided some ways to progress towards a common understanding. The workshops organized by the FAO/UNEP SFS Programme aggregated around a specific topic with diverse presentations from different types of knowledge holders, with different perspectives and points of view. They provided opportunities to share experiences and positions, a first step towards a shared understanding.

The Committee on World Food Security (CFS) has gone further in institutionalizing an interface between knowledge and decision, by creating the High Level Panel of Experts on food security and nutrition (HLPE), an independent scientific body with the mission to provide evidence-based analysis and advice. In turn, the HLPE, in preparing its reports, largely consults stakeholders, who are also knowledge-holders. As a result, its reports and recommendations are particularly adapted to the needs and concerns of actors, in their very diversity. The reports have the objective to lay out a common knowledge ground, enabling all actors to understand complex issues, on which there are often several knowledge perspectives, which need to be holistically combined. A very good example of the strength of the HLPE's methods of work is the wide adoption of its definition of sustainable food systems, including by the SFS Task Force itself. More generally, the HLPE reports, because they are prepared for a multistakeholder discussion in the CFS, are often a very useful basis for discussion in other actor-oriented settings, be it at national or regional level. These examples show: first, the value of a common understanding to ground collective engagement; second, the importance of involving all actors, as knowledge-holders, in its construction; and third, the need to clearly distinguish knowledge building from decision-making.

KNOWLEDGE AND DATA FOR ACTION

The members of the Task Force have frequently insisted on the need for operational knowledge, oriented towards action. It calls for knowledge that can ground and orient the decisions of each specific category of actors, with important consequences on the type of knowledge, tools and data to be made available: for assessments and diagnostics, on practices that could be adopted, on their potential impacts, and on ways to monitor progress.

The Sustainability Assessment of Food and Agriculture systems (SAFA) provides guidelines and tools to assess sustainability of food systems, including the environmental, social, economic and governance dimensions (Scialabba, 2014). It enables actors, at any stage of food value chains, to make a broad assessment, without neglecting any dimension, which can serve as an initial diagnostic of critical issues to determine priority areas of action. It is being used in tools adapted to the needs and capacities of each category of

actors, such as the SAFA Small App designed to address the specific requirements of smallholders (Scialabba, 2015).

Life cycle analysis (LCA) aims to assess impacts induced by products, from production to consumption and disposal. It is a very powerful approach, with methodologies and tools that are largely shared. It was initially developed to assess industrial processes and their environmental impacts, and to identify hotspots and potential improvements. It is being increasingly used for food products. Application of LCA to agriculture is particularly challenging and complex (Masoni, 2015) and is very expensive and extremely data-intensive and time-consuming. The data that are available are derived from many initiatives and there is a need to make them comparable. This raises many complex issues for agricultural products, as LCA results vary from farm to farm, as well as from year to year (depending in particular on yields). Owing to the fact that it is an expensive methodology, it cannot be conducted on all farms, nor undertaken repeatedly. Therefore, the number used has often been calculated in very different situations and generally cannot account for improvements realized over time. These limits require more work on the comparability of methodologies and data. They also invite being careful in the use of the results, particularly in their comparison. Finally, LCA methodologies are not at the same stage of development for all issues. They are currently mainly developed for environmental issues, especially GHG emissions, for resources consumption and toxic emissions, but are of much less use for biodiversity or social issues.

There are an increasing number of methodologies and tools designed to assess and monitor impacts and progress on specific sustainability issues, mainly environmental. They are often tailored made by/for specific communities or networks of actors and therefore well answer their specific needs, capacities and priorities, comforting interest and engagement and enabling significant progress of actors involved. However, such a proliferation of specialized dedicated tools comes with drawbacks. The first is the difficulty to address sustainability in all its dimensions, with the risk of omitting impacts on issues not considered while aiming for progress on a reduced set of issues. The second is the difficulty to share and compare results between groups of actors using different methodologies and tools. These limitations can seriously reduce the global effectiveness of action and call for ways to facilitate correspondence between tools dedicated to the same or to different issues.

