1st Mediterranean Forum for PhD Students and Young Researchers

Designing Sustainable Agricultural and Food Production Systems
under Global Changes in the Mediterranean
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CIHEAM

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Sustainability and food and nutrition security: An indicator-based vulnerability and resilience approach for the Mediterranean Region

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1. **Introduction:** *context, aims, study design*
2. **Materials and Methods**
   - Framework:
     - Developed and adapted framework
   - Study area
   - Focus groups and Delphi survey
3. **Results:** *indicators, appraisal of the framework*
4. **Conclusion:** *methodological considerations, limitations & perspectives*

Introduction:

context, aims, study design

Food system and the global context

- **2.1 billion people are food insecure: undernourished, malnourished and overnourished** (FAO, 2014)
- **795 million people are chronically undernourished worldwide** (FAO, 2015)
- **Agriculture is responsible for 70% of water withdrawal and is a main driver of deforestation and loss of biodiversity** (FAOSTAT, 2012)

Non-sustainability of the western agrofood system

Impacts on natural resources and eco-systems

Increasing non-communicable diet-related diseases

(Padilla, 2008; Allouche, 2011; Lang and Barling, 2012; Ng et al., 2014)

Aims

- Develop a ***multidimensional framework*** to address the understanding of what constitutes the sustainability of diets and food systems

- ***Identifying the main variables*** to formalize and operationalize the abstract and multidimensional concepts of sustainable food systems.

- Defining metrics for ***assessing the sustainability of food systems*** and diets

Metrics

Metrics are an organized **system of information** combined to provide a perspective

What is counted is what counts…

Metrics target three principal objectives:

- **Inform** civil society, industry, public officials and all stakeholders
- **Measure** progress toward defined goals
- **Aid decision-making** processes

Indicators direct us to knowledge and simplify complex messages to transfer information to decision makers
They establish the communicative link between science and policymakers

(Bell and Morse, 2010; Fanzo, 2012)

Defining metrics

Who are the users?

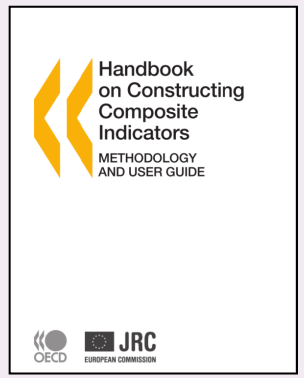
A set of measurements for **policy makers**

"What is badly defined is likely to be badly measured"
(OECD-JRC, 2008)

Developing a theoretical framework

- Defining the concepts
- Structuring its elements
- Identifying selection criteria

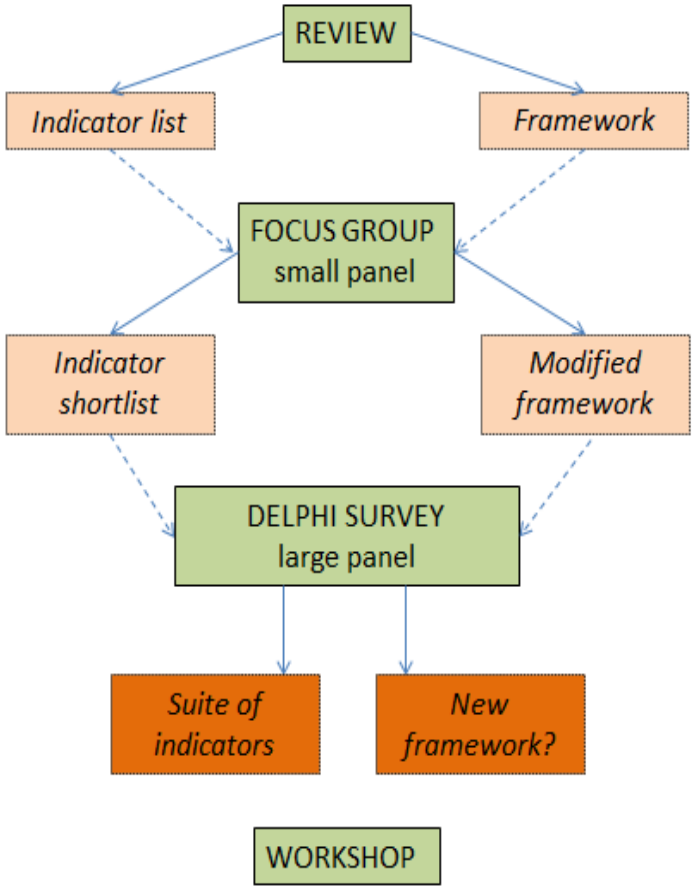
The selection process should ideally be based on what is desirable to measure



(UN, 2007; Bell and Morse, 2011)

Study design

- **Develop a Framework**
- Review and list 1,500 indicators
- Focus group: Set up **a small panel of experts** to discuss framework, shortlist 136 indicators and test an online questionnaire
- Delphi *online* survey: Set up **a large panel of experts** to discuss framework and identify a ***suite of 24 indicators***



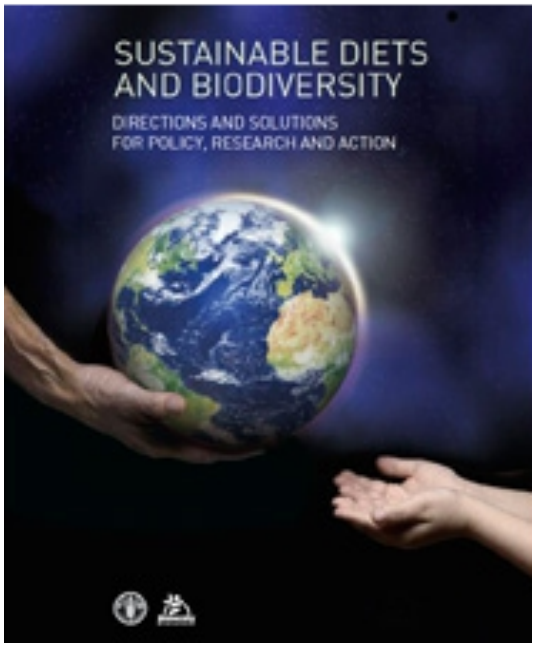
Framework:

developed and adapted framework

A nutrition-driven perspective

- ***Sustainable Development (UN, 1987)***
- ***Sustainable Food Security (UN, 1996)***
- ***Sustainable Development Goals (2000-2015)***

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*** *protect and* ***respect biodiversity and ecosystems*** *while being* ***culturally acceptable***, ***accessible***, ***affordable***, ***nutritionally adequate***, ***safe***, *and* ***healthy***.



Source: FAO and Bioversity International (2012)

Developing sustainable solutions to improved nutrition

A system-orientated approach

- **Diets** – and related outcomes – are the results of complex interactions among interdependent components within **food systems**
- Sustainability is a property of a system

Sustainability as the ability of a system to maintain or enhance its essential outcomes over time

Promoting economically, socially and environmentally sustainable food systems that concurrently ensure food and nutrition security

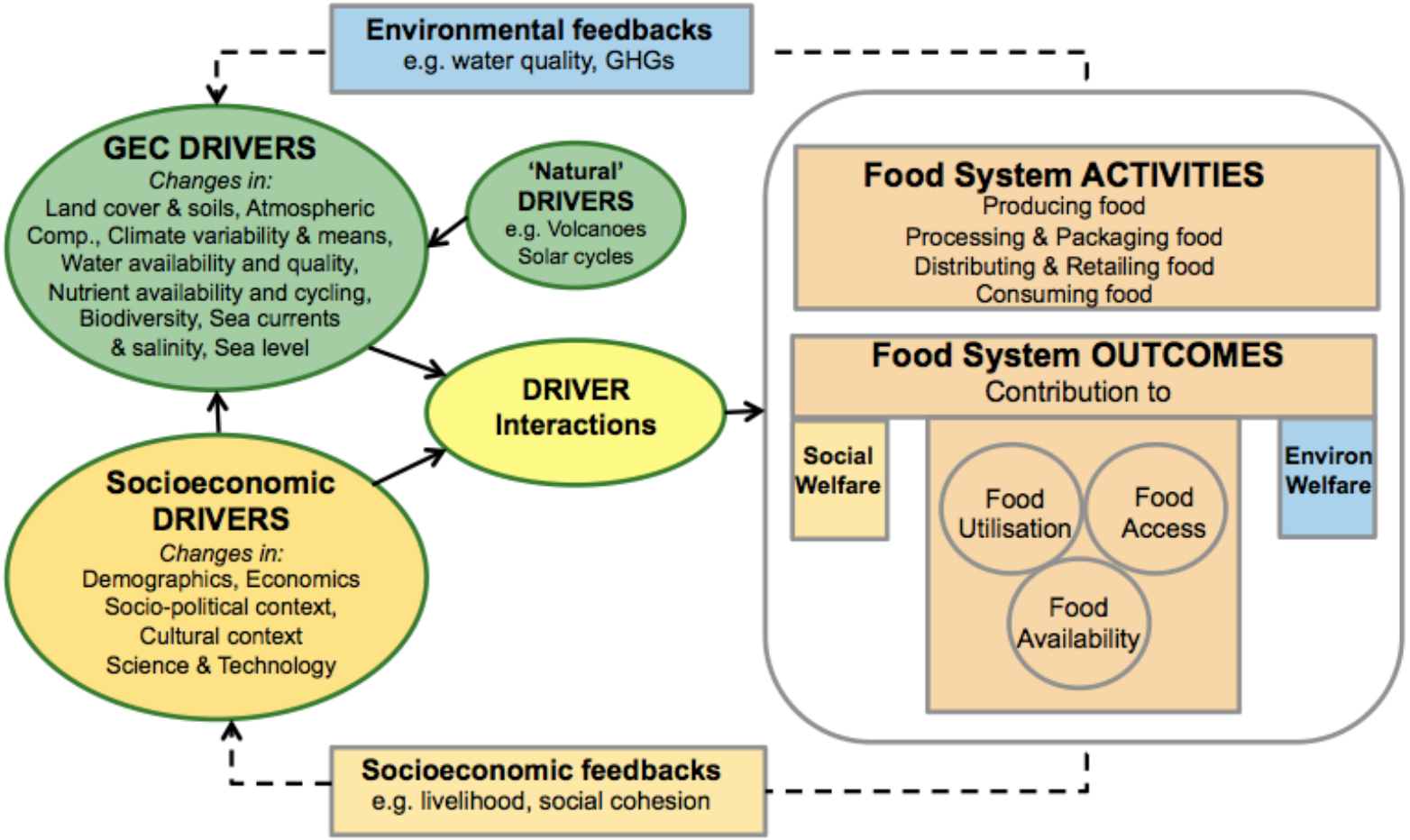
(Hansen, 1996; Ingram, 2011; de Ruiter et al., 2014)

