Healthy People Healthy Planet: linking diets to food production landscapes

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1. What this background paper sets out to do

The rationale behind this paper is to provide the starting point for a discussion at the writeshop and a basis on which to build a position paper. We focus on identifying the key global challenges from a food production and consumption, human health and environmental sustainability perspective. We focus on landscapes and seascapes as the entry point of the global food supply chain, on how their management both impacts and can enable the diversity and quality of food available to human communities, as well as the myriad of additional functions and demands that are increasingly being placed on production landscapes and seascapes. We are also interested in exploring the feedback from human food choices to ecosystem processes, and how we can achieve improved stewardship of landscapes and seascapes through food choices. In particular, we seek to explore the impact of ecosystem management decisions on both human, and environmental health and to identify critical leverage points in food systems that can positively influence production patterns and practices.

To facilitate a multidisciplinary dialogue we provide definitions of key concepts. This section is not intended to focus debate on core definitions, but rather to provide some semantic mediation between the health and production sectors. We have chosen concepts that relate to diversity as we believe this is a key entry point for connecting the understanding of diets and health to what happens in the landscapes and seascapes where food is produced.

2. Background - the overall challenges

2.1 Problem statement from a global perspective

We currently live in the "Anthropocene"; a time of unprecedented global change, where economic, social and biophysical systems increasingly interact and shape each other from local to global scales (Liu et al., 2015). It is an Era of great acceleration (Steffen et al., 2015), where increased speed, scale, size and interconnectedness of the human enterprise, including increasing movement of financial capital flows globally (Galaz et al., 2015) is changing the biosphere dramatically. We are also seeing rapidly changing demographics. For example, just over 50% of the world population is currently living in cities, expected to be 66% in 2050. There is also a changing demographic "PIN code of the world" (Rosling, 2014); from the current 1114 (1 billion people live in Americas, 1 in Europe, 1 in Africa, and 4 billion in Asia), to 1125 expected in 2050. This illustrate that almost 90% of world population in 2050 will live in Asia, Africa and South America; a cultural shift that has implications for how food is produced, processed and consumed with impacts on diet, and dietary choices (Diamond, 2012). A global overview recently showed that this globalised era has increased access to more diverse and relatively cheap food in many places. However, a homogenization of food commodities has taken place at the global scale meaning that there are fewer crops underpinning more universal global diets (Khoury et al., 2014).

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Interestingly, the crops that are expanding the most are relatively low in nutrition (Khoury et al., 2014). The reduction in diversity of species compositions that are foundational for our diets threatens to undermine the resilience of global food production at a time when we see increasing magnitude and frequency of extreme events (Fischer and Knutti, 2015), as well as uncertainties in the behavior of global dynamics and interconnections, including trade (Liu et al., 2015). A similar homogenization can also be seen among actors in the global food system. For example, Howard (2009) illustrated that there are only 6 companies globally that basically drive the whole seed sector. A recent analysis also showed that only 13 companies are responsible for up to 16% of the total global fish catch, and up to 40% of the largest and most valuable stocks (Österblom et al., 2015). We thus see a food system, and actors that are getting more homogenised, but also a system that is highly interconnected; both with regard to the genetic resources that underpins the global food system (Khoury et al., 2015), and with regards to key actors in the system.

2.2. Problem statement from the diet and food systems perspectives

Rising incomes, globalization and urbanization are driving dietary transitions in which diets are shifting in ways that have substantial consequences for both the nutritional status and health of the world population as well as for ecosystems (Tilman and Clark, 2014). Globally, over 800 million people still face chronic undernutrition (FAO, IFAD and WFP, 2014) while two billion suffer from one or more micronutrient deficiencies (e.g. iron deficient anemia). Often malnutrition extremes, such as stunting in children and overweight adults are experienced concurrently. Countries experiencing multiple forms of malnutrition, including under-five stunting, anemia in women of reproductive age and adult overweight are considered the new normal (Haddad et al., 2015). At the same time there is an alarmingly fast paced increase in non-communicable diet-related diseases (diabetes, hypertension), with diet related health problems now topping the charts of the global burden of disease (Forouzanfar et al., 2015).

While links between what happens in the production landscape or seascape, and how consumers behave involves complicated interactions across the full food chain, an in-depth global overview of these two sides highlights that production systems are currently unable to provide the basic elements for what has been deemed a minimal risk, health promoting diet (Forounzanfar et al., 2015). Recent meta-analysis of dietary intakes found a concomitant increase in consumption of both healthy (e.g. fresh fruits and vegetables, whole grains) and unhealthy (e.g. processed meat products, trans-fats, free sugars) dietary components (Imamura et al., 2015). When crop production trend data is viewed from a nutrition lens, there are large increases over the last several decades in oil crops but also vegetables and tree nut crops, with the nutritional ranking of these trends based on the index by Murray running from "harmful through to protective"(Remans et al., 2015).

