GLOBAL ALLIANCE FOR THE FUTURE OF FOOD

FUTURE OF FOOD

TRUE COST ACCOUNTING FOR TRANSFORMATIVE CHANGE

WHAT WE ARE LEARNING FROM EARLY APPLICATIONS

A COMPENDIUM

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FOR INTERNAL USE ONLY

CONTENTS

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- Ruth Richardson (Global Alliance)
- Harpinder Sandhu (Flinders University)
- Abdou Tenkouano (CORAF)
- Stephanie White (Michigan State University)

LIST OF APPLICATIONS AND STUDIES

1. **Application of the TEEBAgriFood Evaluation Framework to Corn Systems in Minnesota, U.S.A.**,
   by Harpinder Sandhu et al.
2. **A TEEBAgriFood Analysis of the Malawi Maize Agri-food System**
   by Stephanie White, Michigan State University
3. **On-Farm Sustainability Metrics**
   by Patrick Holden, Sustainable Food Trust
4. **A Holistic Lens on Rice Value Chain Pathways in Senegal: Application of the TEEBAgriFood Framework**
   by Barbara Gemmill-Herren et al.
5. **Application of the TEEBAgriFood Evaluation Framework to Wheat in the Punjab**
   by Haripriya Gundimeda, IIT Bombay
6. **Food System Impact Valuation and Risk Assessment**
   by Emily Grady, Matt Watkins, and Eva Zabey, World Business Council for Sustainable Development
7. **TEEBAgriFood Country-Level Studies**
   by Salman Hussain and Dustin Wenzel, UN Environment

INTRODUCTION

Why True Cost Accounting for Food Systems?

The economic environment in which farmers, businesses, consumers, and agricultural policymakers operate today is distorted by significant externalities, both negative and positive. Indeed, most of the largest impacts on the health of humans, communities, ecosystems, agricultural lands, waters, and seas arising from different agricultural and food systems are economically invisible and inadequately considered by decision- and policymakers. This reality has a significant impact on how food and agriculture policy and practice effects pressing issues like climate change, biodiversity, soil erosion, nutrition, food security, and public health. By evaluating the significant external costs and benefits inherent in different food systems, and making these costs transparent, decision makers on farm and in governments, institutions, and businesses can make better-informed decisions that take into account the impacts of the available choices.

True cost accounting (TCA) is a strategic priority for the Global Alliance for the Future of Food. Through our work on TCA we aim to make visible the full costs of food by investing in efforts to identify, measure, and value the positive and negative environmental, social, and health externalities of food and agricultural systems, and to deploy innovative strategies to effect associated policy and market change.

Since 2015, the Global Alliance for the Future of Food has been a key supporter of TCA for food systems, and contributor to the TEEB for Agriculture and Food (TEEBAgriFood) initiative, which is housed at UN Environment's TEEB (The Economics of Ecosystems and Biodiversity) office. This compendium of early TCA/TEEBAgriFood applications and brief synthesis of what we have learned from them is a key input into the April 2019 strategic convening "The Future of Food: True Cost Accounting for Transformative Change." This overview informs parallel sessions focused on TCA applications, lessons learned, and what these mean for priority actions to strengthen TCA.

The sections below include the following:

- Explanations of why the Global Alliance is interested in TCA and TEEBAgriFood;
- Descriptions of the TEEBAgriFood Evaluation Framework and approach; and
- Summaries of lessons learned from early applications.

Some of these applications and studies were supported by the Global Alliance. Others were supported by UN Environment or other organizations, and we appreciate their willingness to include summaries of their work. This document and these summaries will provide background information for Brussels convening participants and inform a parallel session on the topic of TCA applications for food systems. During these parallel sessions, study leads will present their work and lead a discussion about action needed to strengthen TCA. For example, what additional data, research, and analysis are needed? What new or improved methodologies are required? What additional applications are needed? How can we take what we have learned from early applications to inform a next generation of studies? How can these applications inform decision-making across food systems? Working together, how can we develop a new narrative for sustainable, equitable food systems that accounts for externalities, both positive and negative?

Several initiatives are working toward developing frameworks for a "true cost accounting" (TCA) of food and agriculture systems,[1] but the TEEBAgriFood initiative is the only framework that is: a) inclusive, b) holistic, and c) comprehensive in its analysis of externalities (environmental, health, social, cultural) — both positive and negative — across value chains and at the global systems level.

The History of TEEB

TEEB for Agriculture and Food (TEEBAgriFood) is a sub-project of UNEP's TEEB office, a global initiative focused on "making nature's values visible." TEEB's objective is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this goal by following a structured approach to valuation that helps decision makers: a) recognize the wide range of benefits provided by ecosystems and biodiversity, b) demonstrate their values in economic terms, and c) where appropriate, capture those values in decision-making. The two most ambitious applications of TEEB are the Natural Capital Coalition (NCC) — formerly TEEB for Business — and TEEBAgriFood.

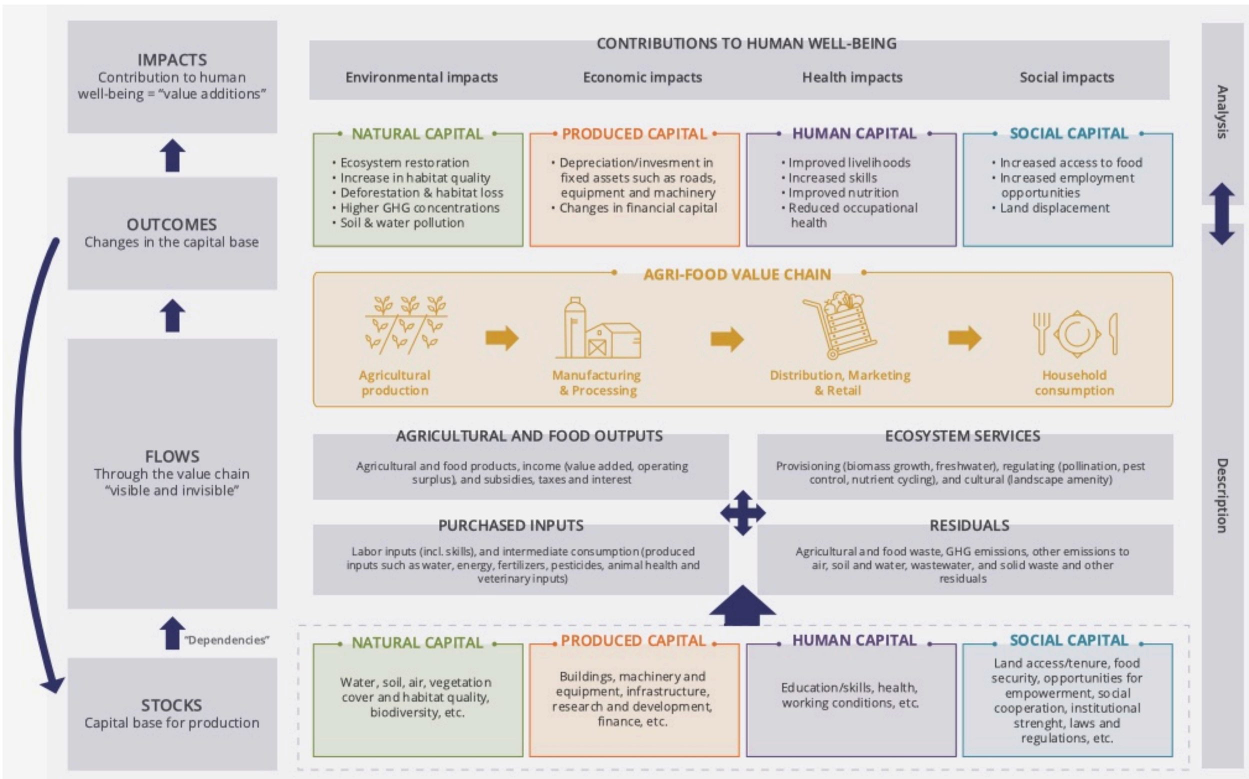
TEEB follows a tiered approach in analyzing and structuring valuation guided by three core principles, as articulated by project founder Pavan Sukhdev:

1. Recognizing that the externalities of human behaviour on ecosystems, landscapes, species, and other aspects of biodiversity is a feature of all human societies and communities and is sometimes sufficient to ensure conservation and sustainable use. For example, the existence of sacred groves in some cultures has helped to protect natural areas and the biodiversity they contain.
2. Valuing these externalities in economic terms is often useful for policymakers and business stakeholders in reaching decisions that consider the full costs and benefits of an ecosystem rather than just those costs or values that enter the markets in the form of private goods.
3. Managing the externalities involves the introduction of mechanisms that incorporate the values of ecosystems into decision-making through incentives and price signals. This can include payments for ecosystem services, reforming environmentally harmful subsidies, or introducing tax breaks for conservation.

1 See Global Alliance for the Future of Food, "TCA for Food and Agriculture Landscape Review" (2019) for more details.

TEEBAgriFood

TEEBAgriFood goes beyond the original TEEB initiative in that it seeks to be inclusive of externalities that are not typically found in environmental economics, including social, cultural, and health-related externalities of food systems, both negative and positive. TEEBAgriFood aims to be applicable across food systems in multiple scales and contexts around the world. The comprehensive Evaluation Framework is an analytic tool addressing the question "What should we value, and why?"



The TEEBAgriFood Evaluation Framework provides a structure and an overview of what should be included in the analysis but does not prescribe methods for valuation. Methods of valuation depend on the values to be assessed, availability of data, and the purpose of the analysis. The application of the Framework requires an interdisciplinary approach, where all relevant stakeholders, including policymakers, businesses, and citizens, understand and identify questions that are to be answered by a valuation exercise. Therefore, stakeholder engagement across sectors is critical to the effective application of TEEBAgriFood in specific contexts and policy arenas.

The TEEBAgriFood Evaluation Framework provides a broad theoretical lens that helps the global community make key systems connections at the global level — it can support progress toward the Sustainable Development Goals (SDGs), as well as help meet global biodiversity and climate targets. The Framework has the potential to provide both conceptual and practical tools for the broader global community as we collectively seek to transform food systems toward greater equity and sustainability.

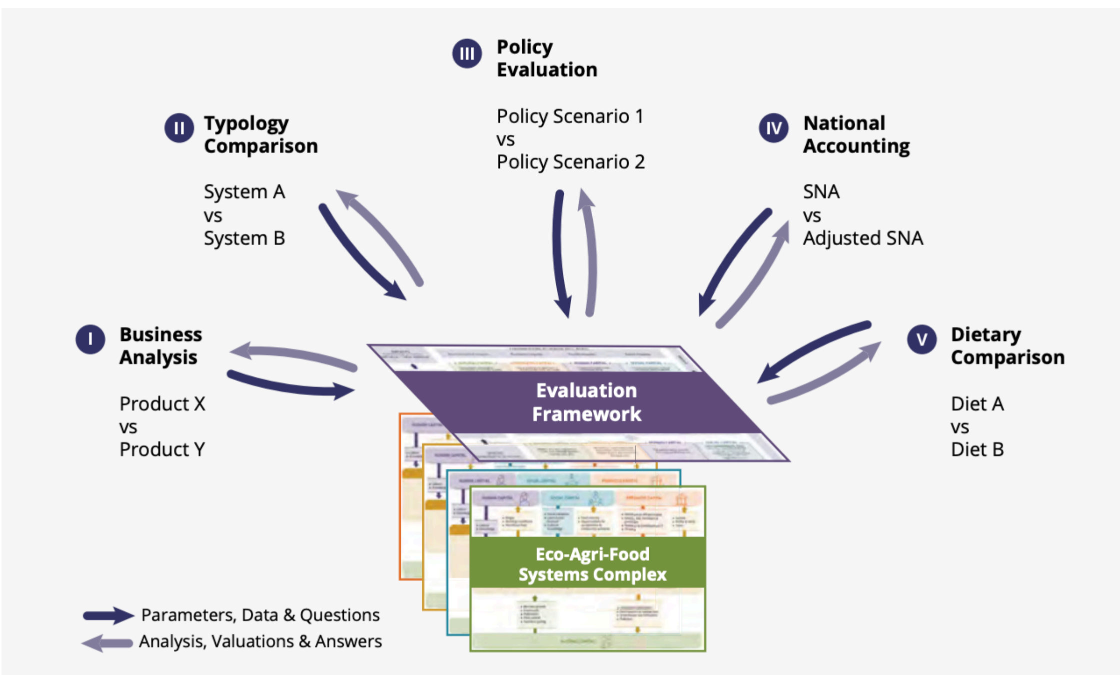
Early exploratory or "feeder" studies on inland fisheries, agroforestry, maize, livestock, rice, and palm oil informed the development of the TEEBAgriFood Evaluation Framework and the Scientific and Economic Foundations report, which was launched in June 2018. Since that time early applications of the Framework have been underway. The purpose of these early applications is to learn from the application experience and to better understand how to provide guidance to future applications.

