The Economics of Ecosystems & Biodiversity

TEEB for Agriculture & Food

Towards a Global Study on the Economics of Eco-Agri-Food Systems

Version: 15.05.2015

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Acknowledgements

The authors would like to thank David Díaz Martín and 100Watt for design and layout.

TEEB is hosted by the United Nations Environment Programme. "TEEB for Agriculture & Food" is supported by the European Commission and the following members from the Global Alliance for the Future of Food: Gordon & Betty Moore Foundation, KR Foundation, The Christensen Fund and V. Kann Rasmussen Foundation.

Alexander Müller, TEEB AgFood Study Leader
former Assistant-Director General of the FAO

"Agriculture is arguably the highest policy priority on today's global political agenda, in recognition of its widespread impacts on food security, employment, climate change, human health, and severe environmental degradation. This study will build on the earlier successes of TEEB by drilling into the heart of these issues and exploring the latest evidence to paint a global picture of our agricultural and food systems. This body of work will provide a detailed look at their dependency on ecosystems and biodiversity, their impacts on human and ecological well-being and health, and the underappreciated role of small-scale farmers. I truly see this as being one of the most timely and important research initiatives in the field of sustainable agriculture, and am honoured to be a part of it."

The GOOD

For millennia, agriculture[1] has been the most visible example of human interaction with nature. Through human innovation, generations of farmers have worked with and cultivated nature's soils, water and biodiversity to create a wealth of knowledge, a wide range of seeds, breeds and farming practices, developing a huge variety of production systems adapted to different ecological conditions. Agriculture represents our most valuable life support system today. Indeed, the world would be a different place without the benefits that we receive from our agriculture and food systems.

The numbers below demonstrate the ubiquity of agriculture and the benefits it provides while painting a picture of just how many of us are directly dependent on agriculture for our livelihoods and well-being, especially those living in rural poverty.

Agriculture employs 1 in 3 people of the world's economically active labour force, or about 1.3 billion people[2]. For the 70 per cent of the world's poor living in rural areas, agriculture is the main source of income and employment[3].

Smallholder farms (i.e. less than 2 hectares) represent over 475 million of the world's 570 million farms and, in much of the developing world, they produce over 80 per cent of the food consumed[4].

Food production systems produce approximately 2,800 calories per person per day which is enough to feed the world population[5].

Agriculture supplies the world with over 130 billion litres of bio-fuel every year (105 billion litres of bio-ethanol and 26 billion litres of bio-diesel)[6] with global demand projected to increase for its use in transportation, electricity and heating.

Agriculture provides everyday needs not just through food, but through the production of raw materials and natural fibres, including wood, cotton, wool and silk, as well as new emerging developing country markets in bamboo, sisal, jute, abaca and coir[7].

Agriculture is an integral part of our cultural landscapes and integral to our cultural identity. It underpins community values, festivity, social cohesion and tourism, and its landscapes are a location and source of recreation and mental/physical health, providing at times a spiritual experience and sense of place.

The BAD

Agriculture and food production systems today apply a diverse range of methods and practices, ranging between industrial and small-scale, organic and conventional, mixed and monoculture, making it virtually impossible to generalize their 'externalities' (see Box 1) on human well-being. Still, there are evolving trends, both globally and within countries, that present serious cause for concern.

Box 1. What is an 'externality'?

An 'externality' refers to the impact of a transaction or activity on any person or institution that did not explicitly agree to this transaction or activity. Such third-party impacts can either be benefits (positive externalities) or costs (negative externalities)[8].

While current food production systems produce a third more calories than needed, an estimated 805 million people in the world are chronically undernourished, the vast majority of which (98 per cent) live in developing countries[9]. Furthermore, over two billion people suffer from nutritional deficiencies in vitamin A, iron, zinc, and iodine[10]. Conversely, almost two billion adults in the world are considered overweight, 600 million of whom are obese[11].

Eighty per cent of new agricultural lands have replaced tropical forests since the 1980s[12], a trend resulting in significant biodiversity loss and ecosystem degradation.

Crop and livestock farming produce between five and six billion tons of CO_2-equivalent in greenhouse gas (GHG) emissions each year[13], mostly in developing countries where the agricultural sector has expanded in recent years.

The agricultural sector utilizes 70 per cent of the water resources we withdraw from rivers, lakes and aquifers,[14] raising serious concerns in terms of sustainability and security.

Agricultural use of fertilizers has also adversely impacted marine and riverine ecosystems, producing over 400 aquatic "dead zones" worldwide, covering an area of 245,000 sq.km through eutrophication (see Box 2)[15].

Food production accounts for 70 per cent of total biodiversity loss[16], while agriculture is a major contributor to the loss of genetic diversity in local varieties of crop or landraces of livestock[17]. For the poorest farmers, and in those places where hunger is most acute, biological and crop diversity may be the best protection against diseases, pests and starvation.

The agricultural sector is the world's largest user of antibiotics, using 70% of all that is manufactured[18]. The use of antibiotics may create resistant strains of microbes in humans, posing serious threats to human health[19].

Box 2. What is 'eutrophication'?