Consumption of processed foods is a growing trend. The food industry generates a wide array of diverse products for the consumer, many of which are aimed at speed and convenience of food preparation. Similar products are often marketed in a diverse array of choices, however many of the products have at their base very few ingredients. Breakfast cereals, for example, offer consumers over one hundred choices however, the majority of this wealth of "choice" is based on the same primary ingredients; rice, wheat or maize and sugar. Ingredients such as nuts and fruits are added in very minor quantities to make the choice seem healthier. In East and Southern Africa, processed foods now constitute nearly 40 percent of the entire food budget of households, and nearly 70 percent of purchased food (Tschirley et al., 2014). Monteiro and colleagues, have measured the level of ultra-processed foods in the diet as one indicator of reduced diet quality in Brazil. In this research a higher caloric share of ultra-processed products is associated with lower protein, lower fiber, higher free sugar, higher fat (including saturated fat), and higher energy density (Monteiro, 2011).

While the health effects of consumption of processed food are beginning to be understood, they are rarely coupled with environmental impacts such as environmental costs of transportation, plastic packaging, and narrowing of food biodiversity. There is a need to reorient food production and marketing systems to a more nutritionally meaningful diversity by directing focus on truly diverse and healthy dietary patterns and increasing nutrition education. Consumers need to become aware of and actively involved in the discussion of potential negative health impacts of highly processed foods, and also build a greater understanding of the impact of processed food products on the environment to build awareness and adoption of more sustainable food purchasing practices.

2.3 Problem statement from the ecosystems and environment perspectives

The global scale of agriculture, and the dominance of high input food production practices, have spillover effects that are measurable in our oceans, lakes and rivers, on natural habitat and protected areas, and even on our climate. For example, production activities (e.g. agriculture, forestry, grazing on rangelands) occupy almost 40% of the terrestrial landscape (Foley et al., 2011), and 29% of the global marine fisheries are overfished and 61% fully exploited (FAO, 2014). The impact of food production and consumption patterns on the biosphere is already staggering; being the largest driver for loss of biodiversity and its ecosystem services (Millennium Ecosystem Assessment, 2005), as well as a principle driver of breaching multiple planetary boundaries (Rockström et al., 2009, Steffen et al., 2015), and consequent socio-ecological regime shifts (Rocha et al., 2015). Increasingly, many of these impacts are exhibiting feedback effects in the form of decreased water quality, air quality, and disease, both communicable (avian bird flu), and non-communicable (diabetes and cardiovascular diseases).

While current food production techniques are often criticized for the negative environmental, and now health impacts, there is an opportunity to repair this damage by shifting our singular focus on the food production functions of agricultural landscapes and recognizing their capacity to provide multiple goods and services including the raw materials of a healthy and diverse diet, improvements in water quality, reduced impacts on climate change, and habitat for wild biodiversity amongst others. The lack of current governance arrangements to consider the full and differential dimensions of food system functions—economic, ecological, and social—at appropriate scales is one of the major aspects behind current food insecurity and loss of resilience (Hodbod and Eakin, 2015). Multifunctionality can thus be seen as a core of the concept of landscape and seascape food production.

Multifunctionality of food production includes three required functions: (1) the production of diverse foods, fibers and fuels that are the basis of healthy diets and productive livelihoods; (2) securing and supporting the resilience and sustainability of ecosystem services that are the basis of production systems (e.g. pollination, pest control, soil nutrient cycling, genetic resources, reproduction habitats for fisheries), and (3) other ecosystem services that can be provided by food producing landscapes and seascapes including habitat for wild biodiversity, regulation of extreme climate events, downstream water quality, and cultural identity for example. The impacts of services provided by production systems on human health as mediated by the diet and disease pathways are receiving increasing attention by the research and development community for their influence in decision making and impact.