The TEEBAgriFood Evaluation Framework will only become widely recognized once it is found to be useful at multiple scales and in multiple contexts. A number of different organizations and individuals are working to apply the Framework. The Global Alliance is currently:

- Exploring the development of an application guidance document and "toolkits";
- Considering how individual Global Alliance members could apply the TEEBAgriFood Evaluation Framework to their investments and programs; and
- Identifying opportunities for the strategic application of the Framework across scales and contexts to make the case for food systems transformation.

Applying the TEEBAgriFood Evaluation Framework

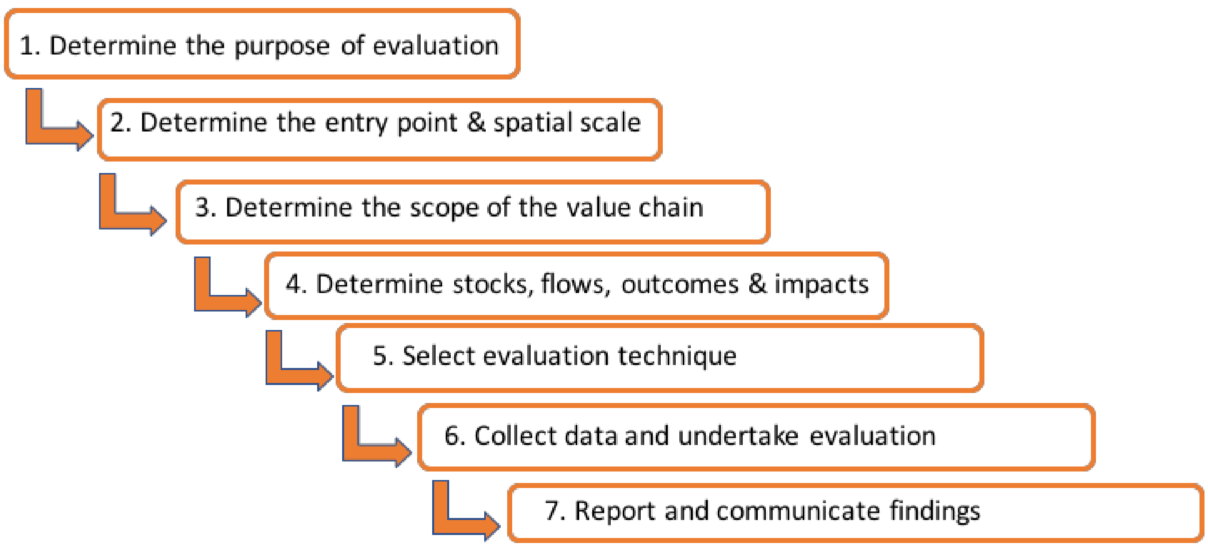
The TEEBAgriFood Economic and Scientific Foundations report outlines five application categories across food systems. The applications outlined below are 1) business analysis (i.e., WBCSD's impact valuation initiative), 2) typology comparison (i.e., corn or rice systems), and 3) policy evaluation (i.e., Malawi's Farm Income Subsidy Program). We do not yet have applications in national accounting or dietary comparison.



The theory of change outlined in the Economic and Scientific Foundations report emphasizes the need for stakeholder engagement throughout the application process to ensure that the process and results are mainstreamed and, as a consequence, food systems are reformed and the ecosystems upon which they depend are restored. Cornerstones of the TEEBAgriFood theory of change are supportive governance systems, and enabling institutions and mindsets (both worldviews and values).

The Global Alliance understands transformations occurring when multiple and diverse initiatives intersected to create momentum, critical mass, and, ultimately, tipping points. Complexity theory explains how dynamic interactions in turbulent and emergent systems result in transformation, and that such transformations emerge from diverse and multilayered innovations and cross-system interconnections and interactions. Enhancing, deepening, and broadening interconnections and synergies among actors using TCA across food systems would constitute a strategic action in support of transformational change.[2]

There are seven steps in applying the TEEBAgriFood Evaluation Framework.



The studies and applications cited in this report followed these steps. These early applications will inform further guidance for study teams. For more information about applying the TEEBAgriFood Evaluation Framework, please see "Appendix A: TEEBAgriFood Background Materials" prepared by UN Environment.

Reflections on the Early Applications

The Global Alliance actively supports or engages with many of the initiatives described in the following pages. Through conversations with study leads and an application review committee convened by the Global Alliance to review the maize in Malawi, corn in Minnesota, and Sustainable Food Trust research, a number of observations and early lessons have surfaced, as follows.

The challenge of systemic framing and a common language

While the TEEBAgriFood Evaluation Framework allows for scaling (up and down), it is challenging to determine the Framework's boundaries across scales. The exercise of providing a description of a system — a key element of the process — is often confused as the application itself. Several questions emerge: How can a whole system be captured? The Framework provides a checklist, but how detailed does this

2 Adapted from Global Alliance for the Future of Food. (2019). "Beacons of Hope."

need to be? What is the best way to describe and represent nested systems? A common approach to describing food systems would support greater cross-disciplinary understanding of each application from the outset as well as provide suitable and stable entry points for systems analysis and discussion, whatever the focus of the specific application. Integrated systemic thinking is the underlying driver for the Framework yet poses significant conceptual and practical challenges.

Context, history, and power

The studies cited in this document recognize the importance of context and history, and how food systems are shaped by these dynamics. For example, the maize in Malawi study describes contemporary maize production as an outcome of colonial policies and programs. Indeed, it is difficult to approach any moment in time without describing the broader context and history. In thinking about capitals and flows, and trying to quantify these, entrenchment and the dependencies that keep the system in place loom large. Coursing through these systems are power relations that also need to be acknowledged. Where does the Framework allow for that analysis? How can we develop common language and systems indicators so it can become more actionable?

Metrics

Study leads and reviewers noted both a lack of data and too much data. Where do we find the right data? What original research needs to be undertaken to support the studies? How do we distil data into key metrics? How do we determine what metrics are meaningful to stakeholders? What is the difference between *true cost* and *true value*? These are socially situated. We use the language of accounting but often the results don't reflect costing and accounting.

Comparing systems

The corn in Minnesota study reflects the difficulty of comparing two different systems at vastly different scales, with different data available. How do we make meaningful comparisons? How do we build alignment across the issues of each study or across a series of studies?

Audience and engagement

The intent of these studies is to influence both policy and practice. Results need to be presented in a way that is useful for both policymakers and practitioners. Stakeholder engagement is a central part of the theory of change, but this hasn't been reflected in all of the early studies. What does long-term stakeholder engagement around TCA for food systems look like? The Sustainable Food Trust study is a good example of the potential for this.

Guidance

What guidance resources can be developed to support study leads? These guidance resources need to reflect the multidimensional aspects of the applications — from study definition and boundaries, to stakeholder engagement, to methodological approaches for calculating different metrics. How can the community of actors interested in TCA and TEEBAgriFood work together to develop and refine these guidance documents and suite of tools?

Next Steps

The following next steps are being considered to support TCA for food systems.

True cost accounting for food systems accelerator

Through discussions with key stakeholders involved in these initiatives, the concept for a "True Cost Accounting for Food Systems Accelerator" has emerged to integrate and coordinate activities, facilitate analysis, support communities of practice, and develop an overarching narrative for work across TCA for food systems.

The goal of the Food Systems Accelerator is to bring TCA to scale, which can be achieved by creating a food systems knowledge hub that reviews, consolidates, operationalizes, and shares the results, learnings, and practical experience of individuals and organizations involved in TCA for food systems.

As opposed to considering singular homes for the Accelerator, TEEBAgriFood, and the TCA CoP, we believe a constellation approach would be strategic and beneficial. A Food Systems TCA Accelerator would act as:

- A central hub for the global TCA community, including practitioners, academicians, business leaders, farmers, policymakers, and other relevant stakeholders;
- A dynamic "repository" for general TCA studies and databases;
- A dynamic "repository" for specific TEEBAgriFood studies and databases;
- A forum for analysis, synthesis, learning, and improvement; and
- A collective voice for the power and potential of TCA to transform global food systems.

The importance of having an Accelerator (versus an organization) to build collaborative communities, attract diverse members with heterogeneous knowledge, facilitate creativity and collaboration in physical and digital space, and connect local and global knowledge and action can't be downplayed.[3] It is critical particularly vis-à-vis the organizations that have vested interests in TCA (Sustainable Food Trust, Natural Capital Coalition, Soil and More, True Price, etc.) and, more so, those that have largely "held" TEEBAgriFood to date (UN Environment).

In this spirit, the Accelerator would provide a connection point to independent and autonomous TCA/TEEBAgriFood work being undertaken (GA application studies, UN Environment Country-level Studies, Sustainable Food Trust metrics and methodology work, etc.), and act as a forum to create working groups around collectively identified and -valued issues and processes, e.g., metrics/methodologies, TEEBAgriFood, policy, etc., that would evolve and emerge over time.

An interim committee is being convened to inform and develop this idea.

3 See https://ssir.org/articles/entry/time_to_define_what_a_hub_really_is

Building a Community of Practice

The Global Alliance has initiated an international Community of Practice for True Cost Accounting in Food Systems. While the genesis of this new project was in part to help strengthen TEEBAgriFood, we see it as a space where all TCA methodologies related to food systems can be explored, and where shared messages, narratives, and strategies for applying them can surface. We feel that only through maximizing collaboration across sectors, approaches, and geographic contexts can we ensure that the most robust methodologies emerge and be taken up by stakeholders.

FoodSIVI

The Global Alliance is collaborating with Oxford University's Food System Impact Valuation Initiative (FoodSIVI), a partnership between academia, industry, and civil society to promote standardized and pre-competitive measurement and monetary valuation of environmental, social, and health impacts of food systems. FoodSIVI's overall purpose is to work with other impact valuation and TCA initiatives to help food systems actors enhance food systems so that they are more sustainable, resilient, and restorative, and deliver better health outcomes. FoodSIVI aims to: 1) improve current impact valuation methodologies and operationalize the Natural and Social & Human Capital Protocols for food systems, and new methods for the valuation of health impacts; 2) promote the development of standardized and comparable data, and convergence of current methods toward a common agreed approach; 3) promote the inclusion of environmental, health, and social data in emerging food information and technology systems, and undertake research in the longer term on the utilization of such systems for impact valuation; and 4) initiate and promote uses of impact valuation for food system governance, regulation, public procurement, research, and consumer labelling through a wide and diverse network.

Inventory

The Global Alliance for the Future of Food is supporting the development of an inventory of best practice examples of TCA for food systems. The inventory will compile, review, synthesize existing studies and databases, and provide strategic recommendations for scaling up TCA for food systems. To understand, improve, and realize the potential of holistic TCA across food systems, we need to systematically review relevant TCA applications to assess and inform best practices, methodologies, and tools appropriate for different users (including private sector, government, institutional, farmer, and civil society). The inventory and systematic review will contribute to the development of a reference database, application tools, and building a broad community of interest in TCA for food systems. Strategic recommendations about how to strengthen a TCA systemic approach across food systems will inform the development of a TCA for Food Systems Accelerator.

Application guidance

We intend to support the development of a TEEBAgriFood Evaluation Framework application guidance document. From this master document, user-oriented tools can be developed to facilitate the application of the Framework by different sectors. Future studies will inform the evolution of this document and associated tools.

APPLICATION OF THE TEEBAGRIFOOD EVALUATION FRAMEWORK TO CORN SYSTEMS IN MINNESOTA, U.S.A.: EXECUTIVE SUMMARY

Harpinder Sandhu (EcoStratex, University of South Australia, and Flinders University, Australia), Nadia Scialabba (FAO, Rome), Chris Warner (Simetrica, London, U.K.), Fatemeh Behzadnejad (Simetrica, London, U.K.), Kieran Keohane (Simetrica, London, U.K., Richard Houston (Simetrica, London, U.K.), Daniel Fujiwara (Simetrica, London, U.K.), Ryan Noe (Institute on the Environment, University of Minnesota, U.S.A.), Peter Hawthorne (Institute on the Environment, University of Minnesota, U.S.A.), Bonnie Keeler (Institute on the Environment, University of Minnesota, U.S.A.), Jennifer Schmitt (NorthStar Initiative, University of Minnesota, U.S.A.)

This analysis of corn systems in Minnesota highlights key positive and negative externalities associated with genetically modified (GM) and organic corn production systems using the TEEBAgriFood Evaluation Framework. The report applies TEEBAgriFood to examine various impacts and dependencies within the corn value chain in Minnesota, as part of Mississippi river basin production systems. It also describes various opportunities for shifting practices and policies to improve outcomes for farmers, industry, and policymakers in the region.

Corn, with a global production of 42 billion bushels from 467 million acres, is second to sugarcane in terms of production. In global trade, it is the second-largest agricultural commodity after wheat. Corn plays an important role in the global economy, with the United States producing over one-third of the global corn supply from 82.7 million acres. In the U.S.A., about 88% of the corn is GM, followed by hybrid varieties, whereas certified organic corn represents only 0.02% of the total area. In order to examine diverse corn-based farming systems, two contrasting management systems — GM corn and organic corn — were selected in this study. GM corn is grown in rotation with soybean as a monoculture, whereas certified organic corn is grown in mixed farming systems.