Fertilizers provide nutrients, such as nitrogen and phosphorus, to enhance plant and crop growth in agriculture. When excessive amounts of these nutrients reach water bodies due to runoff and wastewater discharge, they provide a food source for blooms of blue-green algae ("cyanobacteria") that, as they die and decompose, deplete water of oxygen and slowly choke aquatic life, creating "dead zones". This process is known as 'eutrophication'. In addition to fertilizers, runoff from industrial animal production facilities or "factory farms" can also cause eutrophication.

By concentrating a large number of animals within small areas, industrial meat production also poses risks to human health. Crowded animal facilities increase the risk of contamination by pathogens, and automated methods of slaughtering and meat processing make it difficult to detect contamination[20].

…and the INVISIBLE

Agricultural productivity is dependent on many inputs. Usually we tend to think of these in terms of labour, machinery, technology, fertilizers, pesticides and the like.

Box 3. What do we mean by 'biodiversity', 'ecosystem' and 'ecosystem services'?

'Biodiversity' is described as the sum total of organisms including their genetic diversity and the way in which they fit together into communities and ecosystems.

An 'ecosystem' is defined as the complex of living organisms and the abiotic environment with which they interact at a specified location.

'Ecosystem services' are considered to be the direct and indirect contributions of ecosystems to human well-being.

These critical inputs are considered to be 'visible' in the sense that their value to agricultural systems is recognized and reflected in decision-making agendas at all levels (farmers, industrial sectors, local and national government, and international dialogue).

However, the productivity of agricultural systems also depends on a range of other inputs from nature, including nutrient, cycling, pollination, freshwater flow and purification, biological pest control, etc. (see Box 4 on ecosystem services). Despite their immense value, these clear benefits are not typically accounted for in market transactions and viewed as valueless, or invisible, in economic terms.

The economic invisibility of nature´s flows into the economy, particularly in the agricultural context, is a significant contributor to the degradation of ecosystems and the loss of biodiversity. Indeed, FAO summarizes the current status of agricultural production systems in the following way: "*…global achievements in production (of food) in some regions have been associated with degradation of land and water resources, and the deterioration of related ecosystem goods and services.*"[44] This in turn leads to serious human and economic costs which are being felt now, have been felt for much of the last half century, and will be felt at an accelerating pace if we continue Business As Usual.

Unfortunately, there are very few incentives for farmers to maintain these ecosystems vital to farm productivity. Instead, farmers tend to be rewarded on the basis of agricultural intensification and expansion of agricultural land, both of which favour short-term gains. Maintaining healthy ecosystems, storing carbon, the sustainable use of genetic resources, and other non-marketable services do not tend to generate income for farmers.

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Box 4. Ecosystem Services

Provisioning Services

are the material or energy outputs people obtain from ecosystems

 Food

 Fresh Water

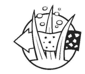
 Raw Materials

 Medical Resources

Regulating Services

are the benefits people obtain from the regulation of ecosystem processes

 Local Climate and Air Quality

 Waste-water Treatment

 Carbon Sequestration and Storage

 Pollination

 Extreme Events

 Biological Control

 Soil Erosion and Fertility

Cultural Services

are the non-material benefits people obtain from ecosystems

 Recreation

 Tourism

 Spiritual Experience

 Aesthetic Appreciation

Habitat Services

are those that are necessary for the production of all other ecosystem services

 Species

 Genetic Diversity

Adapted from the Millennium Ecosystem Assessment´s (2005) classification of ecosystem services, the TEEB reports use a number of icons to represent the wide range of services provided by ecosystems and biodiversity. Icons developed by Jan Sasse.

Externalities in Eco-Agri-Food Systems

The environment in which farmers and policymakers operate in is distorted by significant externalities (see Box 1), both negative and positive (the "good" and the "bad"). Furthermore, our dependency on healthy ecosystems for agricultural production is not recognized either (the "invisible"). Both these information gaps need to be filled if we are to provide the right incentives for managing our food systems for productivity and sustainability. **Recognizing these externalities, demonstrating their pervasive and distortionary influence on agri-food policy, and then capturing these values through regulatory reform and market mechanisms is the core value proposition of TEEBAgFood.** We present the range of externalities in the section that follows, and the rest of this report sets out our proposal for recognizing, demonstrating and capturing these values. In short, how do we enhance the provision of the 'goods', reduce those of the 'bads' and tackle 'invisibility"?