A Social-Ecological System

- Food systems can best be conceptualized as **Coupled Human-Environment Systems** (Ericksen, 2008)
- Preserving essential **human and natural assets and the flows of services they provide** is key
- It requires understanding the ***interconnectedness*** of the food system with the wider environment, climate change, land use, global markets and wider societal issue

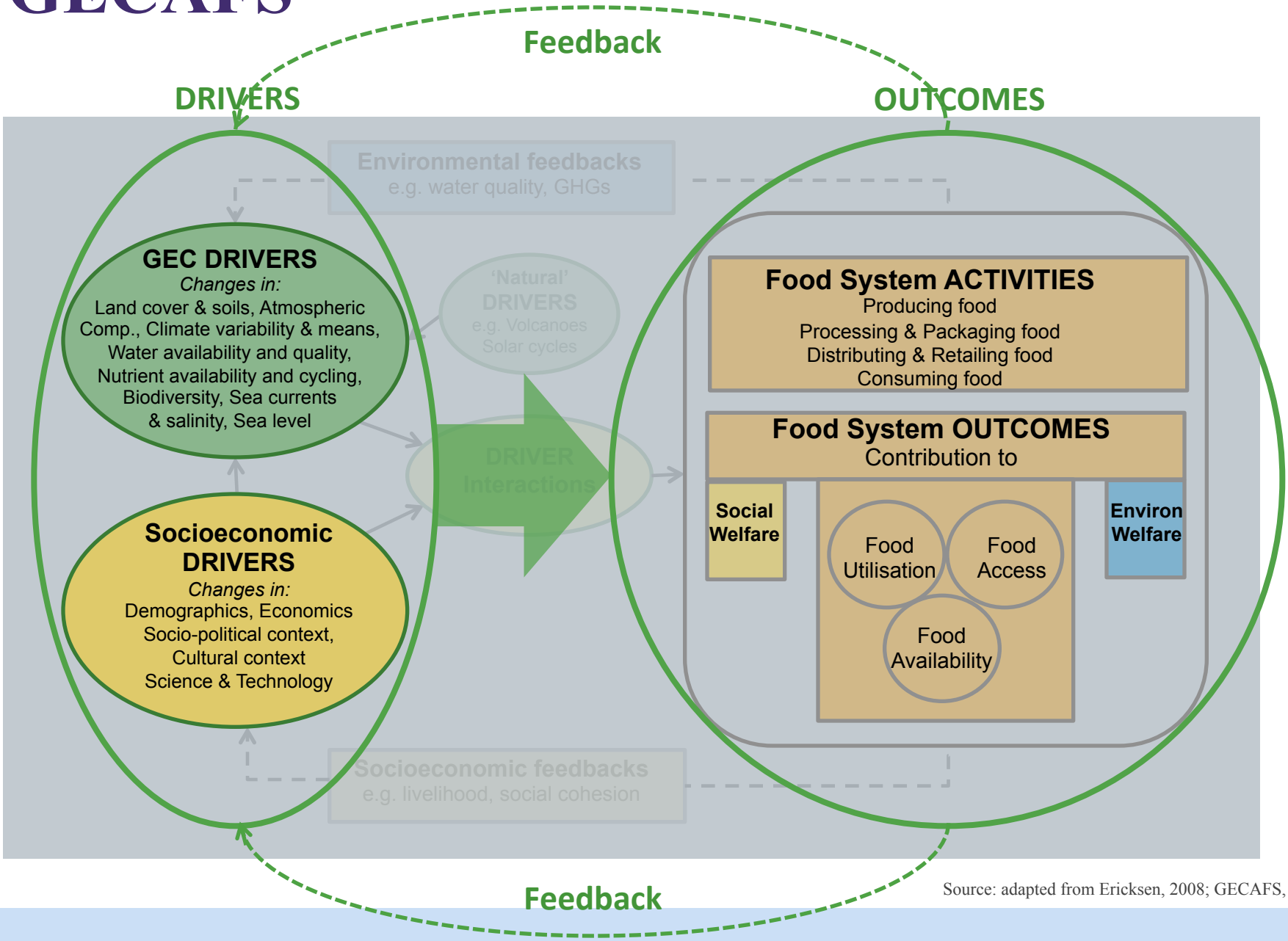
Source: Community conservation

GECAFS food systems framework



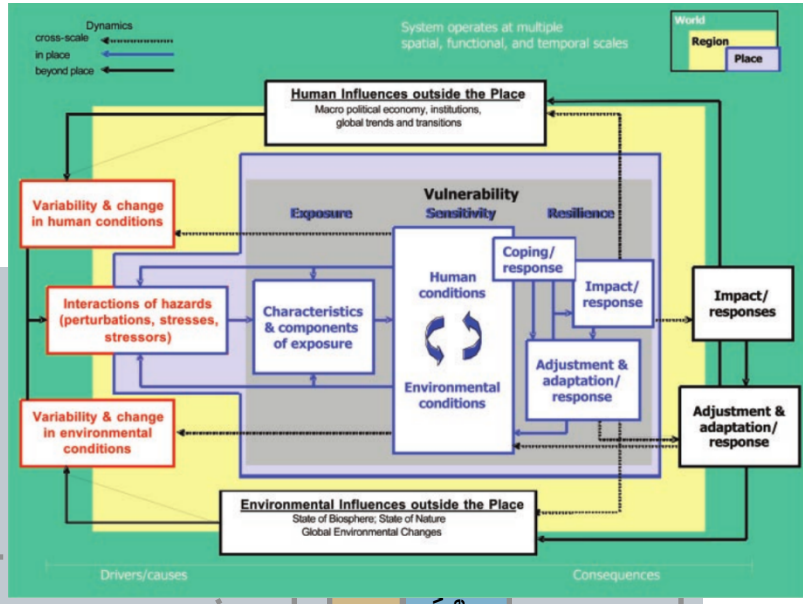
Source: Ericksen, 2008; GECAFS, 2009

GECAFS



Source: adapted from Ericksen, 2008; GECAFS, 2009

Adapted framework



EXTERNAL INPUTS

Global environmental & socioeconomic

DRIVERS OF CHANGE

Climate change,
Water depletion,
Land and soil degradation,
Biodiversity loss,
Air pollution,
Fossil fuel shortage,
Global economic trends,
Global political trends,
Food price volatility,
Income distribution,
Demographics and demo-spatial dynamics,
Nutritional transition,
Advancement in science & technology,
etc.

What are the essential characteristics that allow the food system to *sustain* these changes and achieve these outcomes?

Food System OUTCOMES Contribution to

Food & Nutrition Security

Social Welfare

Source: Turner et al., 2003

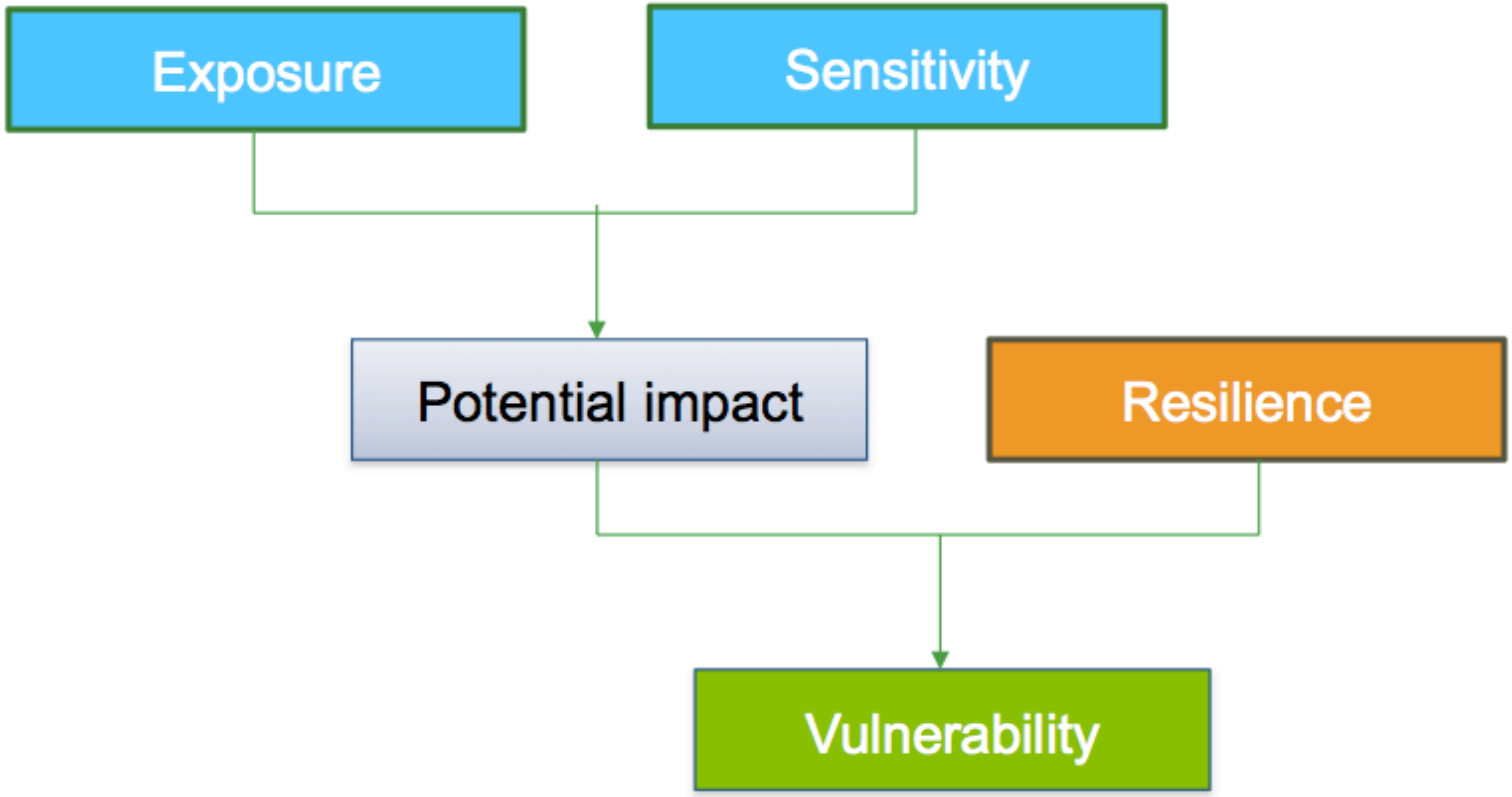
A Vulnerability/Resilience Framework

Vulnerability, as the propensity or predisposition of a system to be adversely affected by a change, is composed of:

- **Exposure**: Presence of essential assets and services that could be adversely affected by a change
- **Sensitivity**: Degree to which a system is potentially affected by a change
- **Resilience**: Ability of a system to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through **ensuring the preservation, restoration, or improvement of its essential basic structures and *functions***

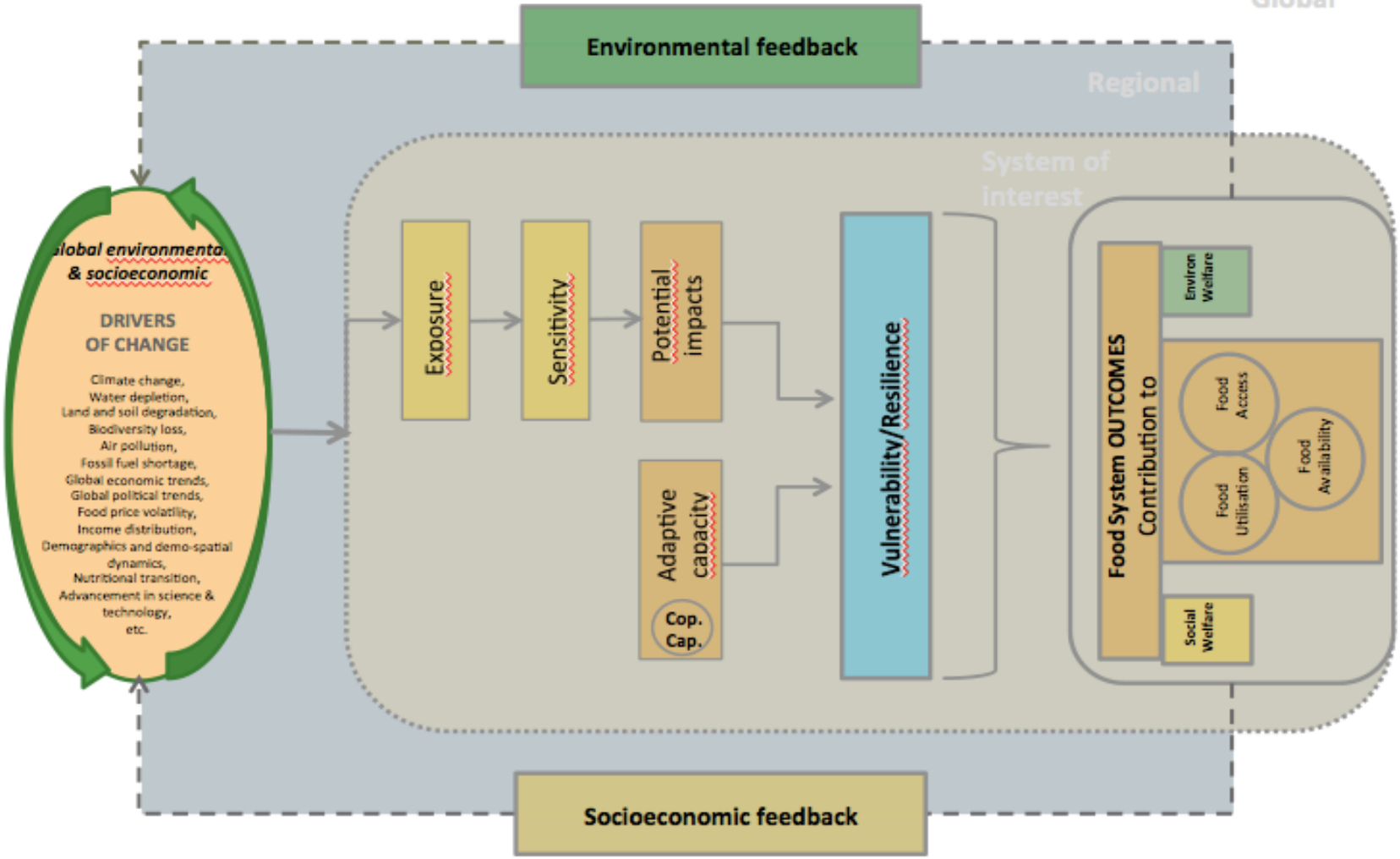
(IPCC, 2012)

A causal pathway



(Source: Adapted from Turner et al. 2003)

Adapted framework



Source: adapted from Turner et al., 2003; Ericksen, 2008; GECAFS, 2009

What is vulnerable to what ?

What are these driving forces ?

Global environmental and socioeconomic changes are occurring concurrently

What outcome do they influence ?

Food systems' principal reason for being: Food and nutrition security (Haddad, 2013)

The human–environment interface is a coupled "system" in which socio-economic and biophysical driving forces interact to influence food system activities and outcomes, both of which subsequently influence the driving forces (Foran et al., 2014)

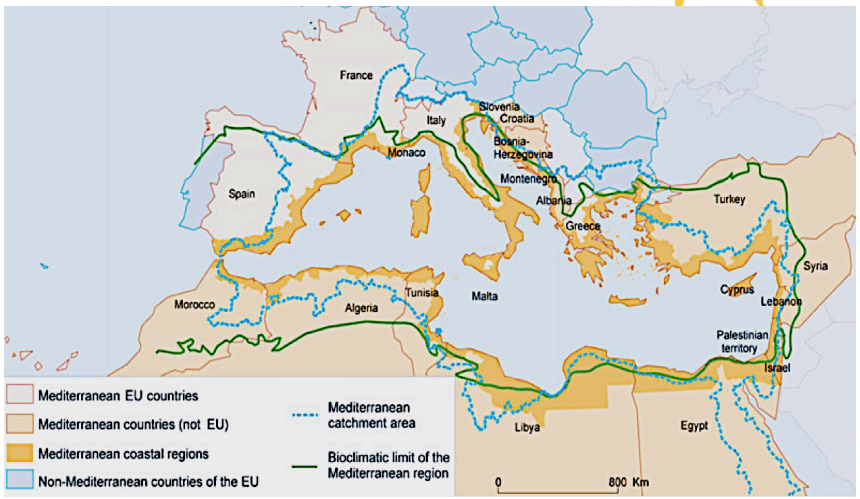
Study area

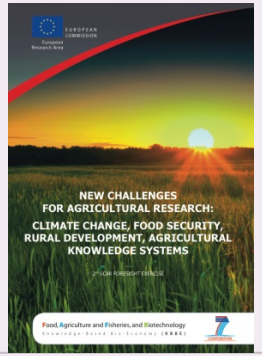
Context–specific questions

Focus on the **Mediterranean region**

Context-specific **literature review** to identify:

- Common national and subnational **Food & nutrition security issues**
- Relevant global & regional **drivers of change**



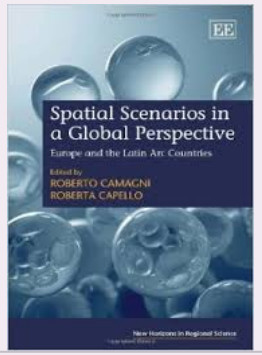


(Brunori et al., 2008; PARME, 2011; Freibauer et al., 2011; CIHEAM, 2012)

Identifying study area

Focus on France, Spain and Italy: the **Latin Arc**.

- Common national and subnational **Food & nutrition security issues**
- Common **biophysical and socioeconomic** common features



Project funded by the EUROPEAN UNION

ENPI CBCMED
CROSS-BORDER COOPERATION IN THE MEDITERRANEAN

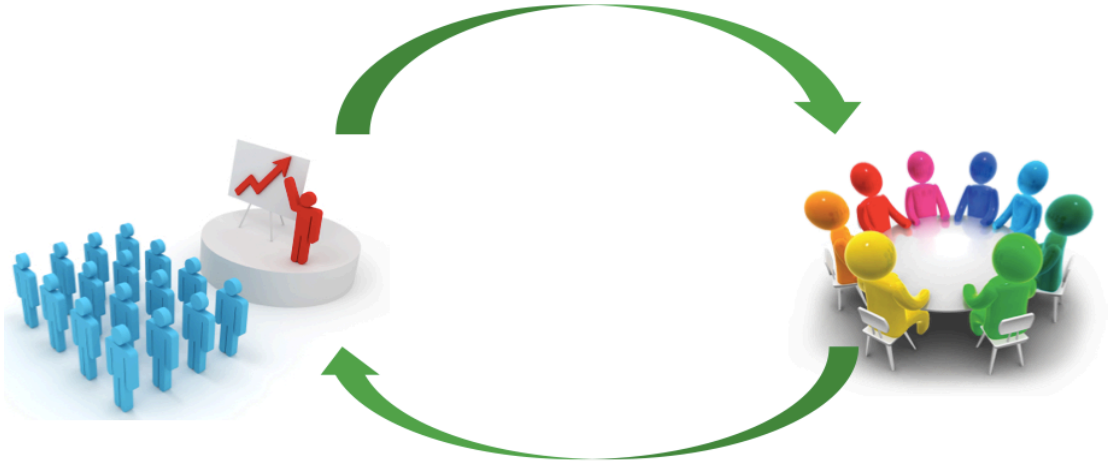
(Camagni and Capello, 2011; ENPI-EU, 2007-2013)