The TEEBAgriFood Evaluation Framework is applied to these two corn production systems along with their value chains in Minnesota to reveal impacts and dependencies on produced, social, human (including health), and natural capital and to evaluate the hidden costs and benefits of corn production. There are four key elements of TEEBAgriFood: stocks, flows, outcomes, and impacts. A systems approach is applied to quantify stocks and flows of four capitals and to identify change in the social, environmental, and economic well-being of farming and wider communities. The study reviewed existing scientific literature to assess all capitals. We used the Minnesota State average corn production data in this study. However, the health impacts of corn are based on primary research conducted for this study. Here the key outcomes of the study are provided as stocks and flows of each capital related to two systems, policy and systems drivers, impact and dependencies highlighted by TEEBAgriFood, and usefulness for decision makers along with key messages and recommendations for research, practice, and policy.

Produced Capital

Corn is a crop of economic significance

The total area planted under corn in 2017 was 90.1 million acres (harvested 82.7 million acres), with an average yield of 176.6 bushel per acre. The total value of corn was USD 48.46 billion (average price of $3.30 per bushel) in the United States. Minnesota was fourth with 8.05 million acres under corn (harvested 7.6 million acres) with an average yield of 194 (range of 131–218) bushels per acre. Total value of corn in Minnesota was USD 4.51 billion (average price of $3.05 /bushel). About 92% of this was GM and the rest was hybrid corn. Minnesota, with over 500 certified organic farms and 130,688 acres, is ranked ninth in the United States for the total number of organic farms. Organic corn in Minnesota is 14% of the total U.S. production but about 1% of Minnesota corn. Corn for grains was produced on about 160 farms with 28,524 acres, yielding average of 150 bushels an acre. Organic corn prices are higher than the conventional corn prices, at USD 7.46 per bushel, where 5-year average is above $10 per bushel.

GM corn as an energy crop

In the United States, GM corn is widely grown for ethanol production with dried distiller grains (DDGs) as a by-product for animal use. Conventional corn is comprised of hybrids, which are also used for ethanol production or other feed, food, or industrial uses.

Organic corn as food crop

Organic corn is grown for niche markets, such as organic animal feed, chips, etc.

Cost of production

Variable inputs cost in GM corn are higher than those in organic corn based on the average yield data in the United States. Fixed capital costs in organic farms are higher than GM corn due to their small size. Corn yield based on average data obtained from USDA suggests higher yield in GM corn than organic corn. Net returns are found to be higher in organic corn.

Contribution to fuel versus food

One bushel (56 pounds) of corn yields about 2.8 gallons of ethanol and about 17 pounds of DDGs. These DDGs used as animal feed can produce 8.5 pounds of beef. Whereas, 1 bushel of corn used directly as animal feed can yield 28 pounds of beef. It is noteworthy that organic corn is directly used for animal feed.

Social Capital

Dominant crop of social importance

Corn is a dominant crop in Minnesota and is vital for the agricultural economy. About 24,000 corn farmers generated more than $4.5 billion for the economy of Minnesota.

Corn-based social networks

Various types of social networks in Minnesota provide required resources, information, and knowledge to corn growers. There are both public and private sector networks and community groups that provide support to corn farmers in Minnesota. There are clear benefits to the farming community, environment, and society from the social networks associated with both types of corn systems. Social networks enable rural community to cope with the increasing challenges of market volatility, climate change, and degradation of natural resources. However, the study did not examine strengths and weaknesses of each network and how they are impacting corn growers' behaviours.

Human Capital

Urban and rural divide

There is growing divide between rural and urban population in Minnesota due to urban migration trends since 1900. Partly this is due to increasing size of GM corn farms in order to achieve economies of scale.

Ageing farmers

The average age of farmers is 55 and over. The majority of the rural population has achieved high-school qualification as opposed to the urban population, where qualifications are higher.

Health costs of GM corn

High health costs are associated with GM corn production. Total annual health costs associated with corn production in Minnesota is USD 1.3 billion, or USD 233 per capita, or USD 171 per acre (for 7.6 million acres of harvested corn in Minnesota in 2017). Increasing intensity of corn cultivation by 1% costs each of the residents within a 10-kilometre radius USD 24.7 per year. These non-financial health costs associated with corn production are equivalent to 28.8% of the total value of corn in Minnesota (USD 4.51 billion). To estimate the health costs, we applied the Well-being Valuation (WV) method, which offers an alternative to the Quality-Adjusted Life Years (QALYs) approach of valuing the non-financial costs of health. Health costs estimated here are based on the production side of the corn value chain, linked to the corn intensity effect on environmental quality. These non-financial health costs do not include capital costs incurred in the public health system, individual medical expenditures, loss of economic productivity, and loss of taxes and Gross Domestic Product (GDP). The main health risk pathways of corn consumption come from GM corn-fed livestock and poultry products that may carry contaminants as well as sweet beverages that contain high-fructose corn syrup (HFCS), with the latter associated with high incidence of obesity and type 2 diabetes. GM and hybrid corn production systems notably use large amounts of ammonium and nitrate fertilizers and herbicides. Improvements introduced in GM corn management are limited to minimum tillage and cover cropping to save resources while enhancing soil fertility without addressing the excess chemical load produced by corn systems throughout watersheds. Fertilizers, herbicides, and dust from corn systems have been associated with different types of cancer (affecting digestive and reproductive organs and blood) and respiratory diseases. With the increasing adoption of no-till systems, NOx and subsequently PM2.5 emissions are expected to decrease in GM systems.

Health impacts of organic corn

Regarding organic corn production, there is some evidence of the reduced adverse health impact of corn intensity associated with the presence of local organic production. However, a more rigorous analysis of the impact of organic production is required. Organic corn farming does not target HFCS production, nor uses GM seeds and synthetic fertilizers, pesticides, and herbicides, so it is assumed that the absence of contaminants in organic corn consumption has a neutral impact on health. In addition, corn consumption *per se* has positive impacts on health, thanks to the absence of gluten, a lower glycemic index, and a higher content of vitamin E and minerals, such as Zn and Se.

Natural Capital

Benefits

The benefits and negative externalities associated with corn production in terms of impacts on climate change, water quality, air quality, and soil quality, are estimated using existing studies.

Costs

Total environmental cost associated with GM corn production is USD 71.60 per acre or $557.65 million annually in Minnesota, however uncertainty and spatial heterogeneity cause this estimate to vary greatly. Environmental costs estimated here are based on the production side of the corn value chain, linked to the inputs in corn production, and do not include environmental costs associated with the transport, processing, and consumption. In addition, costs on agricultural and wild biodiversity are not estimated, nor impacts outside Minnesota, through the Mississippi River watershed.

True cost of corn

Given the data and information presented in this report, we estimate the true cost of corn production as shown in the table below.

Metric	GM corn	Organic corn
Market price (USD/bushel)	3.05	7.46
Environmental costs associated with fertilizer use (USD/bushel)	0.37	Not quantified due to lack of data on organic farms.
Environmental costs associated with energy use (USD/bushel)	0.02	0.03
Health cost (USD/bushel)	0.88	0.00 Although there is some suggestive evidence for reduced adverse association of organic corn production with general health, quantifying the health costs requires data on exact location and planted area of organic corn farms.

Policy and Other System Drivers

National policy

Market forces linked with U.S. federal policy have driven corn production in Minnesota and throughout the Midwest. While corn has been a major commodity in the region for decades, recent policy changes to the Farm Bill and the enactment of the Renewable Fuel Standard have protected and incentivized corn production by subsidizing insurance for corn production and mandating production volumes of corn-based ethanol.

Demand

Increased demand for corn for ethanol and reductions in funding for the U.S. Conservation Reserve Program have resulted in conversion of hundreds of thousands of acres of retired land to corn production. These policies contributed to record corn production expansion in the United States, both through crop switching and expansion onto marginal land.

Market price

U.S. farm policy over the past 50 years has been driving down corn prices, while government support for fruit and vegetable prices has steadily decreased; HFCS is now the cheapest substance to produce and the hardest to avoid. Low corn prices have also contributed to the expansion of grain-fed animals, whose products are higher in saturated fat and cholesterol and lower in beneficiary fatty acids, with antibiotic-resistant bacteria that compound public health risks.

Mapping to TEEBAgriFood Framework

Dependencies

Mapping of information to TEEBAgriFood analyzed in this study reveals the impacts and dependencies of corn production on four capitals. Corn production system is dependent on all four capitals. Mapping of data from the analysis suggests there is increase in produced and social capital in both systems. However, there is much scope to increase all four capitals in organic production systems, as the area under organic agriculture is less than 1% in Minnesota.

Impacts

Natural capital and health impacts of GM corn are significant at, respectively, USD 557.65 million and USD 1.3 billion annually. Current natural capital assessment is based on nutrient use only. However, much of the social costs associated with pesticides use, land use change, biodiversity, etc., remain unaddressed. For GM corn production systems, there are positive economic impacts; however, the divide between small- and large-scale farmers is increasing, leading to negative health and environmental impacts. Moreover, GM corn is used for producing ethanol, as it is supported by the current energy policy and very little is used for animal feed. Therefore, the current corn production regime is not contributing much to the national and global food security, but it is contributing positively to the economic livelihood of farmers. For organic production systems, there are positive economic and health impacts, but limited environmental impacts due to use of tillage and fossil fuel use in operations.

Decision-making

Decision makers at farm and policy level

Decision makers at farm and policy level can use the information about social and environmental costs and benefits to modify practices and relevant policies for better outcomes for agriculture and society. Given the negative impacts associated with some of the practices in GM corn systems, the farming community can adopt best and sustainable practices or alternative management systems (such as organic systems), which are less damaging to the soil, water, and biodiversity of the farm and help in conservation of resources and increased productivity. Macro-level policies can incentivize different types of farming systems for generating positive social and environmental outcomes in terms of employment, food, and ecological security.

Recommendations

1. Practitioners can use the outcome from this application of the TEEBAgriFood Evaluation Framework in corn systems to make a decision about production systems and practices that can improve all four capitals. Whereas, policymakers can use this information to incentivize such systems that can enhance social, environmental, and economic well-being of farmers and society at large. However, this requires a major shift in U.S. agricultural and energy policies that favour the current GM corn systems.
2. For social and human capitals, further research is required to link different production systems with impact on these capitals. We need to understand the bonds and linkages of various social networks of corn growers so that these can be improved for better outcomes for both.
3. Research on health impacts of corn systems provides tentative evidence for a potentially positive effect of organic corn systems, as compared to GM corn operations. However, more research is required, with finer resolution data than district-level data, including detailed locations of survey respondents and planted areas of organic production in order to estimate the health costs of organic corn. Granular data would also facilitate the development of an improved causal framework, affording future research increased confidence in its findings and offering deeper insights. Expanding the analysis to include other corn-producing states would provide evidence as to whether the negative health effects of corn production hold on a broader scale, and in doing so increase sample size available to researchers.
4. The study reviewed impacts of two corn-production systems on natural capital, especially soil, water, and air. Significant social costs are associated with the nutrients (synthetic fertilizers in GM corn and manures in organic corn) applied in both systems. Best management practices (BMPs) such as minimum tillage and using cover crops are effective at reducing nutrient and soil export in both conventional and organic systems, and thus are effective at reducing the social cost associated with nutrient use. Policies that support the use of effective targeting by using integrated assessment models and multi-factor evaluations are required to maximize social benefits. In addition, social costs and benefits associated with indirect land use change, and biodiversity impacts of pesticide use, habitat loss, and water use, need to be further investigated.
5. Corn-based ethanol production has increased the demand for corn and hence associated environmental impacts without a clear reduction in the carbon intensity of fuel. Moreover, corn produced for animal feed is much less efficient at producing human food calories per unit area than crops produced for direct human consumption. Therefore, efficient use of land resources is required as an alternative strategy to minimize the social costs of food (corn) production.
6. TEEBAgriFood Evaluation Framework (used here) is most appropriate for guiding the analyses. However, further improvement is required to allow single metric for various social, economic, and environmental indicators. A guide for practitioners and policymakers will be a useful addition to the existing Framework.
7. This multidimensional assessment has helped in the understanding of key impacts and dependencies and true costs and benefits of two corn production systems; however, we need to understand how farmers will adopt this new information. We also need to develop pathways for change in consultation with farming communities so that the outputs from this research can be conveyed to farming and rural communities. Finally, we also a need to understand: 1) the receptiveness of TCA by the farming community; 2) its utility as a decision-making tool at farm scale; and 3) the processes of its adoption by farmers.