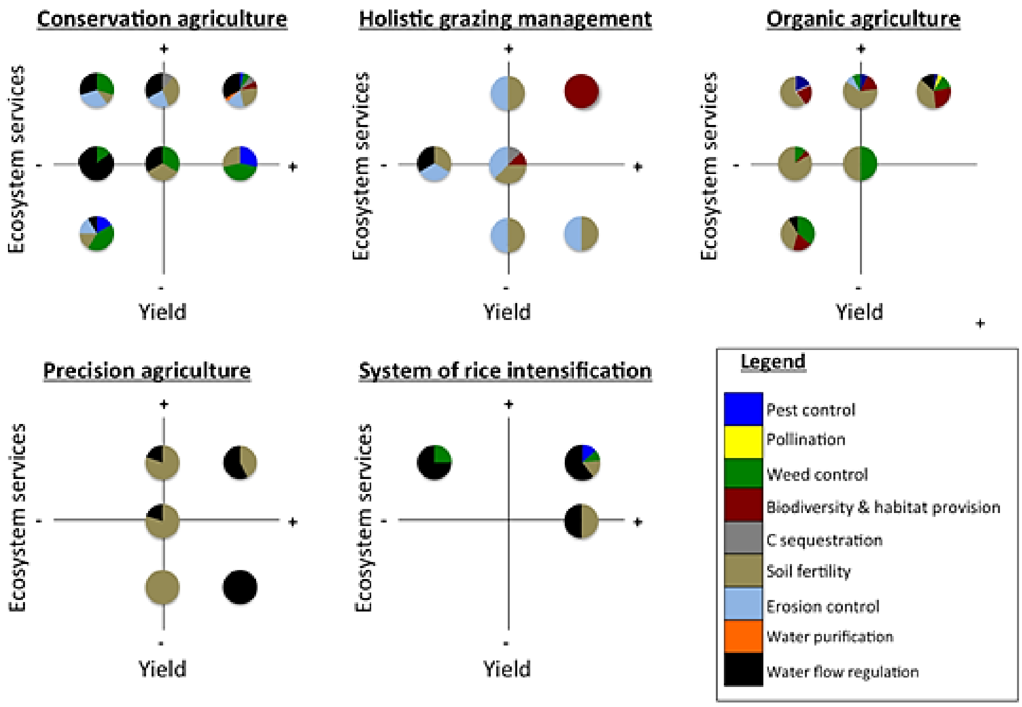

Figure 1: *Garbach et al. (in review) explored the trade-offs between food production (yield) and nine ecosystem services in five systems of agricultural intensification. While there is evidence that some management practices can lead to yield decreases (particularly in conservation and organic agriculture), there is also ample evidence that these systems can be managed to simultaneously increase both yield and the provision of ecosystem services. The study also found however, that there was insufficient empirical research explicitly considering the multifunctionality of these systems.*

Securing changes in food production systems will require a multi-sectoral approach that recognizes the multiple influences on farmer choice. And while research on production systems typically focuses on that choice, including improved seeds, plant nutrition, plant protection, and field based technologies to increase yields, there is growing interest in understanding the influence of human, and environmental health sectors on the production side of the food system.

Overall challenge:
The overall challenge is to identify how multifunctionality, and its contribution to human and environmental health can be *understood, recognized, and communicated* so that *incentives can be developed* for food producers and consumers to *become stewards of the biosphere* in ways that are economically and socially viable, attractive, and resilient.

We therefore need to understand:

- the multiple benefits generated in food producing land- and seascapes, including the management of public goods beyond mere yields with beneficiaries far beyond the farm scale
- the relation between this multifunctionality at landscape/seascape entry point to human diets and health
- the impact of diet on human health, and how production systems are “calibrated” to meet requirement of healthy diets
- which incentives or driving forces are effective means to assist farmers in becoming stewards of broader functions than food production/yields
- how many of the concepts are applicable across individual to global scales and how these incentives can be scalable

3. Linking dietary diversity to ecosystems

3.1 Dietary trends as drivers of land allocation

Access to global-scale health data has allowed for the identification of "harm-causing" foods through their association with increased chronic disease risk. This information has led to the construction of a health-promoting or minimal-risk diet. At the global scale, dietary consumption patterns contributing to ill-health include those that exhibit low fruit consumption, high sodium, low nuts and seeds, low whole grains, and low vegetables. The ideal health-promoting diet, then, requires increases in fruits and vegetables, nuts and seeds, and whole grains, and a reduction in sodium. The concept of the minimal-risk (health-promoting) diet may provide a starting point to lead decisions concerning the allocation of agricultural land and resources to grow the required amount of desirable "protective, and neutral risk" foods from land and sea. For example, at the EAT 2014 event, IHME Director, Christopher Murray (2014b), estimated that *"following the Global Burden of Disease recommended diet would have reduced US health expenditure in 2006-2010 by $130 billion per year – a 6% reduction"* and begged the question regarding what the potential influence of the health sector would be on agriculture.