Pesticides and their degradates from agricultural use can flow into air, soils and water, resulting in the accumulation of toxic substances

Annually, the world uses about 3 million tons of pesticides (including herbicides, insecticides, and fungicides), an estimated .1% of which reach the target pests[25]

Environmental impacts can include widespread decline of birds, amphibians, and beneficial insect populations[26]

Pesticides can also enter human bodies directly and through food chains. For example, traces of DDT, lindane and dieldrin in fish, eggs and vegetables still exceed the safe range in India[27]

As many as 25 million agricultural workers worldwide experience unintentional pesticide poisonings each year[28]

Intensive agricultural practices can compact soil, destroy soil structure and kill beneficial organisms within the soil food web

Conventional farming techniques (e.g. ploughing, tilling and harrowing) can make soils susceptible to wind and water erosion. Brazil, for example, loses 55 million tons of topsoil every year due to erosion from soy production[21]

Unsustainable agricultural practices (e.g. over-cultivation, overgrazing, and overuse of water) can contribute to desertification[22], adversely impacting people, livestock, and the environment

Today's rate of arable land degradation is estimated at 30 to 35 times the historical rate and, every decade, we are losing at least 120 million hectares of land, an area the size of South Africa, to desertification and drought alone[23]

It is estimated that some 50 million people may be displaced within the next ten years as a result of desertification[24]

Agricultural expansion has had a tremendous impact on habitats and biodiversity

Globally, agriculture has cleared or converted 70% of grasslands, 50% of savannah, 45% of temperate deciduous forests, and 27% of tropical forest biome[29,30]

Agricultural expansion is increasingly taking place in the tropics, where an estimated 80% of new agricultural land has replaced forests since the 1980s[31]. As reservoirs of carbon and biodiversity, this trend is having significant impacts on both

At farm level, studies show the negative effects of agricultural intensification (e.g. increased use of pesticides, synthetic fertilizers, and reduced use of diversified farming techniques) & conversion of natural habitats on biodiversity, as measured by plant and bird richness & abundance[32, 33]

Soil organisms perform critical functions for cycling of nutrients necessary for plant growth, but current levels of fertilizer use can be counterproductive and limit this function

It is estimated that 60% of the nitrogen and 50% of the phosphorous applied to crops worldwide is in excess of what is required[34]. Excess nitrogen in soil can lead to less diversity of plant species and reduced production of biomass[35].

The agricultural sector can affect water resources by diverting it from other potential uses, or by impairing water quality through use of chemicals & fertilizers

Globally, the agricultural sector utilizes 70 per cent of the water resources we withdraw from rivers, lakes and aquifers[37], and 60 percent of this water is wasted via runoff into waterways or evapotranspiration[38]

It is projected that there will be insufficient water available on existing croplands to produce food for the 9 billion people expected in 2050, if current dietary and management trends continue[39]

Every year due to eutrophication, a "dead zone" forms around the mouth of the Mississippi River[40], resulting in declines in the shrimp fishery, as well as in other local fisheries in the Gulf region[41]

Crop genetic diversity is useful in managing pests and diseases, as well as enhancing pollination services and soil processes in specific situations

Farmers worldwide have been swapping their multiple local varieties and landraces for genetically uniform, high-yielding varieties. For example, in Serbia and Montenegro, it is estimated that the area sown with old varieties of wheat is less than 0.5 per cent[36]

Agricultural systems create significant amounts of greenhouse gas (GHG) emissions, including CO_2, CH4, and N2O

Agricultural systems contribute to GHG emissions in various ways: (i) using fossil fuels in agricultural production, (ii) using energy-intensive inputs (e.g. fertilizers), (iii) cultivating soils and/or soil erosion resulting in the loss of soil organic matter, and (iv) producing methane from irrigated rice systems and ruminant livestock.

The direct effects of land use and land-use change (including forest loss) have led to a net emission of 1.6 gigatons of carbon per year in the 1990s[42,43]

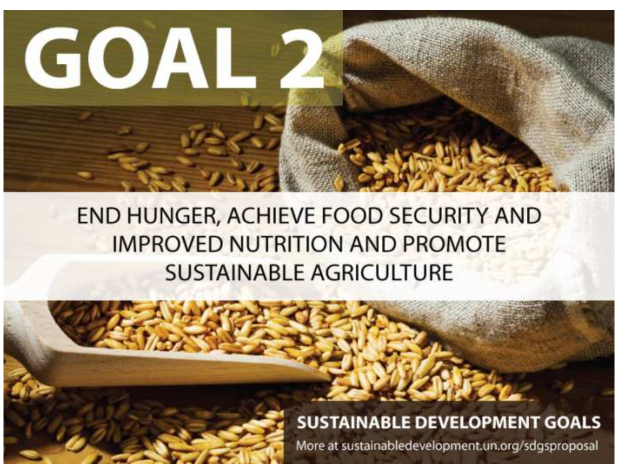
The relationship between ECOLOGICAL, AGRICULTURAL & FOOD SYSTEMS

Providing sufficient food and nutrition and achieving good health for all seven billion humans on earth (and for future generations) is one of the main challenges of our time. Our success or failure to meet these challenge will be determined by our stewardship of ecosystems, agricultural lands, pastures, fisheries, and our management of labour, technology, policies, markets, and food distribution systems. Collectively, we refer to these as "eco-agri-food systems".

As demonstrated by both the "good" and "bads" sections, it is clear that while developments in agriculture have led to substantial gains in food productivity, these developments have also been accompanied by large scale changes in the way we use natural resources, many of which are unsustainable. Both international and national public policies have played an important role in the emergence and development of these trends. The EU's Common Agricultural Policy, the US Farm bill, green revolution initiatives, deregulation of agricultural markets, policies for biofuel use, to name a few, have all helped shape a complex state of Business as Usual.