A TEEBAGRIFOOD ANALYSIS OF THE MALAWI MAIZE AGRI-FOOD SYSTEM: EXECUTIVE SUMMARY

Stephanie White, Michigan State University

The Context: Maize in Malawi

In Malawi, maize is the preferred staple and foundation of the agri-food system. Grown by the majority of farmers on small plots of lands and commonly eaten as porridge called *nsima*, maize occupies a life-sustaining place in Malawian lives. The centrality of maize to economic, social, and personal well-being is reflected in the Chewa maxim, *chimanga ndi moyo* (maize is life). Likewise, policymakers and donors have long conflated maize security with food security. Western economists, for example, have referred to maize as "a ray of hope" to Africa's food security crisis while policy advisors assert that raising maize productivity and improving the performance of maize input and output markets is sine qua non for achieving food security.

Given that many decision makers associate maize security with food security, it is no surprise that huge investments go into raising maize yields. At an international level, public and private agricultural research organizations devote millions of dollars every year to developing improved varieties and cropping techniques. Since 2004, the Malawian government's central policy to bring about maize self-sufficiency is the Farm Input Subsidy Programme (FISP), which seeks to provide around half of farm households with fertilizer and improved seeds at varying subsidized costs. At one point, FISP was celebrated as the Malawi Miracle, but in recent years it is frequently maligned as expensive and inefficient, though many still credit it with creating "macro-level food security."

Though maize output appears to have increased due to FISP,[4] micro-level food insecurity is widespread and diets poorly diversified. Moreover, sustained yield increases are contingent on a number of conditions, many of which are likely to change in coming years. For example, successful cultivation of maize relies on favourable and relatively precise weather conditions, many of which are becoming more erratic in a climate-changing world. In addition, the program, and thus higher maize yields, are contingent on imported nutrients, an increasingly expensive endeavour that relies on fossil fuels.

While some researchers, food security advocates, and citizens have been cautioning about an overreliance on a single crop for many years, only recently have Malawian policymakers formally acknowledged that maize-centricity is problematic. Recent policy documents, for example, such as the 2016 National Agriculture Policy and the implementation strategy for that policy, 2018 National Agriculture Investment Plan, state that "Malawi has over-concentrated on maize self-sufficiency for food…" and recognize the necessity of diversification. Despite this recognition, and the growing chorus of cautionary voices, in 2018 the government of Malawi once again committed over half the agricultural budget to FISP.

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4 Use of the word "appears" is intentional. Recent research calls into question the reported government yield numbers. Readers should refer to the full report for those references.

This report sets out to examine why transitioning away from maize is difficult and seeks to "make visible" the costs of maize-centricity. It does this through the application of the TEEBAgriFood Framework to a desktop review of existing literature. The TEEBAgriFood Framework is a comprehensive evaluation framework that makes visible the social, environmental, and economic externalities hidden in prevailing metric systems. In this way, it hopes to contribute to contemporary debates about both the value and risks associated with maize-centric agri-food systems, as well as the reinforcing practices and relationships that block transitions to more sustainable diets and resilient agri-food systems.

The central assertions of this report are:

1. The focus on maize is disproportionate to the benefits it currently or is expected to provide, especially in light of the devastating and widespread predicted impacts of climate change.[5]
2. Maize-centricity is held in place by prevailing assumptions, values, and analytical frameworks that prevent citizens, policymakers, and development economists from perceiving how and why maize-centric agri-food systems are limited and, perhaps, even antithetical to a goal of food security.
3. Conceptual frameworks that can grapple with the interrelated dimensions of food systems are critical for strategic decision-making that aims for sustainable and equitable food security in a context of climate change, environmental degradation, urbanization, and growing inequality.

Making the Case for Updated Food System Metrics

Efforts to transform the farm sector in low-income countries (LICs) have persisted in one form or another since the inception of the "Green Revolution" in the 1950s, an approach to farming, food security, and economic progress that rested on the assumption that the basic problem in agri-food systems development was low agricultural productivity. At the farm level, the planned transformation of agriculture in LICs was carried out through increased use of modern inputs, which includes hybrid "improved" seeds, chemical pesticides, fertilizers, and insecticides; irrigation and mechanization; land consolidation; and integration of farmers into global markets, which has implications for what crops should be grown. Seventy years after its inception, this basic approach to agricultural development and food security continues to dominate policy interventions and recommendations.

The technologies, policies, and other investments associated with the Green Revolution dramatically boosted aggregate output per person, while income and population growth, policy liberalization, foreign direct investment, and other globalization processes drove exponential growth and consolidation of the retail food sector. In general, the link between agricultural productivity, commercialization, and improvements in well-being are widely assumed, though common development indicators tell a mixed story. They also tell an incomplete story since many outcomes, such as soil degradation, pest build-up or price volatility, or other contextual factors, such as climate change, are left out of analyses and/or treated as separate, unrelated problems. The TEEBAgriFood Framework aims to make visible these hidden outcomes, and how they are interrelated, so they are better considered in decision-making.

5 In its most recent special report, the IPCC predicts reductions in yield and overall food availability in Africa, and the steps that need to be taken to reduce the severity. See http://www.ipcc.ch/report/sr15/.

Historical, Political, and Environmental Context of the Maize Agri-food System

In Malawi, like in many African countries, maize occupies a central position in contemporary agri-food systems. Introduced to West Africa by slave traders around 500 years ago, maize appears to have become common in southern Africa by the mid 1800s. The appeal of maize is clear. For farmers, maize's husk provides it with natural protection against birds in the field and the hard grain of the locally preferred flint varieties protect it against weevils in storage. Compared to other grains, maize yields more food per unit of land and labour and it is more easily processed than the sorghum it replaced. In addition to its agronomic features, maize in Malawi is imbued with cultural meanings that celebrate, enact, and reinforce local identity.

The association of maize security with food security has its roots in colonialism. From about 1912 onward, the British promoted maize as a foundation for food security and used it as a vehicle to exert control over agricultural production and distribution. Following independence in 1964, Kamuzu Banda, who presided over Malawi from 1964 to 1994, continued to use maize-based food security as a means of exerting control, but in ways linked more tightly to Malawian culture. Beginning in the 1980s, Banda's government began to promote hybrid maize and fertilizer use among smallholders. The parastatal marketing board Agricultural Development and Marketing Corporation (ADMARC) turned its attention to the smallholder sector, distributing subsidized fertilizers, marketing farmers' grain, and transporting grain to food-deficit areas during the hungry season. It was this combination of practices that marked the onset of continuous maize monocropping and land tilling.

When Bingu wa Mutharika came into power in 2004, he implemented the Agricultural Input Subsidy Program (AISP), which was later changed to FISP. Between 2007 to 2012, 52% of Malawi's agricultural budget went to subsidies but only 7% to technology and 1% to extension services.

To date, "maize-led development" has produced disappointing outcomes. Despite notable (reported) increases in average national maize yields, human development indicators have scarcely budged and, in some cases, are deteriorating. High volatility continues to characterize maize markets, diets are poorly diversified, malnutrition among children remains high, and poverty levels have increased in recent years. In addition, environmental resource stocks such as agrobiodiversity and soil fertility, which are particularly critical to smallholder farmers who are not able to easily access purchased inputs, are deteriorating due to the continuous cropping of hybrid maize. Climate change is expected to have widely variable impacts that exacerbate uncertainty and extremes. Changes to rainfall distribution are uncertain, but no models project increased precipitation. In the short term, climate change may benefit maize production but increased maize production may worsen soil degradation and deforestation.

Presently, maize occupies at least 60% of cultivated land and is farmed by 97% of farming households on very small tracts of land, ranging in size from 0.5 to 1.5 hectares. It makes up 60 to 70% of total food intake and 48% of protein consumption. Average yields are around 1.2 MT per hectare, which is lower than the average for Africa, 1.8 metric ton per hectare, also considered far below the average potential. Most maize is consumed on farm but commonly does not last for the entire year so many farming households need to purchase maize during the annual "hungry season."

The Farm Input Subsidy Program: Considering Inputs and Associated Dependencies

The basic idea behind Farm Input Subsidy Program (FISP) is simple: Each year, eligible farmers receive vouchers that they trade for fixed quantities of fertilizer and seed. Over the years, farmers have sometimes been required to contribute toward the cost of fertilizer. At the outset of the program in 2004, farmers did not contribute anything to acquire inputs; while in 2005, they contributed 36%. In the most recent year, farmers contributed somewhere around 25% of the cost of fertilizer. FISPs main costs are seeds, fertilizers, transportation, and logistics.

Fertilizer

The costs of acquiring fertilizer are among the highest in eastern and southern Africa, in part because Malawi is a landlocked country. Distribution of inputs are reliant on geographically extensive transportation networks, with plenty of opportunities for delay along the way that are not related to poor infrastructure but to, for example, delays and backups in ports and at borders due to regulations in countries that neighbour Malawi. However, transportation costs are considerably higher than in neighbouring Zambia, also a landlocked country, which suggests other factors are at play, such as the influence exerted by powerful trucking lobbies.

In addition, there are also costs to society that relate to greenhouse gas emissions during its fabrication, transport, and field applications. The costs of a single year's accounting of the greenhouse gasses associated with urea production and field application, for example, represented an additional cost of USD 1,401,345 to society.

Seeds

Many in the development community assert that maize's importance to food security warrants investing in research to create modern hybrids that are "climate smart," which means breeding it to be more drought resistant or capable of growing in shortened rainy seasons. Public investment into maize breeding outpaces investment into any other crop or research program in the CGIAR system. Allocation of resources defines the supply side of research and has an impact on the direction and substance of innovation and adaptation to climate change.

Some researchers argue that investing in a modern seed sector undermines: 1) food sovereignty (by outsourcing seed breeding to the corporate seed sector), and 2) food security (by shifting seed selection away from flint varieties toward dent varieties that have a less desirable flour-to-grain ratio, poorer storage capacity, higher external input requirements, and are more prone to pest infestation). Moreover, because local agricultural knowledge is tied to seed selection, outsourcing seed development and distributing those seeds through FISP and other charitable organizations has a hidden cost of degrading local agricultural knowledge and seed exchange networks (which likely serve as a platform for other kinds of important social interaction and ties, and, potentially, a critical forum for building agri-food system resilience). FISP promotes hybrids, and knowledge about those seeds comes to farmers through agrodealers who are trained by major companies on how to use the seed. Similarly, while FISP has stimulated local maize seed marketing and entrepreneurship, it has stagnated development of other seed enterprises, such as breeding and reproduction, resulting in a vulnerable seed sector rather than a vibrant and responsive one.

FISP-related maize lock-in

Several factors make transitioning away from maize difficult. Cultural preferences for maize, lack of resources to devote to processes and practices that promote transition, and expectations that government will provide yearly subsidies are partly responsible. Less often mentioned are the considerable financial flows that reinforce FISP *and* block efforts to transition away from maize. From 2004 to 2014, distribution of inputs was carried out by parastatals ADMARC and SFFRFM. Since the 2014/15 season, FISP reforms that were ostensibly put in place to spur development of private-sector input markets have served large-scale retailers and multinational companies but have marginalized, or "crowded out," small-scale retailers due to the rules conditioning eligibility. Notably, none of the large-scale retailers or seed companies is locally owned.

Outcomes and Impacts

FISP and a maize-centric food system produce a number of impacts on the capital base that affect human well-being. Four areas are discussed: 1) nutrition, 2) prices and access to food, 3) extension and access to information/skills, and 4) soil fertility and forests.

Nutrition

As of 2016, 37% of children under the age of five suffer from chronic malnutrition, and 30 to 43% are stunted, depending on education levels of their mothers. Children living in urban areas experience less undernutrition and stunting — about a quarter of children in Malawi's cities and towns are stunted. Poor nutrition in childhood has cascading effects throughout life: people are more predisposed to recurring illness, and impaired cognitive and physical development leads to poor outcomes in school, work, and overall self-actualization. The costs of undernutrition are borne by both the public sector and families. The overall costs of poor nutrition in 2012 were estimated at 10.3% of Malawi's GDP, or USD 603,000,000. This represents financial losses to both families and governments that could have been invested elsewhere to build human, social, and other forms of capital. In the absence of concerted effort to improve outcomes and because of projected population growth, the overall numbers of people experiencing undernutrition will grow, which will increase the overall costs to society.

Some research suggests that a FISP targeted solely at maize production encourages farmers to produce maize preferentially so that they can receive the subsidy, which reduces the amount of land allocated to other crops, thus reducing the surplus available for market. While it is not possible to categorically link reduced national crop diversity to national nutritional security, the displacement of other crops could have repercussions in urban areas or among landless farmers vis-à-vis increased prices or reduced food availability. Moreover, because the post-farm value chain is a source of income for many Malawians, continuing reduction in crop diversity could also threaten the livelihood of many small-scale retailers and transporters.

Maize price volatility

Maize price volatility is a key factor in social and market instability. Rapid and unpredictable change in food prices means that producers and consumers never know what to expect or to prepare for, which causes widespread social anxiety. In addition, if households are unable to plan for food expenses, they may be less likely to allocate financial resources to important non-food items, such as health care, education, or investments into economic activities. Food price volatility heightens seasonal food insecurity as households reduce food portions and frequency of meals. Households commonly sell other forms of capital, such as livestock, or members of the family may migrate to other areas to seek work, thus negatively affecting the human capital available to the household and family.