Tilman and Clark (2014) similarly suggested that alternative diets could offer both substantial health benefits in the form of preventing diet-related chronic non-communicable diseases, and if widely adopted, could simultaneously reduce global agricultural greenhouse gas emissions, reduce land clearing and biodiversity loss.

Examples such as Tilman and Clark (2014) and Murray (2014a) draw the conceptual relationship between food production, food consumption, human health, and environmental health. Both highlight the impacts of distinct diets (Murray and the Minimal Risk Diet, Tilman and Clark on Mediterranean, Vegetarian, and Pescetarian dietary patterns) on landscapes. Murray alludes to an idealized proportional allocation of land to specific food products, Tilman and Clark to the impacts of each diet on land use conversion and greenhouse gas emissions (two of the Planetary Boundaries). These two examples emphasize how food choice at large scales can influence changes in resource needs and land use practices. These authors argue that incentives to drive change in diets, or change in land use practices can relate to the external costs of the current system; e.g. the cost of healthcare and external environmental effects as potential drivers of changes in agricultural subsidies and incentives, and external environmental costs.

Reflection Questions:

1. *Many countries where yield gaps persist are relatively poor economies which suffer from significant under-nutrition. What are alternate pathways for securing landscape multifunctionality in the three axes of interest: environmental health, human health, and food security?*
2. *What is the influence of ministries of health in setting minimum land allocation standards based on health concerns including health care costs? Are health care costs a sufficient driver for land use change and the related transformation of food systems?*

3.2. Linking landscape homogenisation/diversification to dietary choices

Linking dietary diversity to ecosystems needs to be considered at different scales of food systems; individual, farm, landscape, and global. From a small-scale point of view, consumer demand for dietary diversity does not directly translate to diversified farm production systems except in subsistence systems (Remans et al., 2011). This means that a food system that secures diet quality at the individual scale may not reinforce a sustainable, multifunctional landscape in return. However, little is known about how trends in production, homogenisation and nutrition actually interact. There is a global trend to larger scale farming/fisheries driven by fewer individuals and companies involved in food production which both leads to homogenised landscapes and actors. There is also a rapid increase in obesity in low and middle-income countries, where undernutrition remains a huge problem. A hypothesis is that the transition from subsistence farming to commercial farming enables economic growth and improved livelihoods, but also result in changes in access to fresh produce and a transition to diets more heavy in processed foods, meat, salt and sugar, that is less healthy (and unsustainable). Mass global food production by few "big players" also drives misperceptions, for instance in the ability of such companies maintaining diversity at the consumer choice and market levels, but driving landscape simplification and degradation (e.g. Shaver et al., 2015). Khoury et al. (2014) similarly demonstrate this challenge in their study: "whereas global diets are becoming more diverse, landscape diversity is being lost with an important homogenization of food systems in aggregate".

Reflection Questions:

3. *Which country case study examples can be drawn upon to illustrate links between dietary and landscape diversity?*
4. *Can we find case studies of transition gradients from smallholder to larger farms, and the repercussions on nutrition and diets?*
5. *How can desires to secure human health and landscape health counteract trends toward homogenization of diets and landscapes?*

3.3. Re-connecting consumers to the biosphere; influencing choice and food literacy

Through the increasingly interconnected global food system, information and knowledge about the origins, and impacts of food production have become less available for consumers (Sundkvist et al., 2005), which has lead consumers in countries where urbanization is widespread to become disconnected with how food is grown and the impact on sustainability. Since consumer choice has been suggested as an important lever to change sustainability and equity related to agriculture production practices, additional consumer information on how and where food is produced could influence consumer purchasing decisions. In a sub-sector of Western markets in particular, there is growing interest and demand for such information. Marketers are meeting this demand in part through improving product labels to include descriptions of how food is produced such as organic labels. Whole Foods new "Responsibly Grown" label is a more recent example. In some cases, such as Rainforest Alliance Certification, labelling alludes to impacts that extend beyond the farm boundary (biodiversity conservation). In reality, however, impacts are typically restricted to the farm scale and to individual crop, failing to address multifunctionality. This remains one of the single greatest challenges of environmental certification where many of the environmental benefits transcend farm boundaries (Tscharntke et al., 2015).

