Biodiversity, agricultural intensification and sustainable diets

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Introduction

- Biodiversity and ***Agroecology***: Aiming at producing **diverse** food and non-food outputs and outcomes

- ***Sustainable diets***: **Demand-side** determinants and nutrition complexity require greater attention

Competing paradigms to Sustainable intensification?

Structure of the presentation

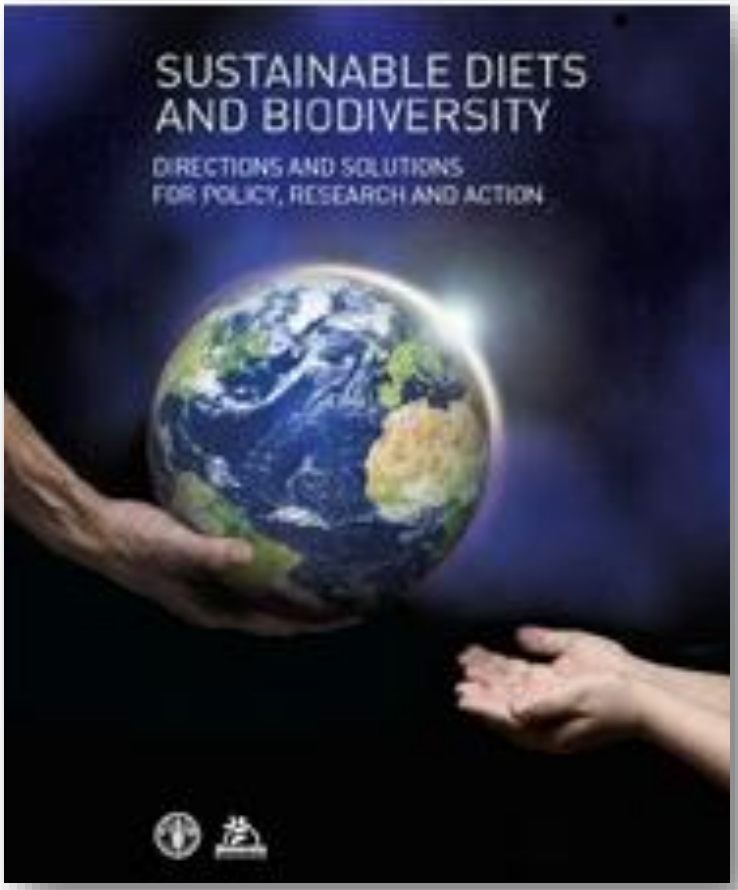
- Sustainable diets: A **nutrition-driven perspective**
- **Contribution of biodiversity** to sustainable intensification and diets
- Bio-economic modeling as a tool to study **synergies and trade-offs**

Sustainable Diets: A nutrition-driven perspective

Concept

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. Sustainable diets and biodiversity. FAO 2012. Also the INTERNATIONAL SCIENTIFIC SYMPOSIUM: *BIODIVERSITY AND SUSTAINABLE DIETS UNITED AGAINST HUNGER,* 3-5 NOVEMBER 2010, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS HEADQUARTERS, ROME

From Sustainability to Nutrition

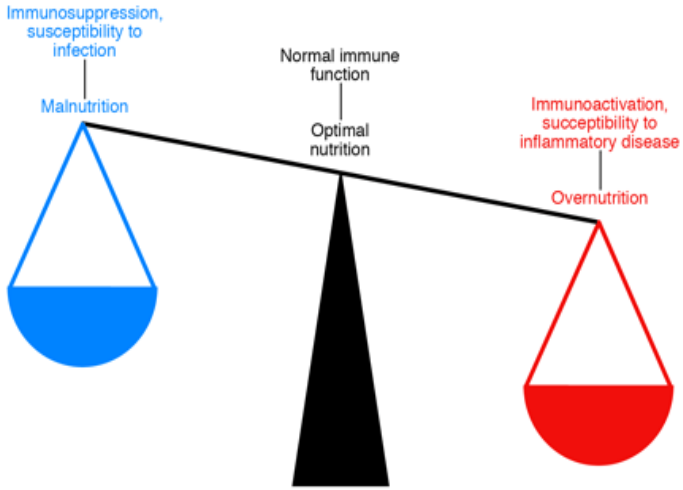
When applied to agriculture and food systems, the three pillar-concept of **Sustainable development** (UN, 1987) should not miss their ultimate purpose: ***Nutrition***