Indeed, it is important to recognize the role of policies to understand the relationship between ecological, agricultural and food systems. At present however, our actions and behaviours at various levels –the individual, firm, and society– are not aligned to address the challenges of sustainable agriculture and sufficient nutrition and health for all; indeed, the current system provides us with few incentives to reduce or reverse the alarming rates of ecosystem degradation and biodiversity loss.

These issues have been recognized and identified as key policy priorities for the sustainable development agenda beyond 2015 (e.g. SDGs 2 and 15).



https://sustainabledevelopment.un.org/sdgsproposal

There is a need to better understand these systems and their interrelationships in order to achieve our goals of stewardship of nature and sustainable management of our agricultural systems. This is needed for three reasons.

First, agriculture is the world's largest employer and plays a critical role in supporting the livelihoods of an estimated 1.3 billion people living in rural poverty[45]. If the responses of governments, businesses, and farmers to significant climate risks and ecological scarcities are not well informed, then we run the risk of significant and potentially devastating upheavals in jobs and livelihoods for decades to come.

Second, the impacts on ecological systems will disproportionately hurt the poor, who are the most dependent upon them (see Box 5). We need to recognize these realities and respond with appropriate policies and measures to ensure that subsistence and smallholder farms are supported, improved and sustained in the face of climate risks and ecological scarcities. Smallholder farming is one important sub-set of the totality of eco-agri-food systems, and one that must be considered in any study looking at the full range of farming systems and interactions between them.

Lastly, recent studies suggest that in the next few decades, food production would need to double to keep pace with projected demands from population growth, dietary changes (especially meat consumption), and increasing bioenergy use[46]. This raises important questions of where these increases would come from, what production systems would be used given the various resource constraints, and how these increases could translate into poverty alleviation strategies.

Box 5. GDP of the Poor

Traditional measures of national income like GDP, which measures the flow of goods and services, can be misleading as indicators of societal progress in mixed economies because of the "invisibility" of many of nature's values. In the original TEEB reports, an adapted measure – the 'GDP of the Poor' - was presented as a new metric that integrates economic, environmental and social aspects, thereby indicating the vulnerability of the rural poor if valuable natural resources are lost. It has been estimated that biodiversity and ecosystem services account for between 40 to 90 per cent of the GDP of the Poor.[47]

To ensure that the above issues are addressed, various interventions would need to take place – these may include, but not be limited to – sustainable consumption and production, agricultural policies reform, improving access to food, supporting smallholder farms, and prudent land use and spatial planning etc.

Many public policies and interventions are based upon, but not limited to, economic rationale. At the same time, many of the significant impacts of the agricultural sector on ecosystems, soil, water resources, biodiversity, and human health are economically invisible. Therefore they do not get the attention they deserve from governments or businesses who often make decisions based on financial rationale. This information gap must be addressed if we are to ensure our goal of providing sufficient nutrition and good health for all, and for generations to come.

TEEB approach to
The ECONOMICS of ECO-AGRI-FOOD SYSTEMS

The **TEEB approach** (see Box 6) with respect to 'eco-agri-food' systems is rooted in economic valuation. Although the services provided by nature are critical to the productivity and health of agricultural and food production systems, they are often invisible in the economic choices we make. Market prices paid for farm produce cover the cost of inputs such as seeds, fertilizers, and seeds, but not the value of bees pollinating crops, or microorganisms cycling nutrients into the soil, the lack of which can cause crops to fail. Likewise, agricultural producers are typically neither fined for causing negative externalities, such as pesticide runoff or soil erosion, nor rewarded for positive ones, such as ensuring groundwater recharge through farm vegetation or preserving scenic rural landscapes. These invisible costs and benefits are missing as key inputs into the economic system in which farmers and policy makers operate, creating a skewed and incomplete picture.

Box 6. The TEEB approach to valuation[48]

TEEB follows a novel approach to the way in which we value nature. First and foremost, it considers valuation to be a human institution, largely dictated by socio-cultural values, norms, beliefs and conventions. As such, different interpretations of 'value' will exist, none of which should be perceived as either incorrect or invalid. In order to better analyze and structure the process of valuation, TEEB outlines an approach that involves three different levels of action:

1. *Recognizing value* – identifying the wide range of benefits in ecosystems, landscapes, species and other aspects of biodiversity, such as provisioning, regulating, habitat/supporting and cultural services
2. *Demonstrating value* – using economic tools and methods to make nature's services economically visible in order to support decision-makers wishing to assess the full costs and benefits of land-use change
3. *Capturing value* – incorporating ecosystem and biodiversity benefits into decision-making through incentives and price signals

It should be pointed out here that assigning an estimated value for a particular ecosystem service does not mean that this is 'the price'; TEEB in no way supports the commoditization (or 'selling off') of nature.

TEEB recognizes that to address various challenges posed to our future food security and well-being, policies have to be better informed - the true cost of business as usual has to be reflected in public and private decisions, including the invisible contributions of nature to our food systems. Before doing so, however, a few prerequisites must be met.