Reflection Questions:

6. *To what degree can labels and increasing consumer demand contribute to driving landscape multifunctionality?*
7. *How can we use growing urbanization to enhance incentives for stewardship of food production landscape and seascapes?*
8. *What are emerging "Re-connecting markets" (Oehme et al. in prep) that aims to connect urban consumers with food producers, such as Alternative Food Networks, Community Supported Agriculture (AGree – Local Foods: Revitalizing community-based food systems, 2015), and facilitation of distant monitoring by consumers of production practices (e.g. Doles Organic Bananas)*

4. Proposed guiding principles and frameworks for the way forward

4.1 Guiding Principles

Management and understanding of food systems multifunctionality has struggled with the complexity it entails, and the degree to which intervention actions and opportunity can be context specific. Garnett et al. (2013) in their review of sustainable intensification in agriculture highlight five primary functions of sustainable intensification in addition to food security:

1. biodiversity and land use, which included a cursory consideration of ecosystem services,
2. animal welfare,
3. human nutrition,
4. rural economies, and
5. sustainable development.

Remans et al. (2015) build on this in their review of the relationship between human health and the environmental articulate ten principles that can guide research action, and intervention evaluation:

1. Be coherent with health based dietary guidelines
2. Maximize nutritional output (energy, land, water, nutrients, labor) in production, post-harvest management, and processing.
3. Maximize biological diversity at different levels of the food system, in the landscape, in markets and in diets.
4. Minimize greenhouse gas emissions.
5. Minimize chemical pollution and water contamination
6. Minimize waste and enhance recycling of nutrients through the food system
7. Maximize food safety
8. Ensure that human rights of worker throughout the food system are supported, including their rights to food and health.
9. Improve equity and affordability of food items
10. Be adapted to local and changing conditions.

They propose indicators for each of these principles that can be considered to evaluate food systems in relation to human health and welfare, and impacts on environmental condition.

Reflection Questions:

9. *What mechanisms, or combinations of mechanism exist to support such principles?*
10. *How would following such principles change the composition and configuration of agricultural landscapes in the developed and developing world?*