Agro-environmental change and access to knowledge

The focus on subsidies has meant that there is minimal support to other areas of the agri-food system. Most of the available agriculture budget is used to maintain and acquire stocks of "produced capital" (e.g., fertilizers, seeds, trucks, distribution points) and "human capital" (truck drivers, FISP managers, agrodealers, scientists) that hold FISP in place. Consequently, there are few resources to strengthen other forms of social, human, and natural capitals that could, for example, support innovation and adaptation toward resilient agri-food systems. Access to technical advice and resources to minimize post-harvest grain loss (PHL), for example, could make a major difference to food security. Data shows that over a 13-year period, PHL resulted in a cumulative loss of 7,396,505 tons of maize, about 2.5 times the average yearly maize production, worth over USD 1.7 billion.

Soil fertility and forests

Due to lack of other livelihood options, high population density, and declining natural fertility, people are extensifying their cropping activities, removing forests and wetlands, cultivating on steep slopes, and using highly degradable, shallow soils. There are multiple causes of land degradation in addition to unsustainable agricultural practices, including charcoal production and wood fuel harvesting. Like unsustainable agricultural practices, unsustainable charcoal production and wood fuel harvesting are caused by underlying factors of poverty, population pressures, a lack of livelihood options, and national policies that undermine sustainable land management.

Though soil degradation rates vary throughout the country, soils generally suffer due to continuous cropping of maize on small tracts of land and are low in available nitrogen and soil organic matter. In 2014, an average of 29 tons per hectare per year of soil was eroding from Malawi's agroecosystems. Soil loss translates into agricultural yield losses of 4 to 25%, while forest loss translates into losses of animal habitat, biodiversity, medicinal plants, timber and non-timber forest products, and food. Malawi has a comparatively high deforestation rate of 2.5% per year, which, according to a recent report by the UNDP-UNEP Poverty-Environment Initiative, translates to a loss of income to 18% of households in the amount of USD 60 million. The loss of forests and wild food sources is particularly detrimental for children and poor households who depend on them for dietary diversity. A recent paper estimates that between 9.5 to 11% of Malawi's annual GDP is lost to land degradation.

The Way Out: Transitioning to a More Sustainable Food System

At the heart of maize-centricity is the persistent narrative that maize security and food security are the same thing. In addition to technical interventions and programmatic investments, there is a basic and fundamental need for a national conversation to challenge that narrative and to engage the population to identify alternatives. They exist! Moreover, those alternatives build on the existing food system *and* the knowledge and cultural preferences of Malawians, qualities that could be leveraged to ease the transition.

In Malawi, a number of ongoing interventions already apply these sorts of insights to improving social and ecological well-being. Though not necessarily framed in relation to "capital stocks and flows," these interventions and research provide evidence for how attention to factors beyond productivity shapes outcomes. Research and community interventions by Bezner-Kerr and Snapp shed light on how systems approaches open up the solution space in relation to rural livelihoods,[6] while the work of White et al. engages with conditions in urban markets and regional food exchange networks.[7]

In addition to the core-obstructing narrative, multiple dependencies keep the maize agri-food system locked in. On the basis of this study, a recommended path forward will include: 1) investments and other forms of support to the public extension system and local food exchange practices, institutions, and processes; 2) use of decision-making frames governed less by imperatives to "modernize" and participate in a global food system and more by socioecological well-being and agri-food system resilience in the face of climate change; and 3) immediate transition to regenerative agriculture practices that reduce reliance on imported nutrients.

Finally, the application of the TEEB Evaluation Framework to a research protocol could help develop alternative strategies in collaboration with farmers and others food systems actors in Malawi. Among the various geographies and ecologies in Malawi, what alternative food crops could help to transition away from maize? What is their cost of production? How do food security calculations change? What existing food practices could be supported to improve income-earning opportunities to diversify not only the maize production system but also other areas of food exchange, processing, and retailing? What are the hidden costs of *other* potential staples *in relation to the daily realties of average Malawians?*

Knowledge creation is a political process. Any metric system comes with embedded values about what matters, and like any metric system, TEEB true cost analysis will be used to further particular interests. Moreover, the TEEB Evaluation Framework is not immune from being used in overly technocentric ways and excluding non-experts from decision-making. To bring about more sustainable and *just* agri-food systems, engagement of marginalized and poor communities should be integral and profound.

6 Kerr, R., et al. (2007). Participatory research on legume diversification with Malawian smallholder farmers for improved human nutrition and soil fertility. *Experimental Agriculture, 43*(4):437–453.

7 White, S.A., et al., (2017). *Urban food security in Lilongwe, Malawi: Consumer reliance on the small-scale urban food sector.* Global Center for Food Systems Innovation. Research Brief. March 2018.

ON-FARM SUSTAINABILITY METRICS: EXECUTIVE SUMMARY

Patrick Holden, Sustainable Food Trust

Following the release of the TEEBAgriFood Foundations Report,[8] and in response to the growing need for the harmonization of farm-level sustainability assessment, the Sustainable Food Trust (SFT) has been working in the United Kingdom to identify the best possible indicators and metrics for providing an accurate representation of the sustainability of all farming systems. In addition to developing a converged framework, much of this work has involved engaging with different stakeholders, including farmers, government, and the market, to ensure we take an approach that could work across the board. This report details: 1) the history behind our involvement in this work; 2) the progress on developing a harmonized framework of farm-level metrics; and 3) plans for next steps.

History and Background

The SFT's involvement with true cost accounting (TCA) began in 2011 in connection with The Future of Food Conference at Georgetown University in Washington, D.C., at which HRH The Prince of Wales gave a keynote address.

During his speech, The Prince referred to "perverse incentives" that distorted the economic environment in which food producers operate, as a result of which sustainable production was less profitable than its intensive counterpart. These distortions derived from the absence of TCA, specifically the polluter pays principle, and the failure to ensure that agricultural subsidies are targeted toward farmers who delivered public benefits.

Responding to growing concerns about food system externalities, the SFT concentrated one aspect of its work on case studies of individual farms. SFT quickly realized that an opportunity existed for the development of a converged farm-level assessment to work alongside and complement high-level frameworks such as the TEEBAgriFood Evaluation Framework, and convened a small group of farmers and land managers to begin developing a model that drew from the best elements of what was already out there.

The SFT believes that this work is critically important and that such a framework and common language would encourage continuous improvement on farms, enable governments to assess eligibility for public purse support, and provide consumers with a more accessible and easily understood means of evaluating the sustainability of food products in the marketplace.

Thus far, much of SFT's work has been focused on U.K. farming systems, due in large part to the unexpected opportunity that Brexit negotiations have provided to re-develop the U.K.'s own agricultural policy. However, the SFT feels strongly that this project has global significance and is now striving to encourage an internationally accredited harmonized framework for assessing on-farm sustainability.

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8 TEEBAgriFood (2018) Scientific and Economic Foundations Report: http://teebweb.org/agrifood/scientific-and-economic-foundations-report/.

Farmers and Land Managers Working Group

The SFT's farmers and land managers working group was first convened in 2017 to discuss how farmers could better use the information and data they provide to various sources each year to improve management practices. From this work, a consensus arose about the need to identify, categorize, and develop metrics to populate a harmonized framework for on-farm sustainability assessment. Such a framework would not only reduce audit burden for producers but also allow farmers to accurately benchmark against one another.

The SFT Farmers and Land Managers Working Group Roundtable with Michael Gove, the Secretary of State for the Environment (fifth from right), at the Waddesdon Estate in December 2017.

The group now includes representation from a wide range of farming typologies and scales, including: large-scale conventional arable; large-scale intensive dairy; extensive beef and sheep; a mixed organic farming estate; and a small-scale organic dairy and cheese-making enterprise. One of the most encouraging outcomes of this engagement with these farmers and land managers has been the degree of consensus between participants, regardless of their farming approach, about the nature of the categories, indicators, and metrics against which outcomes can be assessed in order to inform individual farm annual audits.

Gap Analysis

Under the stewardship of the working group, the SFT commissioned a gap analysis and series of pilot studies of existing tools conducted by the Organic Research Centre.[9] During this study, and using member farms as "testbeds," SFT analyzed four of the most widely used sustainability assessment tools against the FAO's SAFA (Sustainability Assessment of Food and Agriculture systems) framework, identifying areas of overlap (figure 2). SAFA is, thus far, the most advanced attempt to harmonize standards, so it was felt that rather than reinvent the wheel, it should be used as a baseline.

The exercise underlined the importance of the case for harmonization, as it revealed a very large degree of overlap of data between the different assessment tools (>50%), which, when reviewed against the data requirements by U.K. certifiers and government agencies, highlighted the opportunity for convergence, particularly in relation to qualifying for future market access and public purse support.

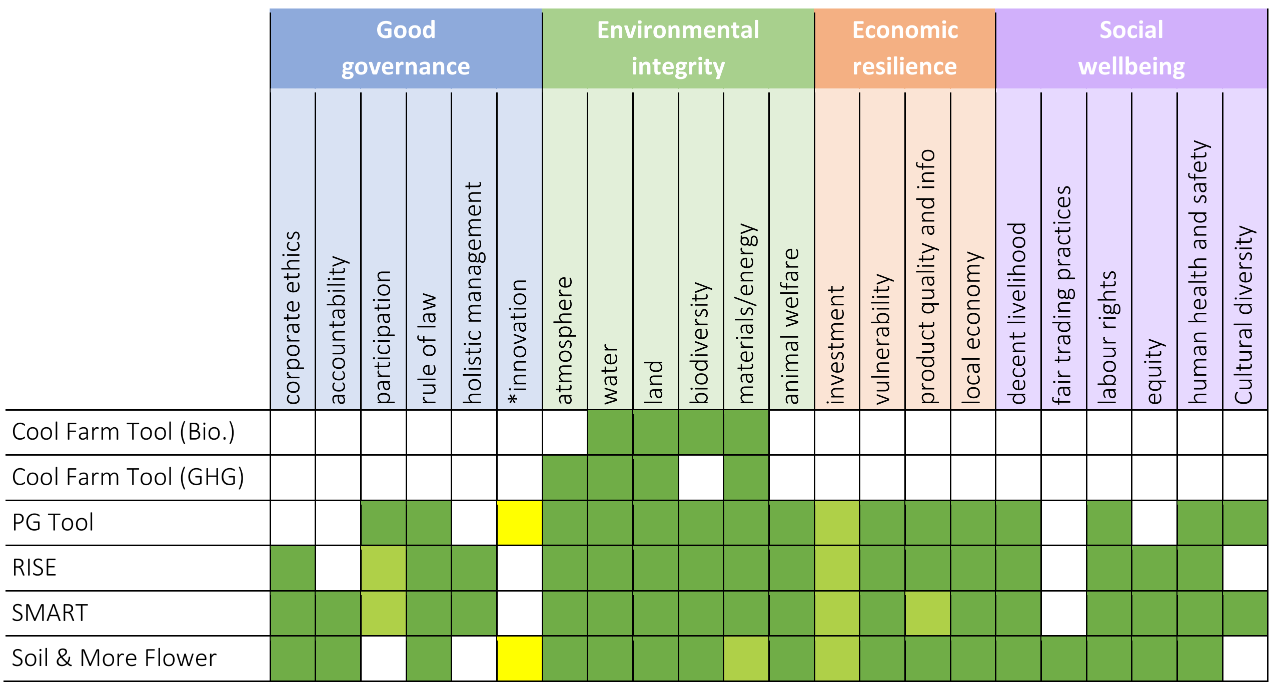


Figure 2: Gap analysis of existing tool mapping areas covered against the FAO's SFA Framework.

9 Smith, L., and Mullender, S. (2017). "Sustainability Metrics: The Case for Convergence." Newbury, Berkshire: The Organic Research Centre.

Harmonized Framework

Following this gap analysis and round of pilot studies, the farmers working group decided to take what they felt were the best elements of the schemes they had piloted, along with the other audits they completed each year, and began developing a draft framework of converged sustainability metrics. Although this framework is still a work in progress, 11 headings have now been agreed as high-level categories of assessment (figure 3), with sub-categories, including indicators and measurements, also listed underneath. The process of identifying which metrics and indicators should be used was driven almost completely by the farmer working group — something SFT felt was of utmost importance as these voices are often forgotten. However, SFT also received help and guidance from experts in the field.

One of the most challenging aspects of this work has been finding the balance between the use of actual "hard" data and proxy measures. SFT feels that although proxy data is an extremely important element of this study, different approaches can be combined and future users of such a framework should consider a mixture of both assumed results based on systems (e.g., taking into account soil type, introducing a herbal ley into a rotation will on average increase soil organic matter by 2% per year) and actual results (e.g., soil testing in a lab).