Looking for a pathway to improved nutrition

Source: Allen et al. (2013)

A nutrition-driven perspective

- Food security is also about **food quality**, not just supply or access
- Increasing recognition of the double or even **triple burden of malnutrition**
- Increasing focus on **dietary patterns**, rather than single food or nutrient

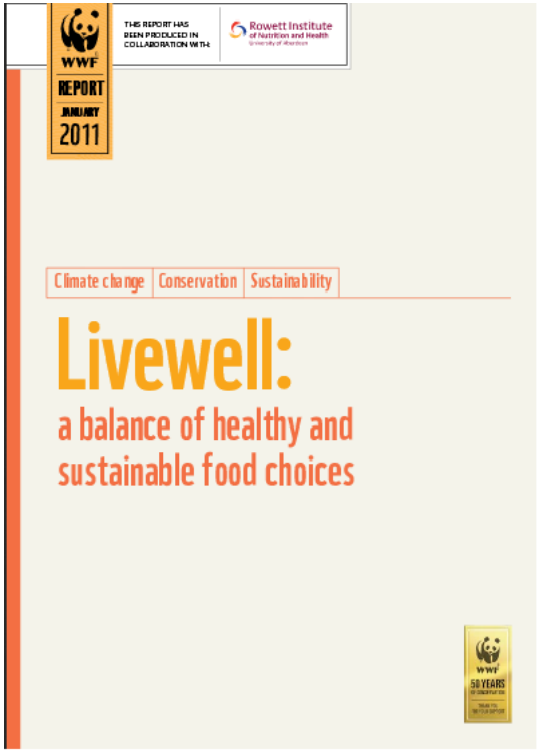


Source: Wellen and Hotamisligil (2005)

How does sustainable intensification engage with the complex issues of malnutrition ?

Optimal diets

- Increasing demand from consumers about the **health, environmental, economic and social impacts** of their food choices
- **What would look like a diet that meets both dietary recommendations and targeted reductions in GHGEs?**
- Coupling Food Nutrient Composition, with similarly framed Food GHG Emission tables
- Using linear programming



Reconciling the indispensable nutrition perspective with a system approach

A system-orientated approach to…

Diet outcomes: ***Food attributes*** or ***system outputs*** ?

- The concept of sustainability evolved from an **approach to agriculture** to a **system property** (Hansen, 1996)
- Diets – and related outcomes – are the results of complex interactions among interdependent components within **food systems**
- Food systems can best be conceptualized as **Coupled Human-Environment Systems** (Ericksen, 2008)

How can the sustainable intensification help address the broader systemic dimension of sustainability ?

Contribution of biodiversity to sustainable diets and intensification

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Simplification of human diets

- Agricultural intensification led to a production model where only **a few crop species dominate our nutritional intakes**
- Around 100 crop species for about 90% of our food supply derived from plants (Heywood, 2013)
- Balanced diets depend not just on diversity of crops, but on the **diversity within the crops** (Mouillé et al., 2010)

Source: Photo by Lois Englberger.