Focus groups and Delphi survey

Refining drivers and issues

Preliminary ***focus groups*** to:

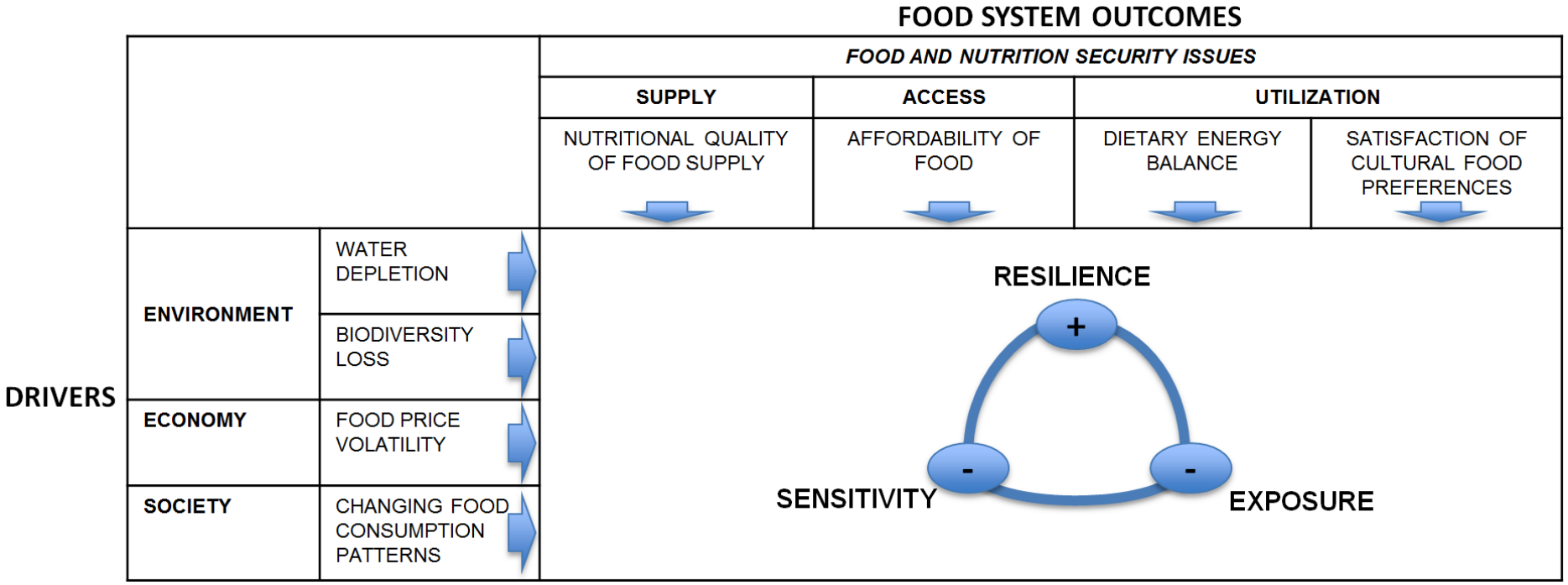
- **Discuss key elements** of the research framework
- **Test questionnaire** and fine-tune protocol
- **Refine list of indicators**
- **Anticipate** understanding and gauge interest from the Delphi panel



Focus group 1: From drivers to outcomes

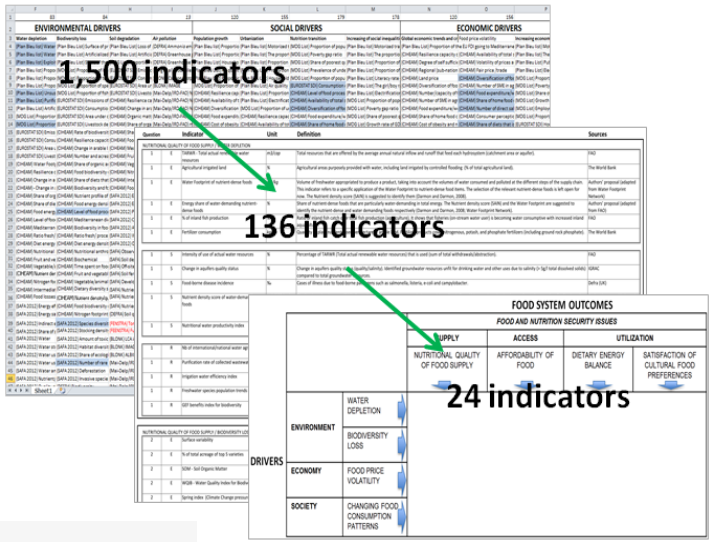
A major question: "Vulnerability/Resilience of what to what?"

- Identification of 4 main *context-specific* food & nutrition security issues
- Identification of 4 main *global and regional* drivers of change



Focus group 2: Shortlisting indicators

- Setting up a long list of indicators derived from the literature
- **Shortlisting 136 indicators discussed during a focus group**
- Gaining ***consensus*** through an exchange of opinions



➡ ***Using a Delphi expert consultation protocol***

- **Testing an *online* Delphi questionnaire**

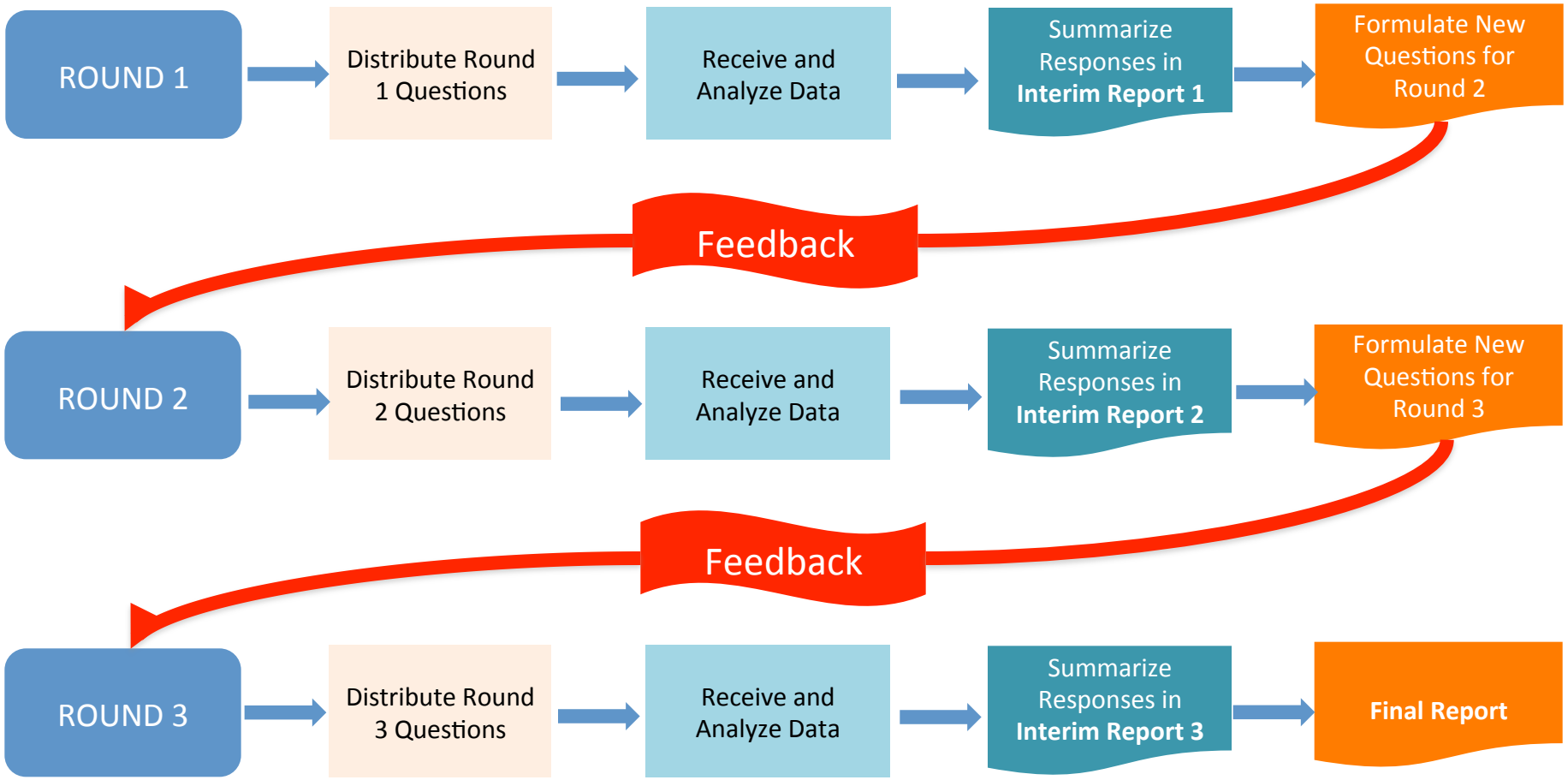
The Delphi technique

An iterative survey of experts:

- A Delphi technique is a structured group interaction process that is directed in **"rounds"** of opinion collection and feedback
- **Opinion collection** is achieved by conducting a series of surveys using questionnaires
- The result of each survey are presented to the group – **feedback** – and the questionnaire used in the next round is built upon the result of the previous round

(Landeta, 2006)