Actors in food systems need to know the impacts of their own decisions/practices. In addition, they need, as much as possible, indicators that link and integrate input/impact with output. They also need to be able to compare them to a benchmark and to what others do, as well as to the impacts of other practices, be it for the same output or for a comparable one. This requires data collection and sharing in an easy, cost-effective and user-friendly way.

SHARING DATA AND INFORMATION

As shown above, actors often need data and information to ground their own choices. This information, most of the time, comes from other actors. This calls for information-sharing both horizontally, inside the same category of actors, and vertically, between different categories of actors, in the same geographic area, or along a food value chain.

Sustainable management of collective resources – water, pastures, fish stocks, etc. – requires a clear knowledge of total uses, which often relies on data collection from all users. Along food value chains, actors, including consumers, can be willing to select products that are produced in a more sustainable way, as part of their own action towards more sustainable food systems, to improve their own sustainability indicators, particularly in an LCA approach and, in turn, to look more sustainable to potential buyers. This has given way to various schemes of information and data transmission, business to business (B to B) and/or ultimately to consumers, business to consumers (B to C) (for examples and a detailed analysis see FAO, 2014a).

Development and use of methodologies and tools for sustainable farming often involve communities of practices and farmers networks, sharing results and good practices, enabling the determination of benchmarks and ways to progress adapted to local specificities, capacities and priorities. This can involve mutual assessment and collective monitoring of progress. The farm energy efficiency diagnosis developed in France by a group of organizations (Bochu *et al.*, 2010; Ademe/Dia'terre, 2011) has given way to the constitution of a comprehensive database through a cooperative mechanism. The diagnosis tool as well as access to the database are provided free of charge to users, who in exchange feed back their results, anonymously, to the database, enabling comparisons and benchmarking. Such collective undertakings require common objectives and mutual trust. These conditions are much more difficult to meet for industrial actors where process and performance are key competitive advantages and thus not likely to be shared with potential competitors. This could seriously limit potential for direct information sharing between "big" enterprises. Moreover, with the development of certification schemes and consumer information, sustainability of information and data is becoming a comparative advantage in itself, driving the constitution of private databases, selling information, particularly for LCA purposes.

B to B cooperation can take multiple forms, from big buyers supporting their providers through technical tools and data collection (Roulin, 2014) to dedicated systems aiming for B to B information transmission like Global GAP (Moeller, 2015). Information transmission along food value chains, from primary producers to transformers, distributors and, ultimately, consumers can play a decisive role for SFS. It enables consumers and intermediate buyers to recognize sustainable production, acknowledge it, give value to it, through prices and/or market shares, which in turn contributes to orient production towards more sustainable practices.

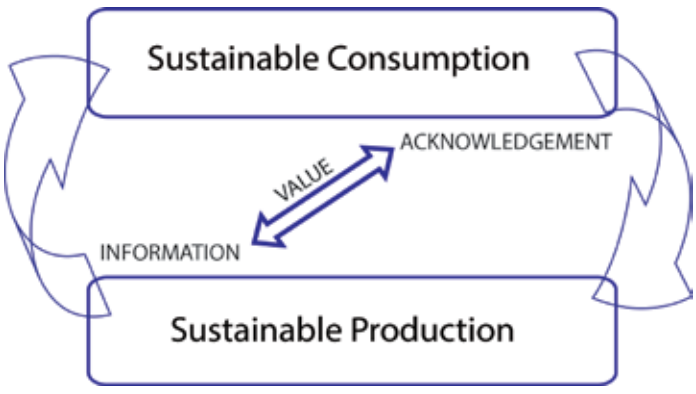

Figure 2. Voluntary standards: information for value
Source: Meybeck and Gitz (2014).

Knowledge that needs to be transmitted to other

categories of actors has often to be transformed to meet their respective needs. For instance, detailed information about agricultural practices is mainly oriented towards farmers. The information transmitted to other food chain actors, e.g. consumers and public authorities, will be that the farm is aiming for environmental performance, as measured by available tools and communicated through voluntary standards or labels. It shows that in some cases readability and efficiency of the information can benefit from using different types of information/indicators, adapted to the needs and capacities of the various actors.