Summary of Metrics	
Category	**Key metrics**
Productivity	Physical output
	Financial output
	Balance sheet — true cost
Soil	Soil organic matter
	Structure and infiltration rate
	Biodiversity (earthworms)
Water	Source
	Sedimentation
	BOD/pollution load
Air	Emissions by source
	Sequestration
	Balance
Energy and resource use efficiency	Energy usage/mix
	Energy self-sufficiency
	Waste/recycled materials
Nutrient management	Inputs/outputs
	Management efficiencies
	Nutrient balance sheet
Livestock management	Management system
	Diversity, health, and welfare
	Nutrition and input efficiency
Plant and crop health	Crops grown/rotation
	Pest and disease control
	Nutritional quality (Brix)
Biodiversity	Agricultural — seeds and breeds
	Natural — key indicator species
	Landscape features
Social capital	Education
	Community engagement
	Public access
Human capital	Employment
	Skills/knowledge of workers
	Health of workers

Figure 3: Summary of headline indicators in harmonized framework of metrics for on-farm sustainability assessment.

TEEBAgriFood

However, in order to enable meaningful comparative research in TCA and in the application of TEEBAgriFood, it is essential to develop harmonized categories, indicators, and metrics for measuring the impact of food and farming systems at a cellular level. For this reason, and to ensure that the TEEBAgriFood Evaluation Framework has a lasting influence, there is an urgent need to work on connecting the valuation of the food systems at a "big picture" level with the capture of on-farm data.

SFT's aim is to ensure that a harmonized approach to on-farm sustainability is fully aligned with the Evaluation Framework, and builds on TEEBAgriFood's progress through the provision of an additional layer to the Framework that is useful and meaningful to farmers, policymakers, and food businesses (figure 4).

Figure 4: Illustration of how the SFT harmonized framework feeds into the TEEBAgriFood Evaluation Framework, providing another layer of assessment that can then be fed into the monetization process.

The Harmonized Framework in Practice: A Case Study

Using SFT's draft framework of on-farm metrics as a starting point, a "bench testing" process was begun to further refine the categories, indicators, and metrics included and link these to the TEEBAgriFood Evaluation Framework. To do this, SFT commissioned Dr. Harpinder Sandhu to pilot the Framework on three U.K. farms, once again representing a range of different systems and scales under the categories of produced, natural, social, and human capital.

This report summarizes the findings from one of the farms assessed, a 1900-acre organic, mixed dairy operation in Gloucestershire, U.K. The farm is made up of 411 acres of arable land (forming part of a 6-/7-year rotation), 318 acres of permanent pastures, 323 acres in grass leys, 20 acres of woodland, and 28 acres of non-farmed area. It had a diverse range of enterprises, including a 180-cow Ayrshire dairy herd plus followers, producing 1 million litres of organic milk per year; with beef and sheep enterprises also on 800 acres of pastureland. There is an arable area of around 400 acres in rotation, a small horticultural operation supplying local markets, and a heritage orchard.

In line with our harmonized framework, the categories, indicators, and metrics assessed were:

Capital type	Category	Indicator
Produced capital	Productivity	Production per acre
		Profitability
	Plant and crop health	Pests/disease management
		Crop rotation
		Seed source
	Livestock management	Stocking density
		Nutrition source
		Welfare
	Energy and resource use efficiency	Source
		On-farm generation
		Resource use
Natural capital	Soil	Fertility
		Health/biodiversity
		Structure
		C stock in soil
	Air	Source/quantity of energy/diesel/petrol/emissions
		Livestock emissions (enteric fermentation, manure, excreta)
		Fertilizer emissions
		Carbon loss/gain by tillage type
	Biodiversity	Crops
		Animal
		Landscape

	Water	NPK in nutrients
		Pesticides in water
		Flood management plan
		Pathogens/pharmaceutical molecules
Social capital	Social capital	Education programs
		Traceability of food produced
		Networks
		Farm visitors
Human capital	Human capital	Skills of farm workers
		Knowledge of farm workers
		Health of farm workers

Figure 5: Framework of metrics used to assess case study 1: Organic mixed dairy

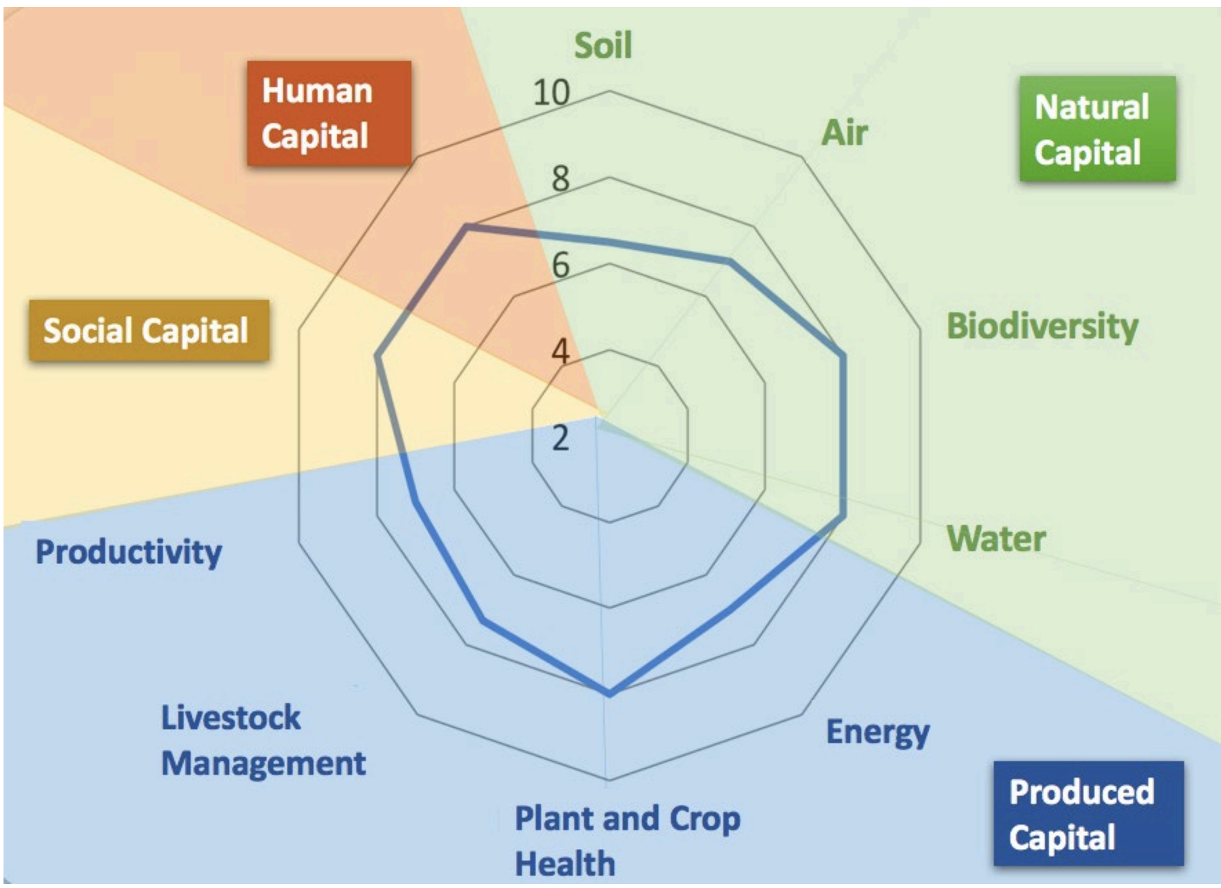


Figure 6: Summary of results of organic dairy/mixed farming system assessment. Each indicator is represented by the blue line on a scale of 1 to 10, where 1 = minimum, 10 = maximum score. High score means higher degree of sustainability for the assessed indicator.

Case Study Conclusions

The score for soil was 6.5, which is slightly above average. Air is rated at a score of 7, which is higher than average. On-farm biodiversity score was also higher at 8. Water quality was rated at 8, as the laboratory test reports do not indicate any nutrients or bacteria detection above the permissible limits. The score for energy was 7, which was higher than average due to use of 100% renewable energy on farm. Plant and crop health score at 8 and is above average. Livestock management score was higher than the average at 7.3. There is much room to improve productivity that scored 7. The score was higher than the average for social and human capital at 8 due to several social networks and skill level of farm workers. Overall the average score for this farm was 7.5, which is higher than average score on all sustainability indicators.

Natural capital

Although the farm has reduced emissions through the non-use of nitrogen fertilizer and relatively modest intakes of cereals in the dairy enterprise, significant greenhouse gas emissions are still linked to the enteric digestion processes of ruminants and manure management. Part of these are already offset by soil carbon sequestration, but it might be possible to consider installing a methane digester, providing the opportunity to generate hot water or electricity, which will reduce net emissions from the farm. Assessment of all woodlands, hedgerows, and corridors around fields is also required to estimate carbon stocks and flows, which should help offset some of the emissions from farm operations. Such carbon sequestration has the potential to make the farm carbon neutral or even carbon positive in response to climate change emission reduction challenges.

Produced capital

Because the farm is organically managed, it not only produces high-quality milk, meats, crops, and other products but also fetches premium prices in the marketplace. As such, it is an example of how environmental benefits can be internalized in market prices. However, for as long as food producers who are not financially accountable for damaging outcomes from their farming systems (such as depletion of natural capital, pollution, and damage to public health), such systems will remain niche in market terms. It may be possible to monetize additional but as yet uncosted benefits, such as the nutritional quality of the crops and other qualitative aspects that would be valued by customers in the marketplace. However, the opportunity is to ensure that the polluter pays and public goods are valued and rewarded.

Social and human capital

The farm has established many extensive networks, both with other farms and with the steady stream of influential visitors. This positive social capital outcome could be further enhanced by including the educational benefit from the footfall of the Highgrove garden visitors. Additional social capital could be generated by enhanced farm workers' training and the inclusion of an apprenticeship scheme; such measures could form part of a Harmony Hub at Highgrove. The farm operating principles could then be adjusted to include social and ethical guidelines in addition to environmental standards.

Case study learnings

One of the key learnings from this study has been how difficult it is to access up-to-date, accurate, publicly available data upon which to benchmark farm-level performance. Going forward, access to data on natural and social capital assets will be critical in order to assess, progress, and monitor change, and this is something that we will be working with government to improve.

Another important learning has been the importance of making the assessment useable and meaningful to farmers. In getting caught up with literature and trends, it is often easy to forget what we set out to achieve — empowering farmers to make change. We remain convinced that if this project is to be successful, it must be driven by farmers but made useable with the different stakeholders who can make use of the data.

These case studies are in the final stages of completion and will be published as a report on the SFT website in 2019.

Response from Government, the Market, and Investment Community

Once these findings are complete, SFT feels confident that we will be in a strong position to offer a prototype sustainability assessment package for wider trials by other interested farmers, organizations and communities of interest, including governments and government agencies, certification organizations, food companies, and impact investors.

To prepare the ground for this, SFT has been liaising with a number of these groups to hear their thoughts and insights on what they feel a harmonized framework must address.

Government

A major development within this project has been discussion arising about the future of U.K. farming and food policy. The SFT has established itself as a significant influence with our Secretary of State for The Department for the Environment, Food, and Rural Affairs (DEFRA), Michael Gove, and his counterpart in the Welsh Assembly Government. Many of the officials involved in the Brexit policy review have participated in farm meetings or other gatherings that the SFT has hosted.

More recently, Adele Jones has been seconded into the DEFRA "gold standard metrics team," an appointment that has enabled us to be a positive influence inside government on encouraging them to base future public purse support on an annual mandatory harmonized sustainability assessment, the architecture of which we are hopeful could be closely related to the prototype that we have developed.

Our harmonized framework of metrics has also recently been accepted as an official trial for "Environmental Land Management" — the principle scheme for delivering post-Brexit farm support, using the mantra of "public money for public goods," which is a very positive development. The purpose of the trial will be: 1) market; certification; and 3) the investment community, as follows.

Market

In parallel with our other activities, SFT has also made contact with a number of food companies with an interest in sustainability assessment, including Nestlé, Unilever, Sainsbury's, Tesco, and Neal's Yard Dairy. In discussions, SFT has emphasized all the points made above and, by and large, our approaches have been well received. Although it is challenging for food companies and retailers to embrace convergence, due mainly to their worry about competition, not one of the companies SFT has approached have disagreed on the principle of working toward harmonization.

Certification

Another key element to this work has been speaking to certification organizations and encouraging them to consider adopting the harmonized framework to help conduct future certification activities. During these discussions, SFT has emphasized the umbilical link between on-farm data collection for sustainability and market labelling schemes, particularly with regard to helping consumers make the right decisions in the marketplace. SFT has also discussed the potential cost- and time-saving benefits for the farmers themselves, since most producers have to undergo multiple audits, often providing similar/the same data under different category headings, resulting in extra cost, time, and bureaucracy that could be avoided.