The Delphi process



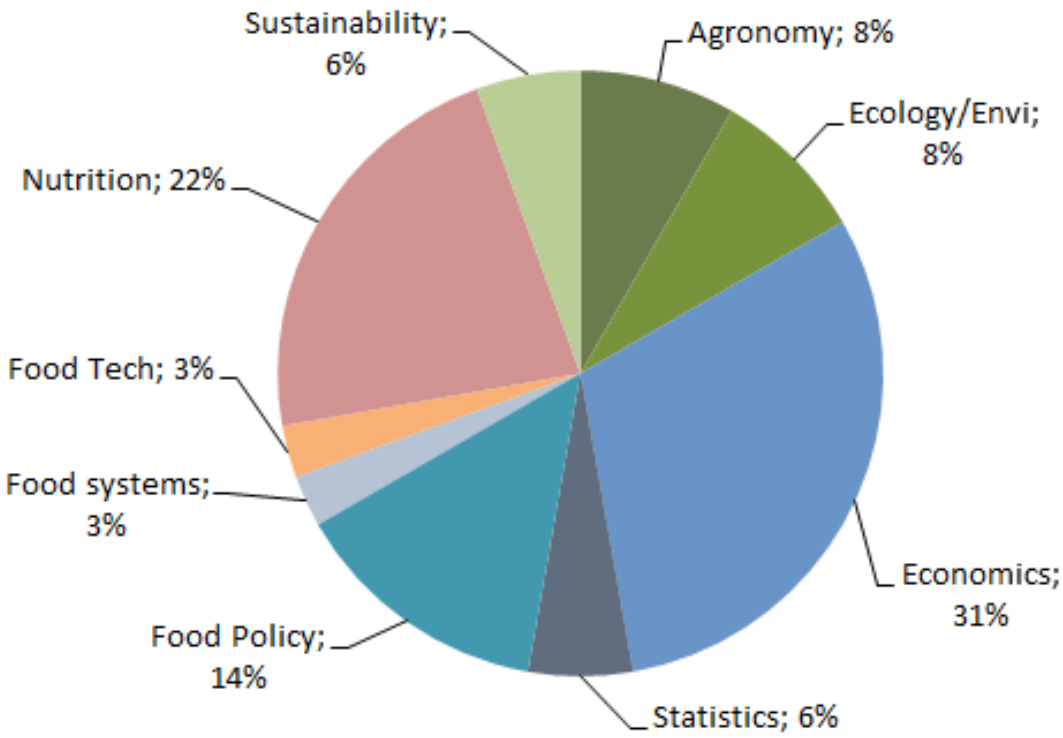
Participation

Invited: 213 experts

Participation: 51 part. [round 1]; 39 part. [round 2]; 36 part. [round 3]

A balanced panel:

- Academic disciplines



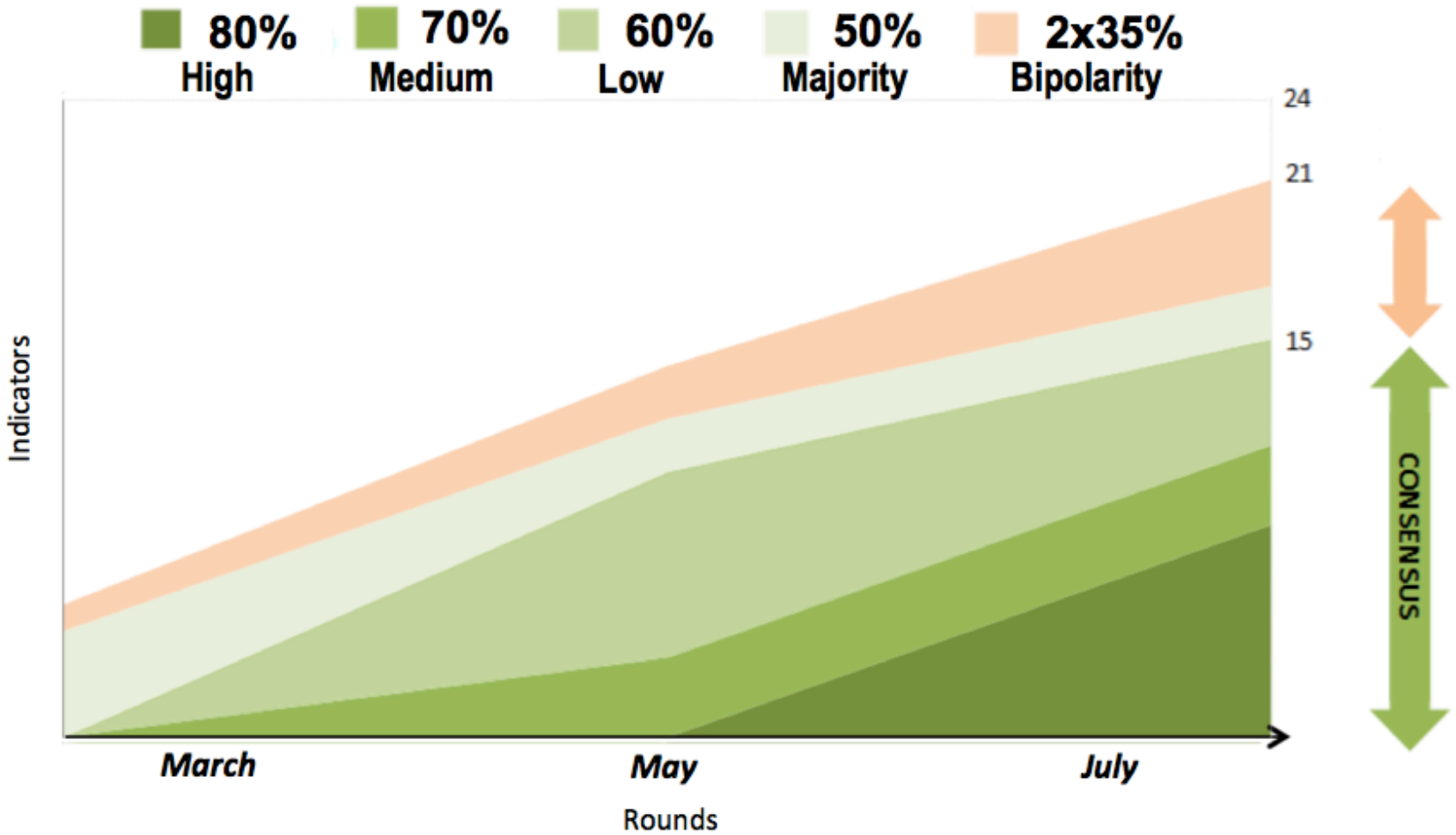
Results:

indicators, appraisal of the framework

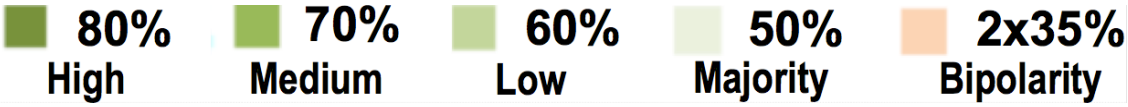
Evolution of the consensus

Increase in agreement

15 indicators [out 24] with **60% or more consensus**



Indicators: Round 1



		NUTRITIONAL QUALITY OF FOOD SUPPLY	AFFORDABILITY OF FOOD
FOOD PRICE VOLATILITY	EXPOSURE	*- % of nutrient intakes from 10 most volatile foods*	- % of food household expenditure - Food Purchasing Power Index
	SENSITIVITY	*- Price elasticity of 10 most nutrient-dense foods*	- Sensitivity to price volatility
	RESILIENCE	- Household Dietary Diversity Score	- Presence of food safety net programs - % of diets produced locally

		NUTRITIONAL QUALITY OF FOOD SUPPLY	DIETARY ENERGY BALANCE
CHANGES IN FOOD CONSUMPTION PATTERNS	EXPOSURE	*- Food Purchasing Power Index*	- At-risk-of-poverty rate - Caloric share of ready-to-consume products
	SENSITIVITY	*- Household Dietary Diversity Score*	*- Prevalence of overweight & obesity*
	RESILIENCE		

		NUTRITIONAL QUALITY OF FOOD SUPPLY	AFFORDABILITY OF FOOD
WATER DEPLETION	EXPOSURE	*- Water Footprint of nutrient-dense foods*	*- Water Footprint for an average diet*
	SENSITIVITY	*- Intensity of use of actual water resources*	
	RESILIENCE	- Irrigation Water Efficiency Index	

		NUTRITIONAL QUALITY OF FOOD SUPPLY	SATISFACTION OF CULTURAL FOOD PREFERENCES
BIODIVERSITY LOSS	EXPOSURE	*- % of total acreage of top 5 varieties*	
	SENSITIVITY	*- Nutritional Functional Diversity*	*- % of diets locally produced*
	RESILIENCE	- Crop Agrobiodiversity Factor	

Indicators: Round 2

80%	70%	60%	50%	2x35%
High	Medium	Low	Majority	Bipolarity

		NUTRITIONAL QUALITY OF FOOD SUPPLY	AFFORDABILITY OF FOOD
FOOD PRICE VOLATILITY	EXPOSURE	- % of nutrient intakes from 10 most volatile foods	- % of food household expenditure
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	RESILIENCE	- Household Dietary Diversity Score	- Presence of food safety net programs - % of diets produced locally

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	SENSITIVITY	- Household Dietary Diversity Score	*- Prevalence of overweight & obesity*
	RESILIENCE		*- Existence of policy plan for overweight/obesity*

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WATER DEPLETION	EXPOSURE	- Water Footprint of nutrient-dense foods	- Water Footprint for an average diet
	SENSITIVITY	*- Intensity of use of actual water resources*	- Price elasticity of D - 10 most water-demanding foods
	RESILIENCE	- Irrigation Water Efficiency Index	- Cross-price elast. of D - high/low of water-demanding foods - % of farmers growing drought-resistant crops

		NUTRITIONAL QUALITY OF FOOD SUPPLY	SATISFACTION OF CULTURAL FOOD PREFERENCES
BIODIVERSITY LOSS	EXPOSURE	*- % of total acreage of top 5 varieties*	*- Import Dependency Ratio*
	SENSITIVITY	- Nutritional Functional Diversity	- % of diets locally produced
	RESILIENCE	- Crop Agrobiodiversity Factor	*- Integration of biodiversity considerations in business*

Indicators: Round 3

80%	70%	60%	50%	2x35%
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Summary results

Consensus is reached for 15 of the 24 desired indicators

- High threshold consensus criteria [80%]: 8 indicators
- Medium threshold consensus criteria [70%]: 3 indicators
- Low threshold consensus criteria [60%]: 4 indicators

Majority [50%]: 3 indicators

Bipolarity [2 x 35%]: 5 indicators

Low degree of agreement [+ High "Don't know" rate] : 3 indicators

Stability of the consensus: Favorite indicators in the second round confirmed by 93% of the experts in the third round

Indicators: Round 3

Consensus on indicators confirmed the ***validity of some interactions***
Other interactions still seem more ***problematic***

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Indicators: Round 3

Commonly validated indicators

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Indicators: Round 3

More unusual indicators. Cross-cutting indicators, combining two dimensions.