4.2 Framework

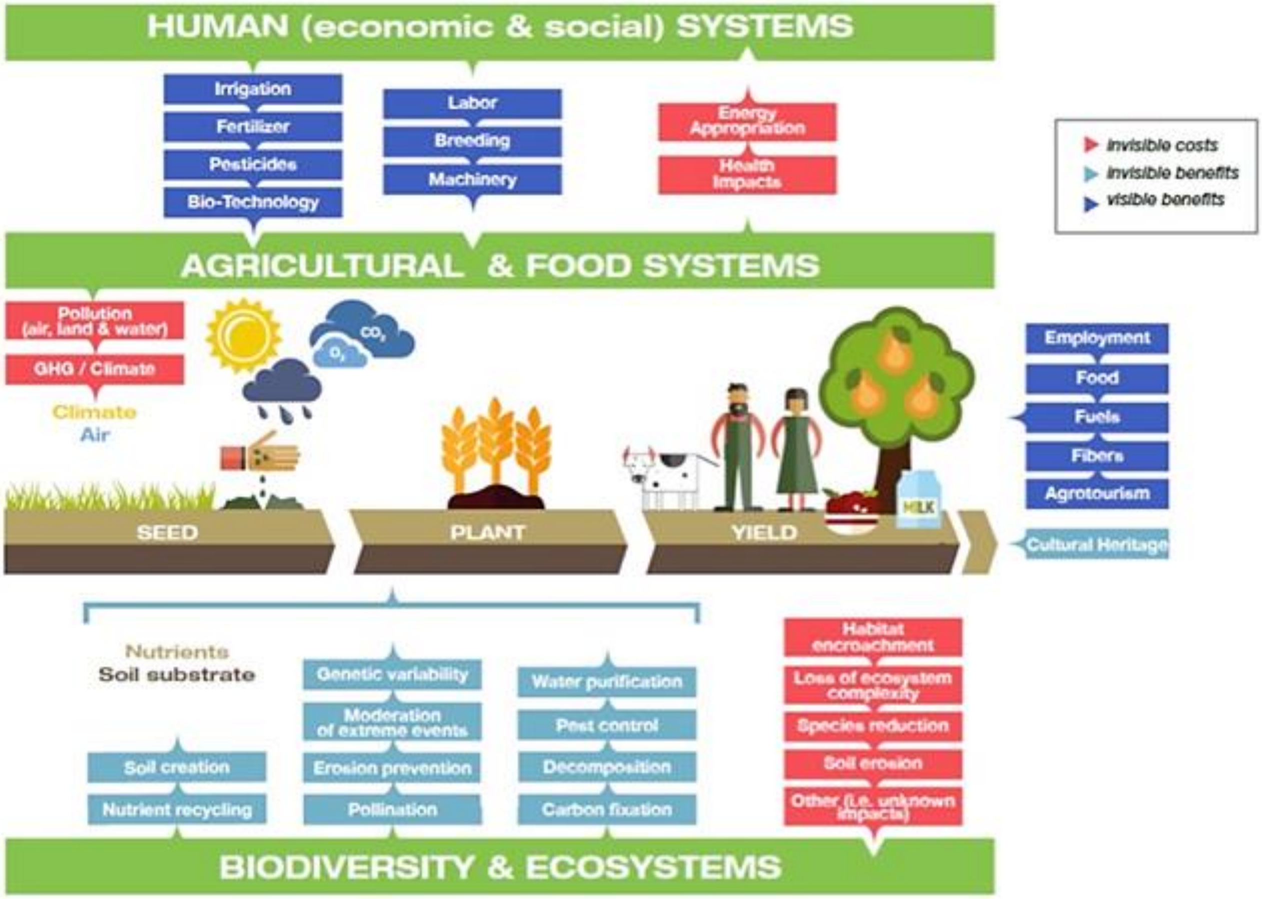

Figure 2: *The TEEBAgFood framework (Müller et al., 2015) which highlight both the benefits that biodiversity and ecosystems provide to agriculture and food systems, as well as the costs of agriculture both on human systems, as well as on biodiversity and ecosystems.*

The Economics of Ecosystems and Biodiversity (TEEB) has recently launched a review of TEEB for Agriculture and Food (TEEBAgFood) which sets a frame for the elements of sustainable intensification. Unlike Garnett et al. (2013), TEEBAgFood is much more explicit about the role of biodiversity and ecosystems services as inputs into production systems. Their articulation of the agri-food-systems makes the externalities of food production, both positive and negative, explicit, thereby facilitating trade-off analysis between individual management options. The health impacts are currently recognized but not expanded on, either through the disease or food pathways (though TEEBAgFood is keen to expand on both of these this pathways). TEEBAgFood is quite strong on the farm-scale implications of sustainable intensification with the aim of scaling up food value chains and consumption, however, as with many, struggles to avoid entanglement in scaling between farm and fork. Using the framework however, provides an opportunity to consider how both the influences of, and influences on, biodiversity and ecosystem services in agro-food systems. It has been used successfully to analyze the trade-offs between specific management practices as highlighted in the box below on California rice production systems (Case Study 1) that emphasizes the strong nature of health driven pressures on agriculture, and in this case, the unintended positive consequence on biodiversity and ecosystems.
Reflection Question:

11. *The EAT Multifunctional Landscapes work shares many of the aspirations of TEEBAgFood (Figure 2) with a greater focus on the Health Impacts of Agricultural and Food Systems. The working group should reflect on whether the TEEBAgFood conceptualization facilitates providing specific examples of interdependencies between environmental systems, food systems, and human health.*

Case Study 1: Human health as a driver of the multifunctionality of California rice production systems
California rice farmers are currently heralded as environmental stewards providing more than 220,000 hectares of wetland habitat used by more than 230 species of migratory waterfowl including more than 10 million wild ducks and geese. However this was not always the case - agricultural expansion was the main driver of wetland loss in the Central Valley of California and rice cultivation was in conflict with waterfowl conservation as rice maturation and harvest coincided with the arrival of migratory waterfowl which fed on the rice driving important yield losses. Two important changes in rice production practices eliminated this conflict. First the development of a fast maturing rice cultivar, CalRose, offset the rice harvest before the arrival of migratory waterfowl reducing yield losses. The second change was driven by air quality and respiratory health concerns of the growing Sacramento metropolitan area which banned the fall burning of rice straw as a means of pest management and rice straw removal. Flooding rice fields in the winter has now become the main means of facilitating rice straw decomposition and has inadvertently doubled the area of migratory waterfowl habitat in the state. Today rice fields in the Central Valley of California, driven by pressure to improve the health consequences of cultivation practices, have become globally recognized for their high yields (9000 kg ha) and quality, contribution to wetland conservation valued at between $35 million to $4 billion annually in habitat and recreational hunting - nearly equal to the $5 billion value of the rice harvest itself. Other recognized functions of this production landscape include flood protection for the city of Sacramento, drinking water quality, and environmental flows to the San Francisco Bay estuary. ***Source:*** *FAO, Bioversity, IRRI. TEEBAgFood feeder study on rice production systems.*