Estimating the true value added by eco-agri-food systems

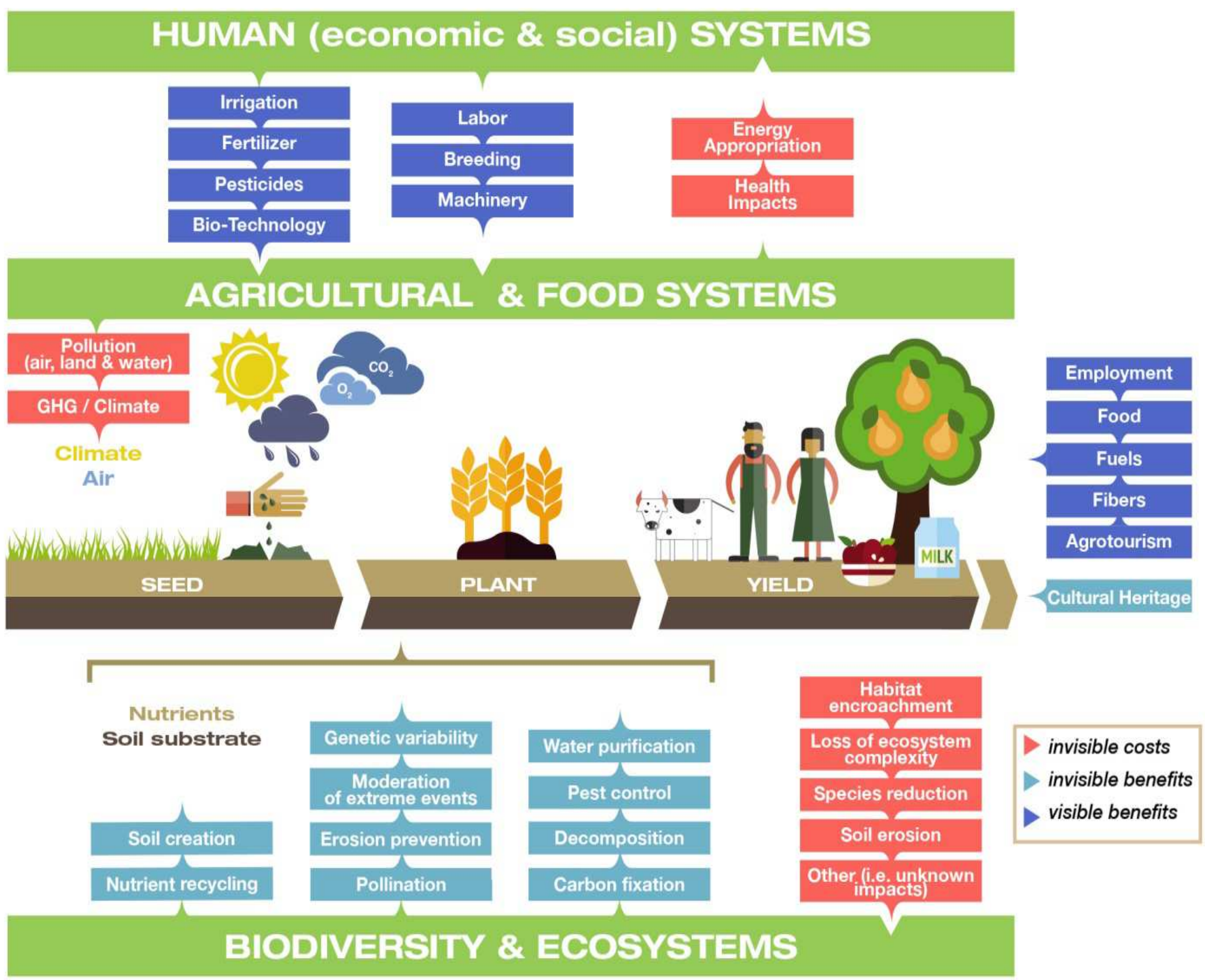
First, there must be clarity about the *appropriate scope and boundary for valuation*. Setting scope is about deciding which agricultural sector, geography, agri-business, or products are being considered for valuation. Setting a boundary is about deciding how much of the value chain to include for the specified scope.

Such an evaluation must consider, to some degree, *the full range of material (i.e. significant) externalities* that emanate from or affect the eco-agri-food systems complex, but are generally missing from policy evaluations, business calculations, and farming decisions due to their economic invisibility. In other words, all material hidden costs and benefits must be revealed and valued in order to support holistic decision-making.

Second, there must be clarity and consistency on *what to value and why*. Social and economic impact is the preferred basis of including - or excluding - various forms of value-addition and externalities. In other words, there must be a widely accepted and consistently followed *valuation framework*. In order to address different kinds of farming systems, ecological thresholds, and social contexts and geographies, establishing some degree of comparability in measurement across these systems is essential for meaningful conclusions to be drawn. It should be noted that *valuation methodologies* (which answer the question '*how to value*?') can be many even if the valuation framework is just one; some guidance needs to be provided as to which methodology is appropriate in what context.