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Indicators: Round 3

Indicators frequently mentioned but not actually defined or applied.

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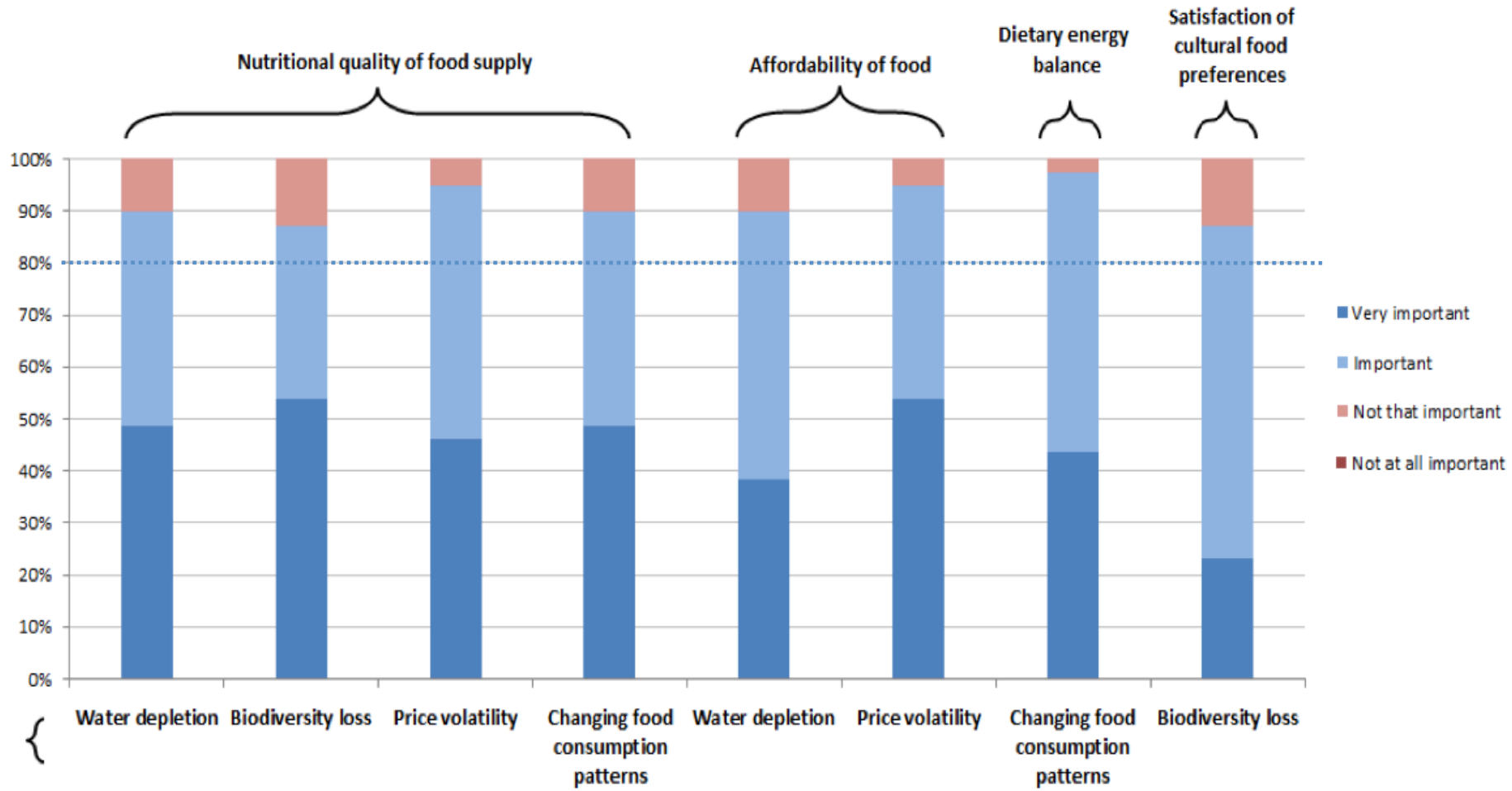
	RESILIENCE		- Funding allocated to nutrition education - Existence of policy plan for overweight/obesity

		NUTRITIONAL QUALITY OF FOOD SUPPLY	AFFORDABILITY OF FOOD
WATER DEPLETION	EXPOSURE	- Water Footprint of nutrient-dense foods	- Water Footprint for an average diet
	SENSITIVITY	- Intensity of use of actual water resources	- Price elasticity of D - 10 most water-demanding foods
	RESILIENCE	- Irrigation Water Efficiency Index	- Cross-price elast. of D - high/low of water-demanding foods - % of farmers growing drought-resistant crops

		NUTRITIONAL QUALITY OF FOOD SUPPLY	SATISFACTION OF CULTURAL FOOD PREFERENCES
BIODIVERSITY LOSS	EXPOSURE	- % of total acreage of top 5 varieties	- *Import Dependency Ratio*
	SENSITIVITY	- Nutritional Functional Diversity	- % of diets locally produced
	RESILIENCE	- Crop Agrobiodiversity Factor	- Integration of biodiversity considerations in business

Appraisal of the interactions

Proposed interactions judged "important" or "very important" by more than 80% of the participants



Inputs from participants (1)

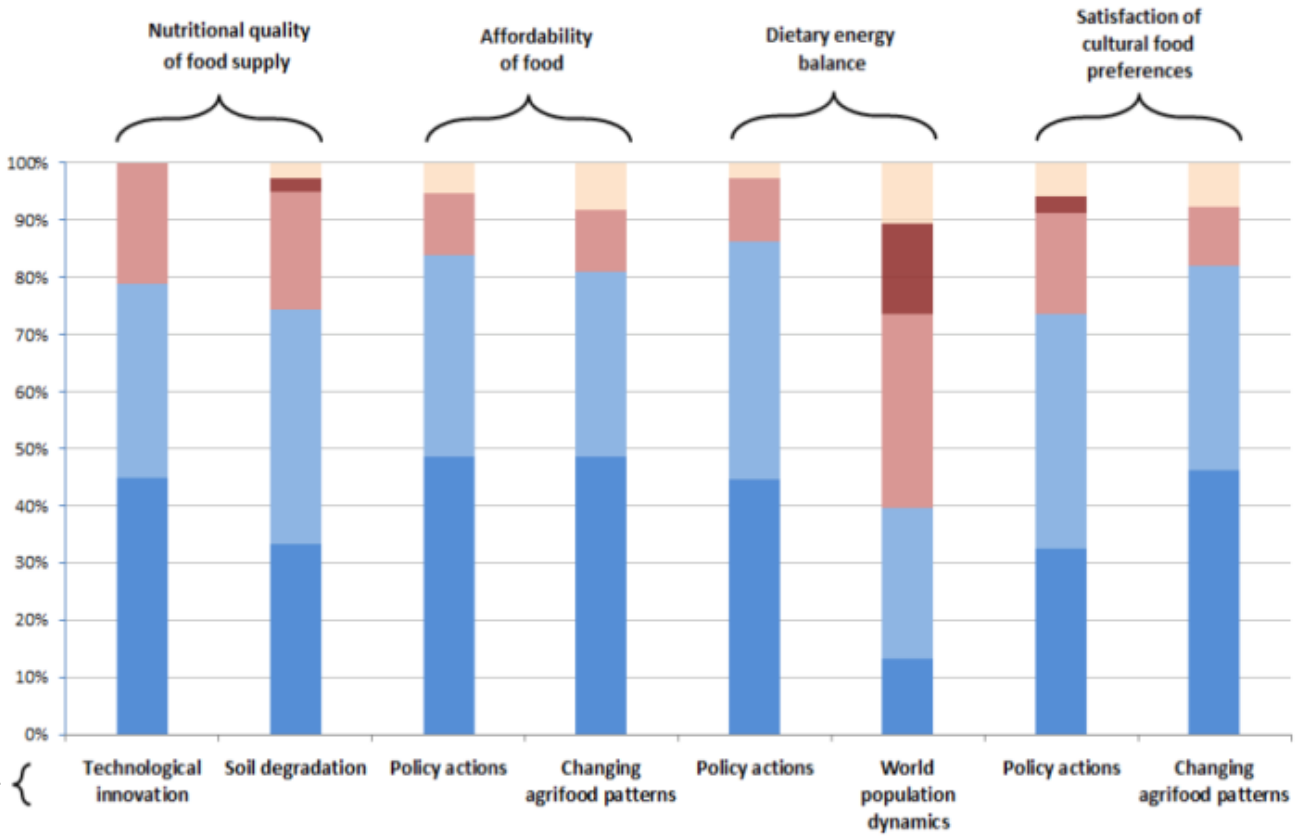
Round 1: Participants proposed 12 extra drivers

Round 2: 3 extra drivers were ranked "important" or "very important" by 80% or more of the participants

Extra drivers:

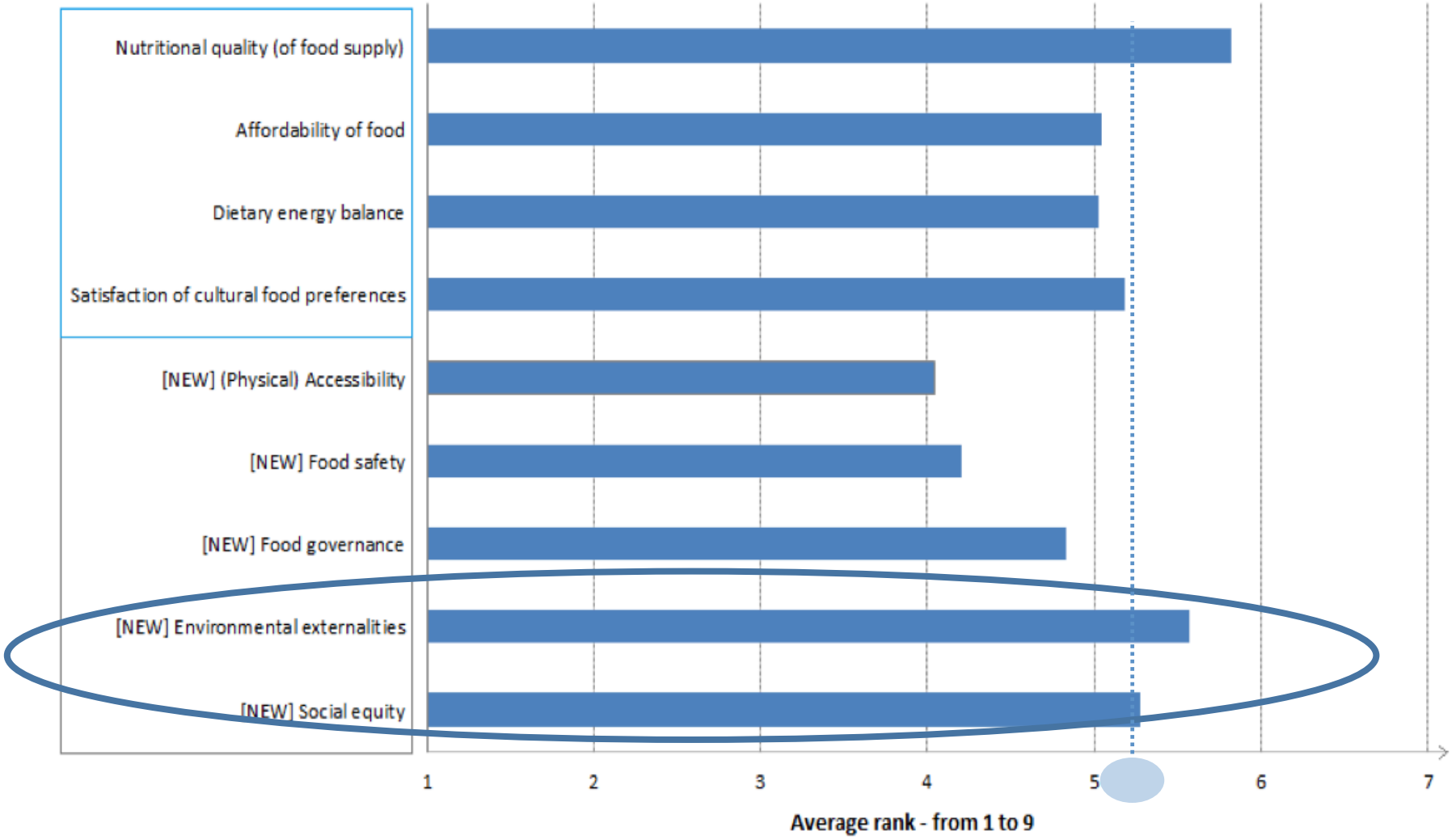
- Changing agrifood patterns
- Policy actions
- Technological innovation

(SCAR, 2008)



Inputs from participants (2)

Two new proposed food & nutrition security issues



Conclusions:

methodological considerations,

limitations & perspectives

Methodological considerations

- **Participation** within validated standards of the Delphi technique (Hasson et al., 2000)
- **Panel** is mainly turned towards **economists** and **nutritionists**
- **Focus group** were key to avoid participant attrition (Jairath and Weinstein, 1993)
- Use of **Internet** and **English** language allowed geographically dispersed participation (Frewer et al., 2011)
- **Standardized method** that clarifies how experts arrive to judgment (Dalkey and Helmer, 1963)
- Recommended method to **provide decision makers with information** under uncertainty in SESs (De Lange et al., 2010)

Limitations

- Social-ecological system approaches interest mainly the scientific community rather than practitioners (Foran et al., 2014)
- Risk of linearity in the causal mechanism of vulnerability
- Several indicators proposed are not measured
- The study is oriented towards **food and nutrition security** as first outcome of the food systems

Food systems are responsible for various environmental, economic and social outcomes

Perspectives

- Further research could be oriented towards:
  - Establishing **relative weights** between indicators
  - Retrieval of **missing data** for quantitative applications
  - **Test** metrics through standard criteria
- The **open structure** allows further applications with **different drivers and issues**
- **Practitioners** tend to consider metrics to measure sustainability (Dicks et al., 2013)

Mapping social-ecological vulnerability and resilience can help identifying the driving causes of sustainability problems of the food systems (Abson et al., 2012)

Outcomes in the scientific literature

Prosperi et al. 2013 (SIDEA, *Sustainability of the Agrifood Systems: Strategies and Performances*)

New Methodological Frontiers for Sustainability Assessment: a Multidimensional Vulnerability Framework for the Agrofood System

Paolo Prosperi[1], Thomas Allen[2], Martine Padilla[3], Iuri Peri[4]

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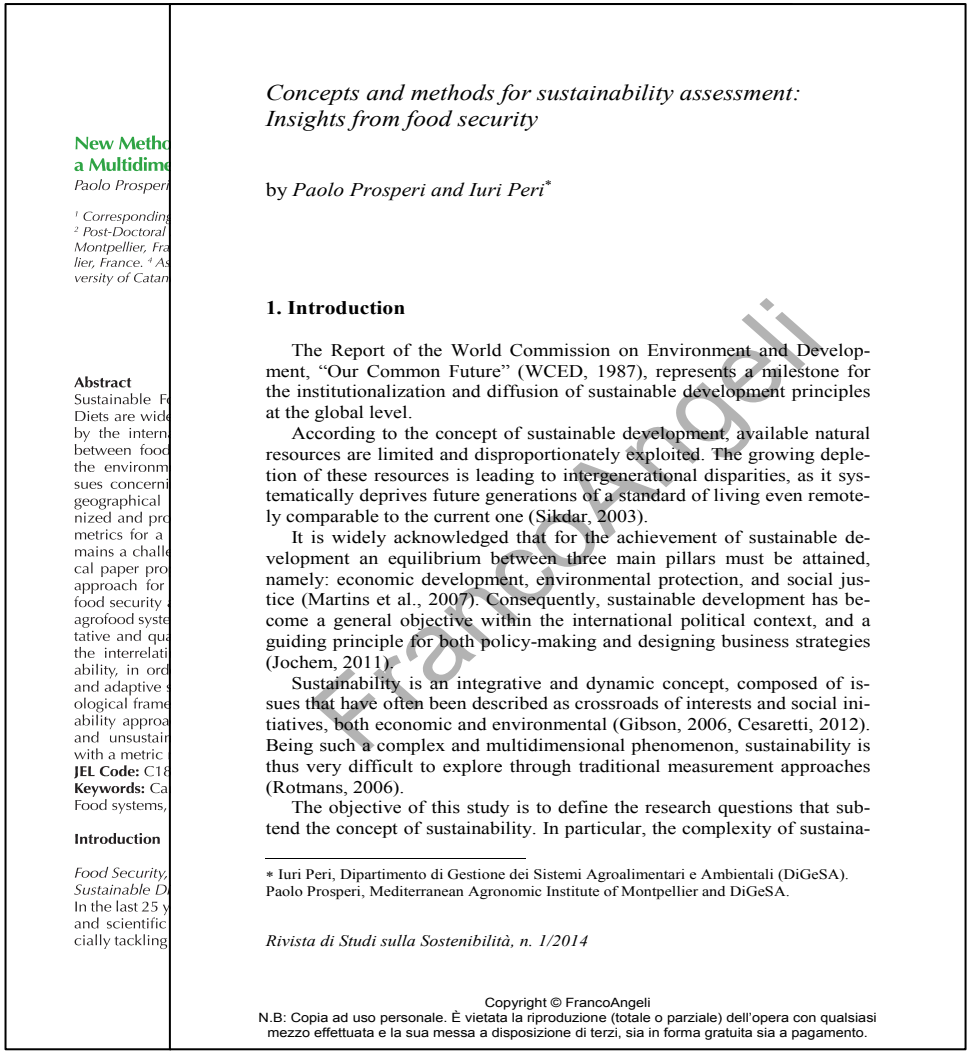
Abstract
Sustainable Food Security and Sustainable Diets are widely acknowledged and studied by the international community. The links between food regimes of populations and the environmental and socioeconomic issues concerning individuals, countries and geographical areas, are nowadays recognized and proved. Nevertheless, identifying metrics for a multidimensional analysis remains a challenging task. This methodological paper proposes a revisited vulnerability approach for an innovative application to food security and sustainability issues in the agrofood system. The aim is to identify qualitative and quantitative methods to consider the interrelating factors leading to vulnerability, in order to inform decision-making and adaptive strategies. An original methodological framework of the integrated vulnerability approach to analyze food insecurity and unsustainability is presented together with a metric methodology.
JEL Code: C18; Q01; Q18.
Keywords: Causal-factors, Decision-making, Food systems, Metrics, Resilience.