5. Future directions

There is growing recognition of the value of systems based approaches to sustainability (Liu et al., 2015; Mace, 2014), and particularly of the ability of systems approach to help unravel complexity, reveal mechanisms and feedbacks between systems component, to synergistically address multiple issues simultaneously, and to improve efficiencies. The central role food production plays in environmental condition and human health begs for a systems approach that can guide policies, incentives, practices and behavioral changes that create the operational space for enhancing the sustainability of food systems. Major challenges of fostering a systems and sustainability frame to agri-food systems include an increasingly centralized food production, processing and distribution systems, and strong concerns regarding the capacity of production systems to meet the needs of a growing, and increasingly wealthy global population. Evidence that sustainable food production systems can meet global needs with the sustainability frameworks (such as the SDG's) are urgently needed, accompanied by innovative tools that support sustainable production systems, policies that recognize the coupling of unsustainable production systems on both human health and environmental health, and value chains that give greater value to the "invisible" benefits, both social and environmental, of food production and consumption.

Annex 1: Concepts and definitions

Landscape and seascape multifunctionality

The multifunctionality of food producing landscapes and seascapes specifically recognizes the ecological processes that generate human benefits; i.e. so called ecosystem services. Ecosystem services are the conditions and processes through which ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997). The definition emphasizes the interaction between people and nature. From a practical point of view, the definition suggests that ecosystem services can be measured and understood through changes in ecosystem state, and the impact of this change on human well-being or livelihood values.

Agroecosystems

Ecosystems are a biological community of interacting organisms and their physical environment. We emphasis here that agricultural systems are also ecosystems, sometimes classified as agroecosystems. Agroecosystems are unique in that the "biological community" is largely human controlled by the selection of cultivated plants and animals. These can be complemented by a suite of associated species that can play positive or negative roles in production systems. Farmer choice of management practices determines the composition and configuration of the biological community of agroecosystems with consequences in both food production as well as a multiple other agroecosystem functions and services, and thus multifunctionality.

(Agro)Biodiversity

Diversity is fundamental for providing ecosystem services in agriculture, and for building resilience of production systems in the face of uncertainty and disturbance (Folke, 2006, Biggs et al., 2012). All landscapes and seascapes consist of a diverse set of organisms that sustain the major functions of that system. *Functional diversity* is the diversity of groups of organisms that have different roles in the ecosystem; e.g. primary producers, grazers, predators, pollinators, nitrogen fixers and decomposers. To sustain these functions over time and in response to environmental change and variability, it is important to maintain *redundancy* of organisms within these functions, so that if one species is lost the function can still be maintained (LaLiberte et al., 2010). *Response diversity is* the diversity of responses that exist in a functional group to different disturbances and is very important for resilience. Two examples that have garnered attention in the recent press are the decline of European honeybees in production systems. California again serves as a good example where pollination services provide a real cost to fruit and nut production valued at (number) in bee hives rented to farmers. The combined pressures of bee parasites, insecticide use, low native pollinator diversity, and now 4 years of drought have placed significant pressure on the European honeybee and its capacity to support fruit and nut production. Some ecologists are investigating whether focusing on increasing in field habitat for native pollinators would be both a more cost effective, and more resilience means of securing this service. Pollination services are particularly important in the production of the basic foods of the low risk diet which in many cases are dependent on pollination for fruit and seed production.

Agricultural sustainability and sustainable intensification

Sustainable intensification means a productive agriculture that conserves and enhances natural resources. It uses an ecosystem approach that draws on nature's contribution to crop growth and applies appropriate external inputs at the right time, in the right amount. (FAO, 2011 "Save and Grow"). The Economics of Ecosystems and Biodiversity (TEEB) has recently launched a review of TEEB for Agriculture and Food (TEEBAgFood) which sets a frame for the elements of sustainable intensification.

Sustainable diets
Sustainable diets are diets with low environmental impacts which contribute to food and nutrition security and to a 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 (Burlingame & Dernini, 2012). Diets have a complex nature, as foods and nutrients are consumed in combinations that can induce interactions and synergies between dietary components.

Diet quality
Diet quality is defined according to the type and amount of foods and/or nutrients consumed, in terms of:

- Desirable foods or food groups to be consumed (e.g. whole grains, fruits, vegetables, fish, nuts and seeds, beans and legumes, milk, and dietary fiber)
- Adequacy of nutrient intake (meeting energy, macro- and micronutrient requirements)
- Restricted intake of specific nutrients (related to a maximum energy contribution by fat, especially by saturated fat, cholesterol, and mono- and di-saccharides)
- Avoidance of unwanted food components, foods or food groups (like sugar, or sugar sweetened beverages, trans-fats, sodium).