Nutrient variability across varieties

Nutrient composition ranges among varieties of the same species (per 100 g edible portion, raw)

	Protein, g	Fibre, g	Iron, mg	Vitamin C, mg	Beta-carotene, mcg
Rice	5.6–14.6		0.7–6.4		
Cassava	0.7–6.4	0.9–1.5	0.9–2.5	25–34	< 5–790
Potato	1.4–2.9	1–2.29	0.3–2.7	6.4–36.9	1–7.7
Sweet potato	1.3–2.1	0.7–3.9	0.6–14	2.4–35	100–23100
Taro	1.1–3	2.1–3.8	0.6–3.6	0–15	5–2040
Breadfruit	0.7–3.8	0.9	0.29–1.4	21–34.4	8–940
Eggplant		9–19		50–129	
Mango	0.3–1.0	1.3–3.8	0.4–2.8	22–110	20–4320
Banana			0.1–1.6	2.5–17.5	< 1–8500
Pandanus			0.4	5–10	14–902
Gac					6180–13720
Apricot	0.8–1.4	1.7–2.5	0.3–0.85	3.5–16.5	200–6939 (beta-carotene equivalent)

Source: Burlingame et al. (2009)

- Different varieties have statistically **different nutrient contents**
- Intraspecific biodiversity (and wild species) are **essential to nutrition security**
- Nutrient content and variability needs to be considered in agricultural policy/research for food security.

Contribution of NUS to nutrition

Neglected and Underutilized Species (NUS) vary in their **nutritional properties:**

- Some are ***nutritionally rich***

  A local fruit, *Berchemia discolor*, was found to contribute in a low cost manner to closing nutrient gaps in Kenya (Termote et al., 2013)

- and adapted to low input, resilient agriculture practiced by **smallholder farmers**

INFOODS initiative: improving the quality, availability, reliability and use of food composition data.

A nutrient-based ecological tool

Nutritional functional diversity (Remans et al., 2011)

- Metric based on species and varieties composition on the farm and the supply of nutritional components of these species and varieties
- Measures the potential of ecosystems to provide the nutritional diversity required for adequate and healthy diets
- Help identify key species contributing to **nutrient availability in agroecosystems**

Bio-economic Models: Synergies and trade-offs

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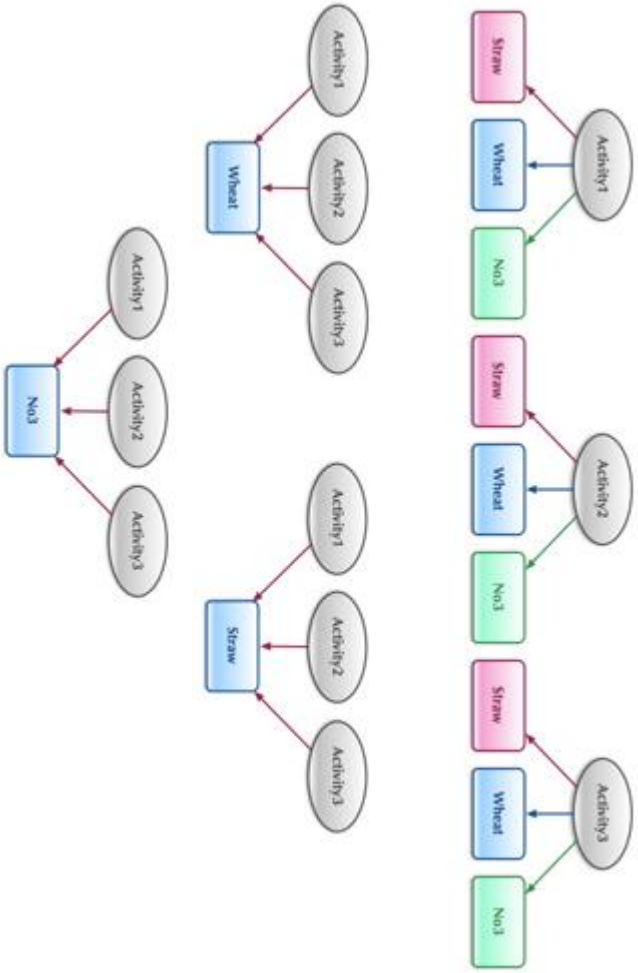
Activities and joint production