Introduction

Food Security, Sustainable Development and Sustainable Diets
In the last 25 years, the international political and scientific communities have been officially tackling the sustainability issues, as the Brundtland Report was agreed in 1987 (United Nations). The Sustainable Development definition "Sustainable Development meets the needs of the present without compromising the ability of future generations to meet their own needs" underlines the necessity to implement a human economic, social, environmental and institutional progress respecting the durability over the time. The worldwide debate about sustainable development passes naturally through the global food security concerns, as it was stated in the 1996's World Food Summit (WFS) declaration that "Food Security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). The 1996's Food Security definition shows the determinants assuring - or threatening if they are lacking - food security for people, identifying four main dimensions: food availability, access to food, food utilization, and the stability over the time of the three previous dimensions.
The result of the normative junction of the pillars that emerge from these two definitions (Figure 1), has led to the identification of several interconnected dimensions that specify the numerous fields comprising sustainable food and nutritional security and sustainable diets. The participants of the International Scientific Symposium on *Biodiversity and Sustainable Diets* agreed in defining sustain-

Outcomes in the scientific literature

Prosperi & Peri 2014 (*Review of Sustainability Studies*)



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Paolo Prosperi

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Concepts and methods for sustainability assessment: Insights from food security

by *Paolo Prosperi and Iuri Peri*[*]

1. Introduction

The Report of the World Commission on Environment and Development, "Our Common Future" (WCED, 1987), represents a milestone for the institutionalization and diffusion of sustainable development principles at the global level.

According to the concept of sustainable development, available natural resources are limited and disproportionately exploited. The growing depletion of these resources is leading to intergenerational disparities, as it systematically deprives future generations of a standard of living even remotely comparable to the current one (Sikdar, 2003).

It is widely acknowledged that for the achievement of sustainable development an equilibrium between three main pillars must be attained, namely: economic development, environmental protection, and social justice (Martins et al., 2007). Consequently, sustainable development has become a general objective within the international political context, and a guiding principle for both policy-making and designing business strategies (Jochem, 2011).

Sustainability is an integrative and dynamic concept, composed of issues that have often been described as crossroads of interests and social initiatives, both economic and environmental (Gibson, 2006, Cesaretti, 2012). Being such a complex and multidimensional phenomenon, sustainability is thus very difficult to explore through traditional measurement approaches (Rotmans, 2006).

The objective of this study is to define the research questions that subtend the concept of sustainability. In particular, the complexity of sustaina-

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Rivista di Studi sulla Sostenibilità, n. 1/2014

Outcomes in the scientific literature

Prosperi et al. 2014 (*SAGE Open*)

Article

Sustainability and Food & Nutrition Security: A Vulnerability Assessment Framework for the Mediterranean Region

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April-June 2014: 1–15
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Paolo Prosperi[1,2,3], Thomas Allen[4], Martine Padilla[1], Iuri Peri[2], and Bruce Cogill[5]

Abstract

Recurrent food crises and climate change, along with habitat loss and micronutrient deficiencies, are global issues of critical importance that have pushed food security and environmental sustainability to the top of the political agenda. Analyses of the dynamic linkages between food consumption patterns and environmental concerns have recently received considerable attention from the international and scientific community. Using the lens of a broad sustainability approach, this conceptual article aims at developing a multidimensional framework to evaluate the sustainability of food systems and diets, applicable to countries of the Mediterranean region. Derived from natural disaster and sustainability sciences, a vulnerability approach, enhanced by inputs from the resilience literature, has been adapted to analyze the main issues related to food and nutrition security. Through causal factor analysis, the resulting conceptual framework improves the design of information systems or metrics assessing the interrelated environmental, economic, social, and health dynamics of food systems.

Keywords

food systems, sustainable diets, environment, resilience, metrics

Over the past 25 years, the international and scientific community has repeatedly attempted to deal with the issue of sustainability. "Our Common Future" (United Nations [UN], 1987), commonly known as the "Brundtland Report," argues that sustainable development should meet "the needs of the present without compromising the ability of future generations to meet their own needs." It stresses the necessity to implement economic, social, environmental, and institutional progress that can be maintained over time. Worldwide concerns about sustainable development are also reflected in the global food security debate, which states that "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization [FAO], 1996). The 1996 World Food Summit (WFS) identifies four main determinants of food security: food availability, accessibility to food, food utilization, and the stability over time of the three previous dimensions; depletion in any one of these leads to food insecurity.

The first crucial change from the supply-based food security concept of 1974 (UN, 1975) came with the access-related definition of food security (FAO, 1983; World Bank, 1986) using Sen's entitlements approach (Sen, 1981). Then, the nutrition approach guided the notion of utilization (Staatz, D'Agostino, & Sundberg, 1990), highlighting the need for quality, including good and culturally accepted feeding practices, food safety, and nutritional value. During the same period, Maxwell and Smith (1992) sustain the theory that household access to sufficient and nutritious food at all times is key to food security. Building on the 1986 World Bank report "Poverty and Hunger," the stability dimension, related to the temporal dynamics of food insecurity, was explicitly acknowledged.

Associating sustainable agriculture and food security, Speth (1993) suggests orientating development strategies toward the combined socioeconomic–environment goal of sustainable food security.

Sustainable food security is actually the concept underpinning the 1996 definition of the WFS where environmental and social issues were further stressed, especially for climatic risks, water availability, biodiversity losses, and cultural food preferences. The term *sustainable food security*

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Outcomes in the scientific literature

Allen et al. 2014 (*Proceedings of the Nutrition Society*)

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Joint Meeting between the Belgian Nutrition Society, The Nutrition Society and Société Française de Nutrition was held at the Faculté de Médecine, Lille on 28–29 May 2013

Conference on 'Sustainable diet and food security'
Symposium 2: Food production system

Agricultural biodiversity, social–ecological systems and sustainable diets

Thomas Allen[1]*, Paolo Prosperi[2,3,4], Bruce Cogill[5] and Guillermo Flichman[2]
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The stark observation of the co-existence of undernourishment, nutrient deficiencies and overweight and obesity, the triple burden of malnutrition, is inviting us to reconsider health and nutrition as the primary goal and final endpoint of food systems. Agriculture and the food industry have made remarkable advances in the past decades. However, their development has not entirely fulfilled health and nutritional needs, and moreover, they have generated substantial collateral losses in agricultural biodiversity. Simultaneously, several regions are experiencing unprecedented weather events caused by climate change and habitat depletion, in turn putting at risk global food and nutrition security. This coincidence of food crises with increasing environmental degradation suggests an urgent need for novel analyses and new paradigms. The sustainable diets concept proposes a research and policy agenda that strives towards a sustainable use of human and natural resources for food and nutrition security, highlighting the preeminent role of consumers in defining sustainable options and the importance of biodiversity in nutrition. Food systems act as complex social–ecological systems, involving multiple interactions between human and natural components. Nutritional patterns and environment structure are interconnected in a mutual dynamic of changes. The systemic nature of these interactions calls for multidimensional approaches and integrated assessment and simulation tools to guide change. This paper proposes a review and conceptual modelling framework that articulate the synergies and tradeoffs between dietary diversity, widely recognised as key for healthy diets, and agricultural biodiversity and associated ecosystem functions, crucial resilience factors to climate and global changes.

Food security: Sustainable development: Nutrition-sensitive agriculture: Dietary diversity: Food policy: Integrated assessment: Bio-economic modelling

Humanity faces a global nutrition crisis, with the dual problem of hunger and obesity. A total of 842 million people still suffer from undernourishment[(1)] while obesity has become a significant public health issue with 500 million obese adults[(2)]. More than 1 billion adults are projected to be obese by 2030 if no major effort is made[(3)]. Meanwhile, climate change and environmental degradation are massive threats to human development. Indisputable and unprecedented changes in extreme weather and climate events have been observed and will increasingly have detrimental impacts on livelihoods, particularly in combination with other environmental threats[(4)]. Above all, global biodiversity is constantly declining, with substantial ongoing losses of populations, species and habitats. Vertebrate populations have declined by 30 % on average since 1970, and up to two-thirds of species in some taxa are now threatened with extinction[(5)]. These global changes have major implications for food and nutrition security.

Abbreviation: GHGE, greenhouse gas emissions.
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Outcomes in the scientific literature

Prosperi et al. 2016 (*Environment, Systems and Decision - Springer*)

Environ Syst Decis
DOI 10.1007/s10669-016-9584-7

REVIEW

Towards metrics of sustainable food systems: a review of the resilience and vulnerability literature

Paolo Prosperi[1] · Thomas Allen[1] · Bruce Cogill[2] · Martine Padilla[3] · Iuri Peri[4]

Abstract Food and nutrition security is a persisting global issue and, in addition, food systems are now facing a new set of intersecting economic, social and environmental challenges. Recurrent socio-economic and biophysical changes put the sustainability of food systems at risk. There is an urgent need to develop knowledge-based tools to assess and monitor food sustainability and to identify pathways for food security and resource conservation. The systemic nature of these interactions calls for multidimensional approaches and integrated assessments for decision-making to guide change. This paper reviews social–ecological system frameworks with the view to conceptualize the sustainability issues that affect the food systems. It is argued that the understanding of the food systems as social–ecological systems, and inputs from the theories of vulnerability and resilience in particular, can provide the concepts necessary to understand and model the complex system dynamics involved in the multiple interactions between human and natural components.

Keywords Food and nutrition security · Sustainable development · Resilience · Social–ecological systems · Systems of information

1 Introduction

Food insecurity[1] is a persistent global issue, and the food system is now facing a new set of intersecting social, environmental and economic challenges. Food security depends on ecosystems and associated services, and during the last 50 years, the physical and functional availability of ecosystem services has fallen faster than ever before (IAASTD 2009). Global environmental change, apparent in climate change, ocean acidification and biodiversity loss, has a growing impact on stocks and flows of ecosystem services at a global level (Ingram et al. 2010). Besides environmental change, numerous socio-economic factors bear critical responsibilities in food systems and drive food security outcomes.

Food systems rely on physical resources such as land, water, biodiversity and fossil fuels, which are becoming ever more fragile and scarce. Meeting the food demand remains challenging due to disturbances brought by global

P. Prosperi and T. Allen are first co-authors.

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[1] The current definition of food security, used by FAO, IFAD and WFP, considers food security as "A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: food availability, economic and physical access to food, food utilization and stability over time" (FAO, IFAD and WFP 2015).

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Outcomes in the scientific literature

Allen & Prosperi 2016 (*Environmental Management - Springer*)

Thanks for your attention

Merci pour votre attention

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Thanks for supporting and working together

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