The U.K. government is currently considering different options for working with certification groups to encourage them to embrace a harmonized framework of metrics. One possible option would be for governments and certification bodies to form collaborative projects and share common data. Through such mechanisms as "earned recognition" (the recognition of operators who show high standards of compliance), farmers could then be subjected to just one annual audit instead of multiple different ones, with the data then being fed to the different places it needs to go. However, in order for this model to be successful, common language, categories, indicators, metrics, and units of measure must be applied.

The SFT has been in discussion with a number of certification schemes in the U.K., Europe, the U.S., and Australia, and have received interest in trialling our harmonized framework from several organizations, which is a positive next step.

The investment community

SFT has recently been in touch with a number of significant partners in the impact investment community who would like to invest in sustainable agriculture but need a common yardstick upon which to make decisions and monitor the progress of the natural and social assets. SFT feels this is a critically important piece of this work, as more significant investment in the right kind of food and farming systems could go a long way in helping to improve the economic climate for the type of systems that regenerate our natural resources.

Next Steps

- **Working group**: Expand the metrics working group to further ensure that it represents an even broader spectrum of farming enterprises, scale, and level of knowledge of/engagement with sustainability issues. Continue SFT's program of regular meetings, refining and developing the framework, categories, and metrics.
- **Harmonized framework:** Continue to work to refine the harmonized framework, drawing on advice and guidance from experts within each category of assessment. This work will also include debating where hard measures should be used and where proxy system-based measures work better to ensure the right balance is struck.
- **Useable tool:** SFT is now in the beginning stages of creating a piece of software behind the 10 categories so it can be used by any farmer at any time without the need for individual analysis of each case study. As stressed, SFT does not intend to reinvent the wheel, but in order to reach the number

and breadth and farmers needed to create something that could work across the board in preparation for the DEFRA trial, we need to make our current model more useable.

- **Collaboration:** Guided by the producer working group, SFT will promote and encourage the concept of a harmonized framework to government, research institutions, farming bodies, certifiers, and tool developers.
- **True cost accounting and TEEBAgriFood:** Work with TEEBAgriFood and those who have been involved with the development of the Foundations Report to ensure our harmonized framework for measuring on-farm sustainability is fully compatible with the evolution of the TEEBAgriFood Evaluation Framework to ensure the two can be used in parallel.
- **Government:** Work alongside DEFRA and the devolved administrations to develop a proposed framework for assessing the sustainability of farming systems in a post-Brexit environment. This will also require meetings with the Treasury, the Number 10 Policy Unit, the Department of Health, and the Department of Education to encourage an aligned approach to thinking about these issues.
- **Food Businesses:** Continue to build relationships with businesses and retailers to encourage them to take up the metric framework to assess the sustainability of their suppliers and then use this information to improve transparency in the marketplace.
- **Communications:** Publish a report detailing the farm pilot studies alongside a public education campaign, promoting the opportunity for governments to reward producers providing public good and retailers who use the framework as a tool to communicate the sustainability of different food products to consumers. This will include a launch event, organizing sessions at related conferences, and liaising with mainstream media about the key messages resulting from the report.
- **Report:** This project will contribute to a new report, "Why sustainable agriculture hasn't gone mainstream and what can be done about it." The report will identify key barriers that are preventing sustainable food production systems from becoming mainstream internationally, to replace their present unsustainable counterpart and to make recommendations about how they can be overcome. One such recommendation will be the introduction of an internationally harmonized framework of metrics upon which to measure continuous improvement.

A HOLISTIC LENS ON RICE VALUE CHAIN PATHWAYS IN SENEGAL: APPLICATION OF TEEBAGRIFOOD FRAMEWORK

Barbara Gemmill-Herren, Renée van Dis, Tabara Ndiaye, Jean Michel Waly Sene, Henok Yimer, Gunda Zuellich, Seydina Ousmane Sene

Introduction

Rice is a critically important staple food crop in Senegal and is the most consumed cereal; however, in order to provide the needed quantities for domestic consumption, a considerable portion of rice is imported (estimated at around 80% in 2005). This makes Senegal the second-largest rice importer in Sub-Saharan Africa (SSA). Rice has long been a valued crop in Senegal, with increasing importance over the last decades. Since the 1980s, the country has emphasized rice production through subsidies, extension, and infrastructure but has failed to compete commercially with imported rice.

Dimensions of Rice Beyond Yields

The contribution of rice — or any agricultural product — to the livelihoods of a people has far greater significance to human (and the Earth's) welfare than is captured by yields or production statistics alone. For example, the act of growing rice remains, in most countries, labour intensive, with "green infrastructure" built and maintained by generations of farmers working together. With its long history of cultivation and selection under diverse environments, rice has acquired a wide adaptability enabling it to grow in a range of environments, from deep water to swamps, irrigated and wetland conditions, as well as on dry hill slopes. When irrigated rice is grown under organic conditions, it creates its own "agricultural ecosystem of unrivalled complexity," harbouring a surprisingly rich level of biodiversity, thought to be among the greatest of any tropical rain-fed system.

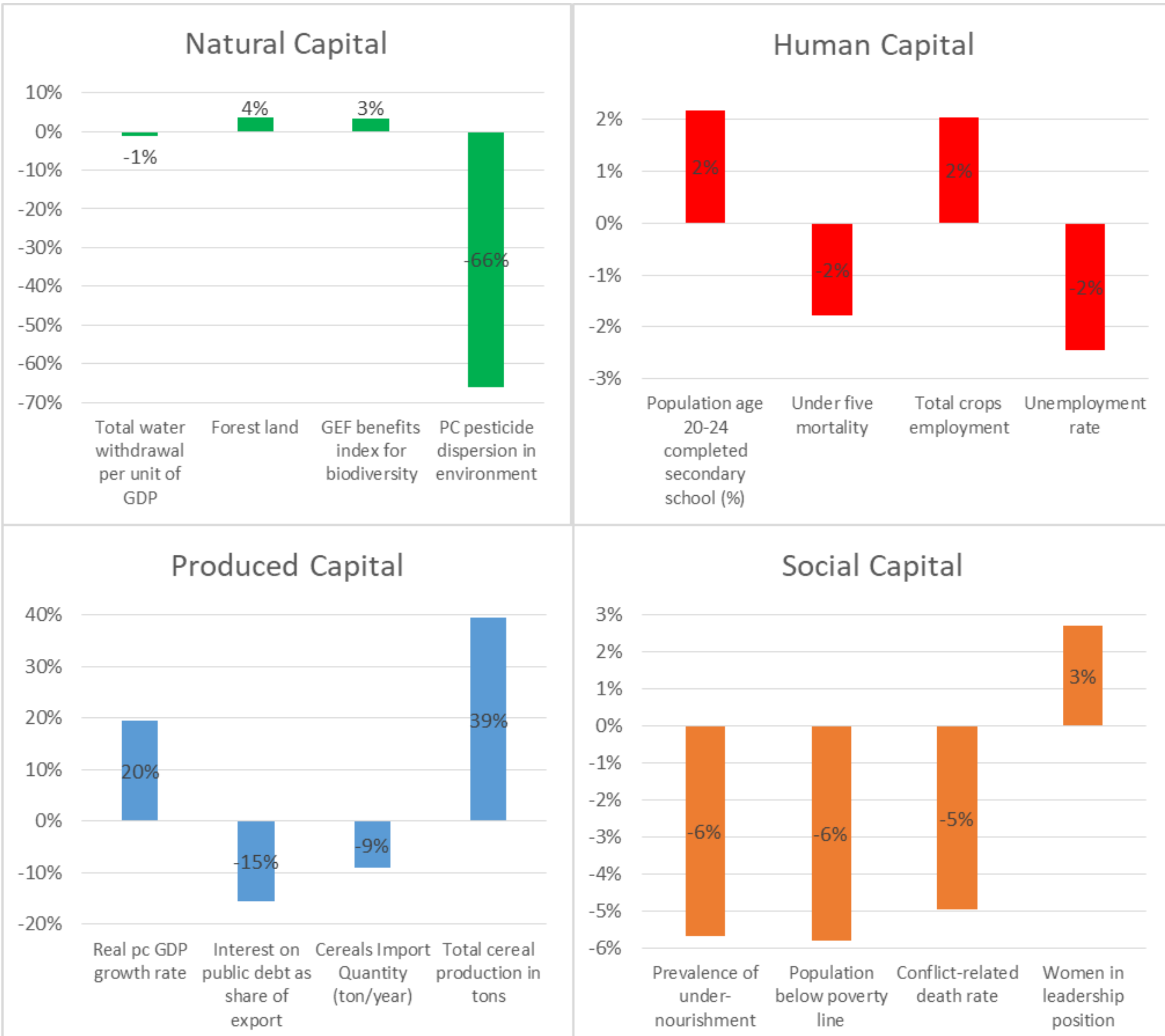
Application of the TEEBAgriFood Framework

To carry out the present analysis, information has been collected about the current status of as many of the stocks and outcomes presented in the TEEBAgriFood Framework, across the rice value chain. Stakeholders from four different groups — a female farmer, two researchers, a civil society representative, and people who have been interacting in an agriculture/governance think tank — were then asked to reflect on the predominant issues for each of the aspects considered. From their articulation of prevailing issues, possibly policy interventions have been formulated.

Application of Systems Thinking

The TEEBAgriFood Economic and Scientific Foundations report makes a strong case that systems thinking should be a guiding principle in the application its Evaluation Framework. The Millennium Institute has been carrying out work with the government of Senegal to develop a systems dynamics-based model to support national development planning around the Sustainable Development Goals (SDGs), structured to analyze medium-long-term development issues at the national level and integrating the economic, social, and environmental aspects of development into a single framework. Thus, it was possible to model two different scenarios: one "business as usual" and the second with possible policy interventions along the rice value chain implemented to 2050 and to review the outcomes; in particular, it was possible to model outcomes on key indicators of the Sustainable Development Goals (SDGs).

Results of scenario simulation: Impact on four types of capital



Impact of changes in rice production on key indicators in 2050 as change in the % in the Agroecological (AE) scenario compared to the Business as Usual (BAU) scenario.

APPLYING THE TEEBAGRIFOOD FRAMEWORK TO WHEAT IN NORTH INDIA

Haripriya Gundimeda, Professor, Department of Humanities and Social Sciences, Indian Institute of Technology, Bombay, India

Introduction

The state of Punjab, often considered the "Grainery of India," has become a post-green revolution success story due to bumper productivity of crops. It is also an example of the dark side of the green revolution due to the impending effects of the excessive use of chemical fertilizers and withdrawing of water. Characterized by crop monocultures, subsidized access to inputs (energy for water extraction, fertilizers, pesticides) and increasing fertilizer use, six decades of intensive wheat cultivation in Punjab has led to a perverse scenario of excessive depletion of groundwater, decline in soil quality and productivity, loss of biodiversity, and severe environmental pollution, culminating in adverse impacts on human health. There are massive externalities in rice-wheat production leading to severe health externalities and ecosystem damages. Most of the externalities in wheat production are due to the input use, the land preparation process, and post-harvest residue management.

In Punjab, farmers follow a rice-wheat cropping system, and in order to accommodate the wheat crop, they harvest the rice early with little time left to prepare the land for wheat. Farmers get rid of the rice stubble (arising due to the use of combined harvesters) through open burning, which has extensive impacts on farm as well off farm. A similar approach is adopted for wheat post-harvest. The burning of wheat and rice residues releases aerosols that mostly contribute to the PM2.5 fraction. In addition, several other human health hazards are due to direct occupational poisoning as a result of spraying of pesticides, as well as secondary health impacts caused as a result of the degradation of air, water, and soil from various input uses. Undernutrition is also an impact of these practices and the policies that support them.

Study Objectives

The study evaluates all significant impacts and externalities for a chosen eco-agri-food system (rural wheat cultivation in the state of Punjab, Northern India), thus testing two applications of the TEEBAgriFood Evaluation Framework: a) typology comparison, and b) alternative policy scenario evaluation. The study looks to highlight the hidden costs and benefits of wheat cultivation in Punjab, applying the TEEBAgriFood Framework, and seeks to develop a common assessment for: 1) conventional versus organic wheat cultivation systems, and 2) existing farm subsidies versus an alternative system of transfer payments to farmers. It will compare costs and benefits holistically, on the basis of economic, environmental, and human impacts, as well as social values and risks and uncertainties. The evaluation explores the possibility of delivering fewer impacts by correcting for policy failures, as farmers might automatically reduce input use (energy, fertilizer, pesticides) or may transition to sustainable alternatives.

Key Results

The study illustrates the application of the TEEBAgriFood Evaluation Framework using very detailed farm-level data for the state of Punjab. The inputs are all quantified and illustrated for both organic and inorganic farming (see Figure 1), and the externalities are estimated (see Figure 2) for the rice-wheat farming system (due to burning of rice residues) for the year 2014. Figure 3 illustrates the projected net returns in organic and conventional wheat production, over time, in the absence of subsidies for conventional farming. The work is still under progress and the results are only illustrative.