- Bio-economic models refer to models that couple both an economic and a biophysical component (Knowler, 2002)
- Multifunctionality of agriculture and **multiplicity of objectives** assigned to the agricultural policies
- Relationships between inputs and outputs might be better captured by considering the **variety of activities** involved (Flichman et al., 2011)



Source: Flichman et al. (2011)

Introducing (agro)biodiversity

- **Multi-objective optimization**: Generating Pareto-optimal solutions (Holzkämper and Seppelt, 2007; Groot et al., 2007)
- **Setting contraints**: Optimization under incrementally varying conservation requirements (Van Wernum et al., 2004)
- **Assessing outcomes**: Addressing effects of land use intensity and landscape development (Schönhart et al., 2011; Mouysset et al., 2011)
- **Modeling activities** considering agrobiodiversity jointly with technics and agronomic constrainsts (Belhouchette et al., 2011)

Considering them sequentially

Quantifying trade-offs and policy simulation

Step 1

- **Multi-objective optimization**
- In a normative approach
- Identify a set of optimal solutions and quantify trade-offs

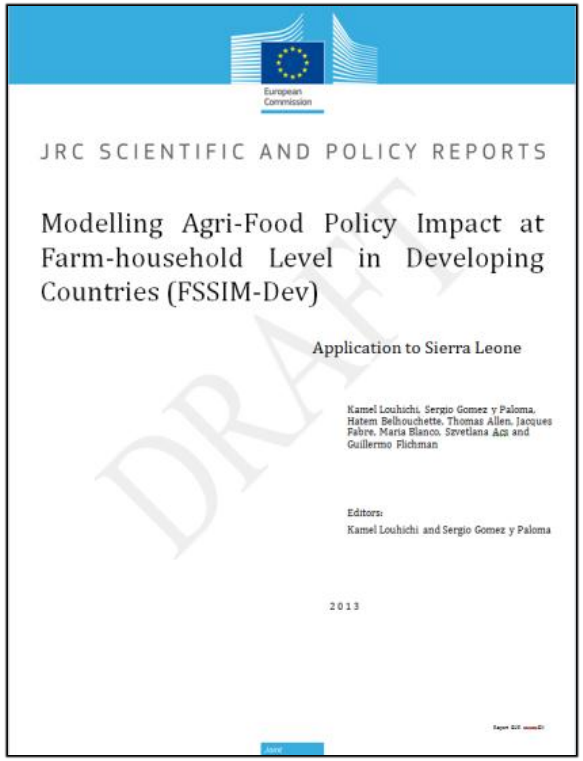
Step 2

- **Policy tool simulation**
- In a positive approach
- Assess different environmental and/or economic measures to achieve targets by scenario analysis
- Estimation of cost efficiency

FSSIM-Dev

A Bio-Economic Farm-Household model

- **Bio-economic model**: Integrated system combining biophysical and socio-economic models
- Farm-household **system simulation**: Assuming non-separability between production and consumption decisions
- A modular structure
- Application to Sierra Leone



Building on FSSIM-Dev

A fully systemic approach:

Linking agrobiodiversity and diet diversity at farm level: A **farm-household bio-economic model** to assess the contribution of agrobiodiversity and the joint outcomes on biodiversity and dietary quality

Methods:

- Expanding existing model to include biodiversity and diet diversity
- Focus on **small-holder farmers**
- **Multidisciplinarity**: Agronomists, ecologists, economists, nutritionists, sociologists
- Application to high burden countries in **Africa and elsewhere**

Conclusion

Sustainable diets stresses that:

- **Nutrition** is a core dimension of sustainability of agriculture and food systems
- For guiding change, characterization should be **system-oriented**, **predictive** and allow **diagnosis**
- **System analysis** and **simulation models** are tools that incorporate all these elements
- *…joint efforts* are key.

Thank you

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