Annex 2: Linking concepts, challenges and barriers to change across agriculture-ecosystems-nutrition

Here we "pair" challenges and/or concepts that have mostly been addressed separately in the different fields of agriculture/ecosystems on the one hand and health/nutrition on the other. We do know that we simplify the arguments.

A. Yield/Energy Intake vs Resilience/Diet Quality

Agriculture
Focus has been on increased production and yield with feeding a 2050 populations as the rallying point. Shift needed towards multifunctional and resilient landscapes that also provide adequate and nutritious food of higher quality

Nutrition
Focus has been on overall energy intake sufficient for body mass/growth and development Shift needed towards adequate nutrient intakes (both macro and micro) that come from a food system that is environmentally responsible/supportive.

B. Functional Diversity/Dietary Diversity

Agriculture
To provide ecosystem services, require many different plants and animals that offer various functions within a landscape, to build resilience of the system should a species disappear, another can serve that function.

Nutrition
To provide adequate nutrition, many different plant and animal sources need to be consumed. As seasonal change in food supply occurs, this diversity allows for one nutritious food to be replaced by another that will maintain adequate nutrient intakes year-round.

C. Pairing (Synergies)

Agriculture
Pairing certain plants/animals together creates benefits over and above what each can contribute on its own.

Nutrition
Pairing certain foods together enhances nutrient absorption and satiety, and can ensure intake of all essential amino acids (especially for vegetarian/vegan-based diets) and nutrients in the amounts required on a daily basis for optimal health.

D. Culture & Tradition

Agriculture
Traditional agriculture tied to cultural values, heritage, generational connection, increased plant and animal diversity, connection with the land (emotional, mental and physical well-being).

Nutrition
Traditional diets tied to cultural values, heritage, generational connection, special occasions, increased diet diversity, connection with and greater appreciation of the land responsible for food production (emotional, mental and physical well-being).

E. Keystones

Agriculture
Keystone plant and animal species identified in ecosystems that are disproportionately important for its success in providing services and/or building resilience.

Economic/Food Industry
Keystone actors that have the potential to massively impact and revamp landscapes, seed supply, agriculture and food supply on a global scale.

F. The importance of re-education and re-connection with food systems

Agriculture
Loss of traditional knowledge and learning about farming techniques (crop rotation, plant pairing/pest resistance strategies, zero tillage, seed conservation and trade, home gardening technologies, simultaneous plant and animal land use) and loss of agricultural training/exposure in schools/the community/media/national programmes.

Nutrition
Loss of traditional knowledge and learning about food preparation/preservation/cooking methods that retain nutrient content of foods, how to utilize multiple parts of plants and animals (currently 1/3 of food is wasted or lost (Remans et al., 2015)), how to plan ahead for dry season/changes in food availability, loss of balanced and nutritious traditional food recipes, children not exposed to food production or whole foods, only packets. Children unable to identify foods, particularly fruits and vegetables, let alone which foods are nutrient-rich.

G. Certifications/Standards

Landscapes
Landscape certification is still in its infancy, but considered to be an important concept in securing landscape functions and motivating change (Tscharntke et al., 2015).

Agriculture
Certification systems have essentially pushed smallholder farmers out of business or into loan traps. Decreased diversity in crops due to requirement to use commercial seed. More organic/traditional farming techniques not viable to produce marketable (and therefore profitable) food as do not meet strict and technical certification standards.

Nutrition
Smallholder or traditional food producers unable to sell foods on an international scale/build capacity due to strict health and safety codes associated with the collection, processing and preserving of food products (even though this type of food production has proven safer and healthier than large factory/farm production).

H. Impact of Modernisation/Globalisation on agriculture and nutrition/health

Agriculture
Began as highly diverse, multifunctional forest and sustainable grassland, plentiful in ecosystem services, showing high functional and response diversity and high resilience

- then shifted to - somewhat diverse agricultural land with crop rotation, trees present, the use of buffer strips
  - again shifted again to - monocrop agricultural land requiring large amounts of external inputs, high water usage, no crop rotation
    - which has resulted in - ecosystem degradation, and contributed to climate change

Nutrition
Began as traditional diverse diets, largely unprocessed, inclusion of wild edibles, nutrients were retained, and cultural linkages were strong

- then shifted to - both decreased and increased diet diversity, more international import and export, decreased nutrient content due to high processing and distance from farmer to plate
  - and shifted again to diet made up of staple foods, highly processed or reformulated
    - which has resulted in - double burden of nutrition = malnutrition/obesity

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