Figure 1 below presents our framework for this study, outlining the processes and relationships that characterize eco-agri-food systems. An important element of this framework are the positive and negative externalities which we consider to be 'material' to the discussion. Some striking examples are highlighted in more detail below, demonstrating that their inter-connectivity is real and needs to be thoroughly evaluated in order to shed light on the key research questions for this study.

Figure 1. TEEBAgFood framework for analysis



The WAY FORWARD

"When we talk about agriculture and food production, we are talking about a complex and interrelated system and it is simply not possible to single out just one objective, like maximising production, without also ensuring that the system which delivers those increased yields meets society's other needs [such as] the maintenance of public health, the safeguarding of rural employment, the protection of the environment and contributing to overall quality of life.
[We should] not shy away from answering the big questions. Chiefly, how can we create a more sustainable approach to agriculture while recognizing those wider and important social and economic parameters – an approach that is capable of feeding the world with a global population rapidly heading for nine billion? And can we do so amid so many competing demands on land, in an increasingly volatile climate and when levels of the planet's biodiversity are under such threat or in serious decline?"

-HRH Prince Charles, the Prince of Wales
"On the Future of Food" speech, 2011

TEEB is setting out to answer these "big questions" through the establishment of the **TEEBAgFood** Study. This will be achieved by bringing together economists, business leaders, agriculturalists and experts in biodiversity and ecosystem services to systematically review the economic interdependencies between agriculture and natural ecosystems, and provide a comprehensive economic valuation of eco-agri-food systems. We hope this information would reflect the various environmental and social costs across various food production systems, allowing policy makers to make better informed decisions .

As a first step, a number of sector-specific 'feeder studies' have been commissioned (on rice, livestock, palm oil, inland fisheries, maize and agro-forestry), each focused on assessing the social and environmental externalities of producing a particular agricultural commodity. The studies also look at the dependency of the various production processes on biodiversity and ecosystem services. These analyses not only provide a wide geographical spread (Figure 2), but also include varied types of production systems (See example for inland fisheries in Table 1).

Figure 2. Global mapping of TEEBAgFood 'feeder' studies

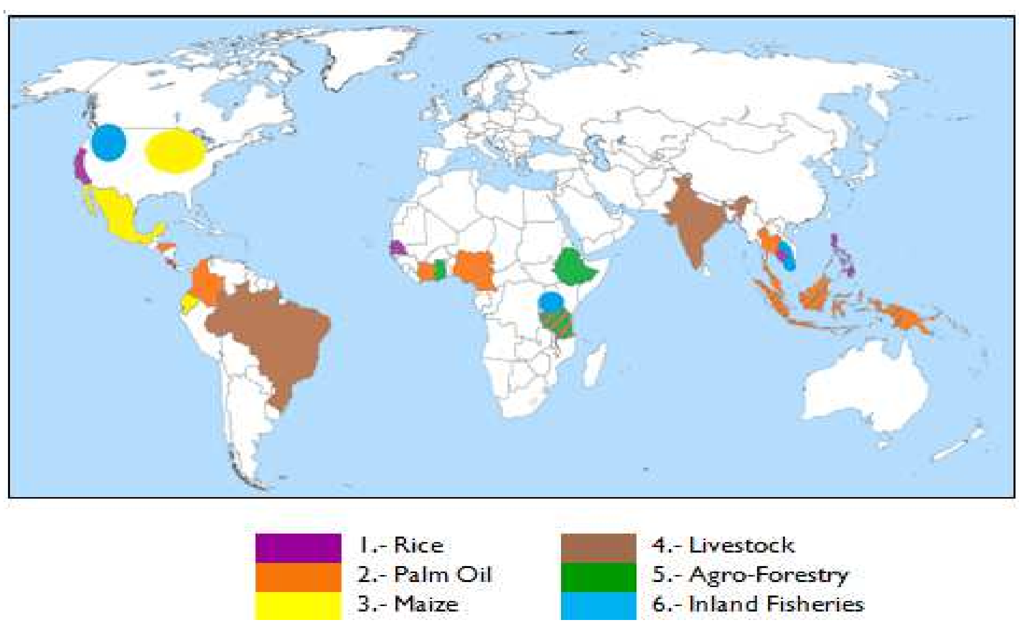


Table 1. Typology of production systems assessed in inland fisheries

Case study area	Production systems and main water management practices assessed
1. Lower Mekong Basin, South-East Asia	- Rice fields with fish production: (artisanal fisheries, including floodplain rice-field fisheries). - Cage aquaculture in reservoirs - Culture-based fishery or Pond aquaculture
2. Lake Victoria, East Africa	- Industrial fisheries (Nile perch) - Cage aquaculture in lakes
3. Columbia River, USA	- Recreational/small-scale fisheries

The findings from these sector feeder studies (see Box 7, 8 and 9 for preliminary findings) are to be documented in an **Interim Report** due to be published in October 2015. The Interim Report will include not only an assessment of these sectors but also, *inter alia,* the further development of the **TEEBAgFood** conceptual framework, the role of natural capital accounting, the potential role of agro-ecology in providing a pathway for change, and how the findings from these studies feed into the main body of work for **TEEBAgFood**.