Since its inception, the Task force has pointed to the need for specific tools, data collection and sharing oriented towards small operators along food value chains, including transporters, transformers and retailers. For instance, the studies conducted by FAO on food losses and waste (FLW) along various food value chains confirm the importance of improving practices at all stages to achieve significant results (FAO, 2014b; 2014c) and the HLPE recommends training and capacity building all along food chains to reduce FLW (HLPE, 2014a). This points to the need for knowledge, methodologies and tools adapted to the specificities of each category, including being available in a variety of languages.

KNOWLEDGE AND DATA GAPS

Drawing from the analysis above, from the focus on operational knowledge, on the needs identified and their typology, we propose to distinguish, for each specific sustainability issue, four broad steps in knowledge building for SFS:

1. Awareness and common understanding.
2. Availability of methodologies and tools for assessment, monitoring of impacts and identification of priority areas of action.
3. Availability of data, collected in such a way to enable assessments, comparisons and benchmarking.
4. Identification of good practices and formulation of recommendations adapted to specific situations/contexts.

These steps are broadly successive, each one being grounded, explicitly or implicitly, on the ones before with, however, at each stage, gradual improvements in coverage, detail and accuracy. Gaps can be identified in terms of issues covered, availability of methodologies and tools, availability and accessibility of data, and identification of good practices, for a specific issue and/or a specific group of actors.

From the activities and discussions developed in the SFS Programme it seems, pending a more thorough review, that some sustainability issues in food systems have been given less consideration than others. Globally there has been much more attention to environmental issues with, however, less operational work on some topics, such as biodiversity, than on GHG emissions, for instance. Social issues, including gender (Sisto and Seilern, 2015) are, in spite of their importance, often much less present in sustainability approaches to food systems. This also emphasizes the need for a much more systemic approach, integrating the three dimensions of sustainability. It seems also that more attention has been given, including by research, to the sustainability of primary production rather than of transformation, distribution and consumption, and to the links between consumption and production. There is a need to better understand the interrelationships between

consumption, including nutrition, and food systems as a whole. This has been clearly highlighted by the work developed by the SFS Programme on sustainable diets (Dernini, 2015) as well as by the HLPE in its note on critical and emerging issues for food security and nutrition (HLPE, 2014b).

These remarks also call for a thorough survey of existing information, methodologies and data as well as of ongoing initiatives as a first step of any new activity – a key issue often being to make existing information available and accessible to all stakeholders.

DISCUSSION AND WAY FORWARD

Improving knowledge collection and sharing is central to progress towards more sustainable food systems. A preliminary analysis enables characterizing knowledge needs for SFS and ways to address them. The instruments and mechanisms to be put in place need to be actor-centred, adapted to situations (Loconto, 2015) and enable exchange of information between categories of actors including, as appropriate, methodologies to adapt the information to their various needs.

Preliminary insight on knowledge gaps towards SFS enable distinguishing two broad types of potential areas of activities useful to guide priorities of action towards SFS at a particular level:

- Areas where there is already a lot going on and where there could be "low hanging fruits" that could catalyse and orient action.
- Areas less explored, but important from a systemic perspective, and for which some initial work is needed to stimulate reflexion and action.

These conclusions can be of use to orient and ground the future 10-YFP, both in terms of substance and of modalities of work. They also show the need for a thorough screening of existing information, methodologies and data, building upon partnerships with research and actors' networks and to develop appropriate information-sharing mechanisms.

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The FAO/UNEP joint programme is catalysing partnerships among United Nations agencies, other international agencies, governments, industry and civil society to promote activities that can contribute to sustainable food systems.

Improving knowledge collection and sharing are key areas of work to progress towards more sustainable food systems, taking into consideration the environmental, economic and social dimensions. This work aims to better identify the requirements and perspectives of the various types of actors, in terms of data and means to access them, to identify and assess existing data and gaps, and to identify and assess existing knowledge-sharing tools and mechanisms.

The FAO/UNEP programme organized, in September 2014, a workshop on "Knowledge and Information for Sustainable Food Systems". The various sessions of the workshop considered the needs and perspectives of the various stakeholders and ways to address them. This publication is a compilation of the papers presented at the workshop, and the workshop summary.

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