As the results from the feeder studies are received, the process has allowed us to identify a number of methodological challenges and opportunities for strengthening future project activities. First, in addition to data availability and data quality concerns, the issue of mapping ecosystem condition to ecosystem services, and to other economic and social indicators, remains a steadfast challenge. This calls for a deeper look into valuation methods, particularly as they relate to agricultural externalities. Second, while the feeder studies look principally at monocultures, it is important to extend the analysis to more complex and diverse forms of food production such as mixed systems. Third, as one agricultural commodity may be used as input for the production of another, there is also the need to reflect the relationship between different agricultural sectors in the analyses, e.g. corn as feed for livestock. Lastly, to have a more comprehensive analysis of our food systems, we need to understand the life cycle impacts of food production, and include entire supply chains.

In light of the above, the **TEEBAgFood** reports that follow the Interim Report are likely to include further sectorial level analysis, new cross-sectorial analysis, global assessments, and a critical appraisal of methodological approaches used to account for the externalities of eco-agri-food systems.

In order to accomplish the above, a **Call for Evidence** will be issued to the wider agri-food community to collect a range of case studies with a broad geographical spread, covering a range of ecosystem services and approaches to their inclusion in decision making. This work would contribute to two reports to be published in 2016.

Box 7. Key interim findings from the TEEBAgFood palm oil study

In a preliminary assessment by Trucost (2015), the top eleven palm oil producing countries were evaluated based on their 'natural capital'(ecosystems and biodiversity) and 'social capital' (livelihood and welfare) costs. These costs were determined by evaluating three main criteria: (i) yield and conversion rate; (ii) quantity and type of inputs; and (iii) the monetary value per quantity of emissions.

Some high-level results* are summarized below. While the full set of findings will be published in the Interim Report, it is clear that production methods and agro-ecological conditions are having a huge influence on the natural and social costs of production. The global market is not reflecting these externalities in an appropriate way.

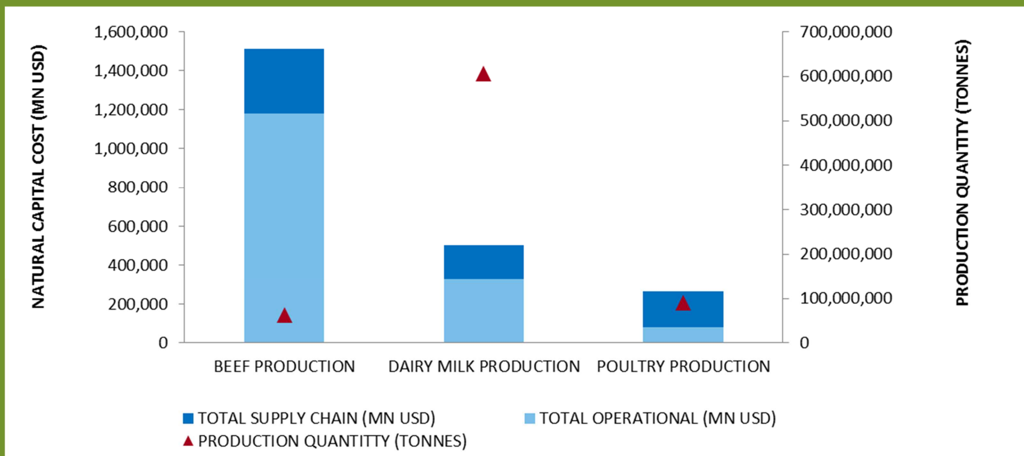
- Palm oil is the world's most consumed vegetable oil with over 56 million metric tons consumed in 2013, a number which is expected to grow as demand is forecast to double over the next 40 years for use in food, cosmetics and biofuels.
- Palm oil and palm kernel oil production generates natural and social capital costs, consisting largely of carbon emissions and their impact on global warming (58 per cent), fertilizer application (23 per cent); palm oil mill effluent emissions (12 per cent); manufacturing of inputs (4 per cent); and pesticide application (3 per cent).
- In total, palm oil and palm kernel oil production in the top eleven producer countries generates natural and social capital costs of US $44 billion per year, ranging between US $271 and US $1,300 per ton, depending on the practices used and the ecological conditions.
- The top two producing countries contribute 66 and 26 per cent (respectively) of the total costs, largely driven by their high production quantity and high intensity (i.e. cost per ton).
- Palm oil production in countries with higher rates of peatland drainage and forest conversion is significantly more costly (a difference of $563 per ton).
- In countries with poor access to safe drinking water, the health impacts of fertilizer application, in particular, nitrate emissions to water, is one of the most material impacts of palm oil production.
- The Final Study will also present an in-depth analysis of producing oil-palm in Indonesia, comparing natural and social capital costs of various production methods.

This study is one of the feeder studies commissioned by TEEB. Please note that the results are preliminary and not as yet peer reviewed.

Box 8. Key interim findings from the TEEBAgFood livestock study

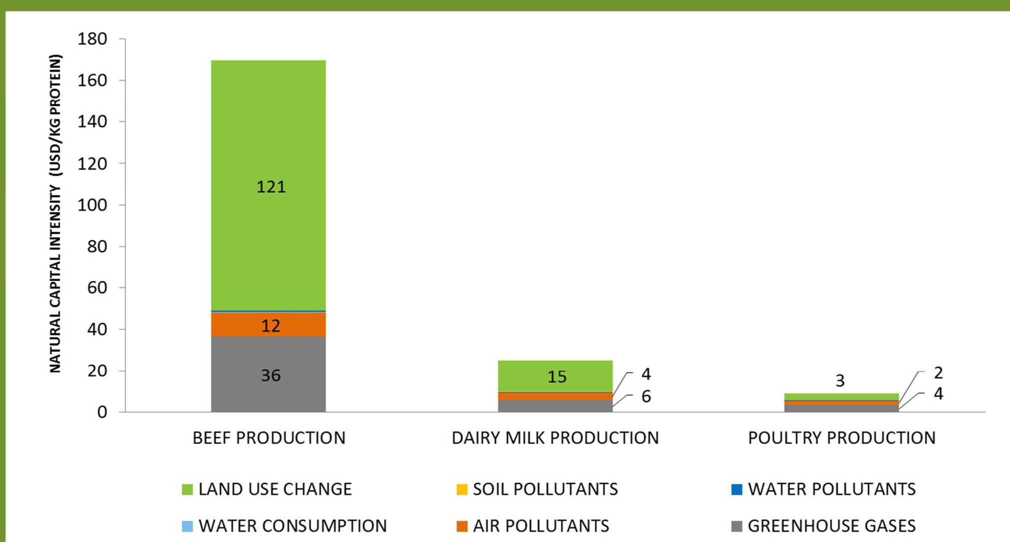
The livestock research team are assessing beef, dairy milk and poultry production. Some key interim findings:

1.- Beef production has the highest impact on natural capital at a global scale. The total natural capital cost of beef production worldwide is approximately three times higher than that of milk production and six times higher than poultry production.



2.- As compared to beef and dairy milk, poultry production has significantly smaller impacts at the farm level, partly due to less land required per animal, and lower GHG emissions, e.g. methane.

3.- In assessing impacts per unit protein produced, poultry production has the lowest impacts due to a combination of the high protein content and low impact on natural capital.



This study is one of the feeder studies commissioned by TEEB. Please note that the results are preliminary and not as yet peer reviewed.

Box 9. Key interim findings from the TEEBAgFood rice study

A study by FAO (forthcoming, 2015) argues that rice production systems deliver various benefits to humans in terms of the provisioning of food, water quality, water quantity, raw materials and climate change mitigation. However, there exist a diverse range of rice production systems and management practices around the world, involving certain trade-offs and/or synergies among the benefits provided. In order to analyse these trade-offs and synergies in more detail, FAO looked at different management systems and practices across five different case study regions, namely the Philippines, Cambodia, Senegal, Costa Rica and California (United States).

In the Philippines, for example, traditional rice terracing practices are often used, which are considered to be feats of landscape engineering for watershed management and water control. Essentially, they capture floodwaters during monsoon periods, and recharge groundwater that may be used during drier periods. Yet these traditional methods are increasingly giving way to more modern forms of production, which might lead to higher yields, yet provide less benefits in terms of water storage. This demonstrates that certain production systems and techniques are perhaps better equipped to maximize synergies and reduce trade-offs than others.

Depending on each management practice or system, these relationships are shown to have either positive, negative or neutral effects on different aspects of rice agro-ecosystems. The next step is to quantify these effects and deliver a detailed biophysical assessment of rice agro-ecosystems that will then build the basis for the monetary valuation exercise to be conducted by project partner, Trucost.

This study is one of the feeder studies commissioned by TEEB. Please note that the results are preliminary and not as yet peer reviewed.

A **'Scientific and Economic Foundations' report** will address core theoretical issues and controversies underpinning the valuation of the biodiversity and ecosystem services within the eco-agri-food system. The report will also set a theoretical context for a broader assessment of agricultural policies allowing decision makers to assess the environmental and social impacts of agricultural interventions. It will also include methodological frameworks for sector-level assessments wherein a shift from one production system to another can be evaluated in terms of ecosystem services provisioning as well as the distributional impacts thereof.

Building upon the foundations of valuing ecosystem services for agriculture, there is a need to investigate the 'theory of change', i.e. how can these valuations form an integral part of decision-making, and what are the institutional changes required to do so? A **'Policies, Production and Consumption' report** will focus on assessments of different agro-ecological production systems within different socio-economic contexts, considering the factors that might lead to policy reform. Moreover, since TEEBAgFood concerns not only agriculture but the entire food systems, the report will also consider food policies, including those targeting distribution, waste and food safety along the entire food chain, from production to final disposal.

The aim of the **Synthesis Report** is to have clearly articulated key messages and policy recommendations arising from the findings of the core reports, written with a broad readership in mind. It will be supported by an extensive communications strategy.

NOTES

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[48] For more information on the challenges of valuation and TEEB's responses see: http://bit.ly/TEEBchallengesresponses