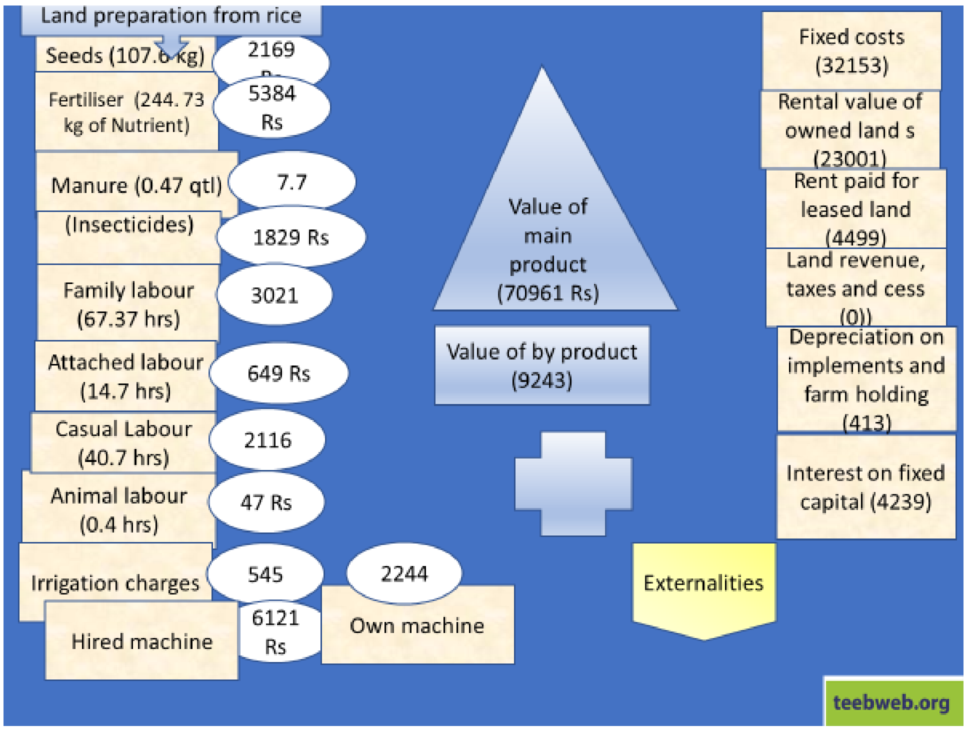


Figure 1

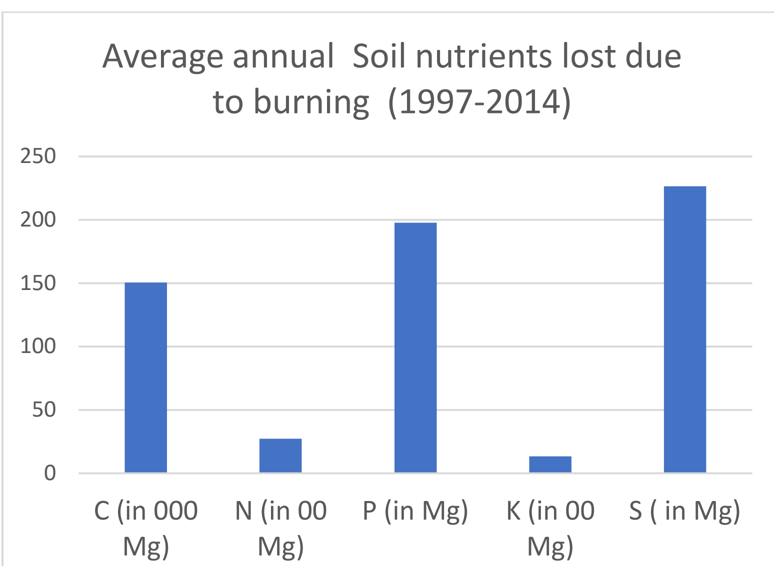


Figure 2

Net returns in organic and inorganic wheat production in the long run in the absence of subsidies on inorganic farming

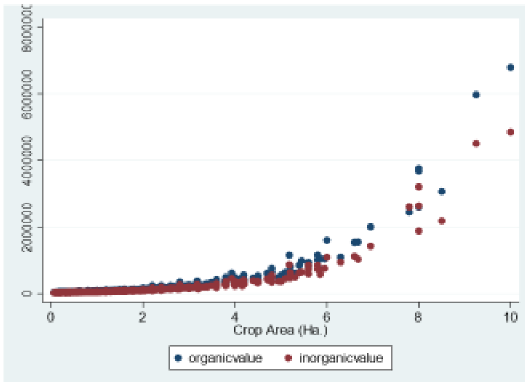


Figure 3

FOOD SYSTEMS IMPACT VALUATION AND RISK ASSESSMENT

Emily Grady, Matt Watkins, and Eva Zabey, World Business Council for Sustainable Development

A collaboration between WBCSD's Redefining Value and Food & Nature Programs, as well as many other leading organizations

Introduction

The world's food systems have the power to nourish and degrade, generating both positive and negative value for society. They bring us juicy strawberries in the middle of winter, the joy of sharing a meal with family, and the satisfaction of a full stomach each day — at least for many of us. They are the means of providing us with the energy and nutrients we need to lead fulfilling lives.

Food systems also let us down — they leave some of us hungry, unable to work and function, or over-nourished, struggling with heart disease and obesity. And while some production systems regenerate soil, many degrade it and are responsible for deforestation, climate change, loss of biodiversity, collapsing fisheries, and more.

Food and agriculture companies depend on the very resources that are being depleted — or altered — to operate. They also generate some of the conditions that lead to over-nutrition and poor health. These factors present significant risk: risk to continuing business as usual, risk to long-term human health and well-being, and even risk to getting next week's meal on the table.

The World Business Council for Sustainable Development's work on Food System Impact Valuation and Risk Assessment strives to advance how we measure and value:

- The **impacts** generated by agri-food companies;
- The **dependencies** of companies on natural, social, and human capital; and
- The **risks** of continuing business as usual.

We aim to help inform decisions today to mitigate risk in the future. We see impact valuation and risk assessment as levers to drive the food systems transformation forward, advancing the Sustainable Development Goals (SDGs) and the Paris Climate Agreement through agri-food sector corporate leadership.

What Are We Doing?

We are driving food systems transformation by helping agri-food companies measure and manage their impacts, dependencies, and risks, informing strategic decisions, and unlocking new opportunities.

There are three pillars of work:

1. **Understand the landscape of impact valuation approaches, frameworks, and datasets of coefficients** through a research partnership with Oxford's Food System Impact Valuation Initiative and the Global Alliance for the Future of Food.
2. **Develop actionable, prescriptive, generally acceptable, and scientifically robust guidelines for integrated impact, dependency, and risk valuation for agri-food companies** drawing on, for example, the TEEBAgriFood Scientific Foundations Report and the Natural Capital Protocol's Food

and Beverage Sector Guide. Critical issues to agri-food sector companies, such as soil health, biodiversity, nutrition, and water, will be highlighted in this work.

3. **Engage with, and inform, investment decision makers on material agri-food sector risks and how companies are managing them.** By encouraging a more consistent impact valuation approach, we envision a clear progression to better internal planning, stronger and more decision-useful external reporting, and better investment opportunities for leading agri-food sector companies.

Why WBCSD?

The World Business Council for Sustainable Development (WBCSD) is the catalyst for private-sector leadership on multi-capital accounting and risk assessment in the food sector.

WBCSD has a long track record of helping companies measure and manage risk, gain competitive advantage, and seize new opportunities by understanding environmental, social, and governance (ESG) information. WBCSD led the development of the Greenhouse Gas Protocol with WRI (2001), Natural Capital Protocol (2016), Social & Human Capital Protocol (2019), and the COSO-WBCSD Enterprise Risk Management Guidelines (2018).

WBCSD also launched the True Cost of Food working group in 2018, consolidating the state of play in private sector TCA in a 2018 discussion paper. Together, about 70 agri-food companies are joining forces through WBCSD on related issues like climate smart agriculture, food loss and waste, positive nutrition, protein diversification and improvement, and more. Collectively, they are reforming business as usual on the ground and up to corporate executives and boards.

TEEBAGRIFOOD COUNTRY-LEVEL STUDIES

Salman Hussain and Dustin Wenzel, UN Environment

Since the launch of the Scientific and Economic Foundations' report in June 2018, the focus of the TEEBAgriFood community of practice has been on shifting from analysis to action by "pilot testing" several applications of the Framework. The immediate next step was to move from analysis to action and commission pilot studies that use and apply TEEBAgriFood and its Framework on the ground. In addition to the country projects funded by the European Union (DG-DEVCO and Partnership Instrument) and German (BMU) International Climate Initiative, the two pilot studies described below were developed with support from the Global Alliance for the Future of Food to deliver quick feedback and results on the viability of the Framework.

Framework-testing studies
http://teebweb.org/agrifood/projects/framework-pilots/ Donor: Global Alliance for the Future of Food Timeline: April/May 2019
Soybean and cattle food chains in Brazilian Amazon – A comparison of externalities faced and relative costs of abatement at different scales of cattle raising from smallholder through ranching. – Impact of policy instruments on transition from BAU to sustainable livestock intensification or low-input crop production. Wheat value chains in northern India – Describe, compare, and (where appropriate) value the magnitude and variability of impacts and externalities between: a) conventional and organic wheat production, and b) between a prevailing policy context of many subsidies — for energy, water, pesticides, fertilizers — and a context of direct transfer payments to farmers through the new unique identity (UID) automated system in India.

TEEBAgriFood in Africa: Assessing options to improve livelihoods
http://teebweb.org/agrifood/projects/devco/ Donor: European Commission Timeline: April/May 2019
TEEBAgriFood Africa will focus on Sub-Saharan Africa, featuring a regional analysis and narrative on the economics of the agriculture and food sector, particularly in terms of the positive and negative externalities it generates, and the national and international (e.g., 2030 Development Agenda and Sustainable Development Goals) policy context in which these realities exist. It will also showcase key findings from three case studies of Framework-testing applications (see below) and situating them within the regional context. Finally, it will present a theory of change, offering some insights into policy opportunities and recommendations for capturing externalities in decision-making so as to lead to better livelihood outcomes. – Rice in Senegal – Livestock in Tanzania – Agroforestry in Ghana (cacao) and Ethiopia (coffee)

Supporting biodiversity and climate-friendly land management in agricultural landscapes
http://teebweb.org/agrifood/projects/iki/ Donor: Germany (BMU) International Climate Initiative (IKI) Timeline: December 2019
By following the TEEB approach, the project brings stakeholders together to identify agricultural land use decisions that would benefit from valuation ecosystem services and biodiversity. This would be followed by modelling impacts of land use, assessing subsequent changes in ecosystem services provisioning, and valuing them so they can be part of the economic calculus of policymakers. A core part of the analysis would be to assess distributional impacts of land use decisions, the income-poor in particular, and provide policy recommendations. – Colombia (Putumayo department) – Kenya (deforestation pressures on the Greater Mau Forest Ecosystem) – Tanzania (land use change between pasture, crops, and plantation forests in the Southern Highlands area) – Thailand (organic versus conventional rice production in the northern region)

Promoting a sustainable agriculture and food sector
http://teebweb.org/agrifood/projects/partnership-instrument/ Donor: European Union Timeline: December 2022
This project aims to protect biodiversity and contribute to a more sustainable agriculture and food sector in seven EU partner countries, with a view to moving toward a level playing field by avoiding unfair competition through low environmental standards. It is based on an internationally agreed methodological framework, introduced in the G8+5 context by the EU, addressing the economics of ecosystems and biodiversity. – Brazil – China – India – Indonesia – Malaysia – Mexico – Thailand

APPENDIX A: TEEBAGRIFOOD BACKGROUND MATERIALS

Provided by UN Environment TEEB team

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focused on drawing attention to the economic benefits of biodiversity including the growing cost of biodiversity loss and ecosystem degradation. TEEB presents an approach that can help decision makers recognize, demonstrate, and capture the values of ecosystem services and biodiversity.

The TEEB for Agriculture and Food (TEEBAgriFood) study seeks to review the economic interdependencies between human (economic and social) systems, agriculture and food systems, and biodiversity and ecosystems. In doing so, it addresses the economic invisibility of many of these links while exploring how biodiversity and key ecosystem services deliver benefits to the agriculture sector and also beyond, itself being a key contributor to human health, livelihoods, and well-being.

A major output of TEEBAgriFood is a Scientific and Economic Foundations report, which addresses the core theoretical issues and controversies underpinning the evaluation of the nexus between the agri-food sector, biodiversity, and ecosystem services and externalities including human health impacts from agriculture on a global scale. As part of this research, authors have developed an Evaluation Framework that provides broad categories of all interactions that may exist within a given "eco-agri-food system."

Since the launch of the report in June 2018, the focus of the TEEBAgriFood community of practice has been on shifting from analysis to action by pilot testing several applications of the Framework.

Introduction to the TEEBAgriFood Evaluation Framework

Why use the TEEBAgriFood Evaluation Framework?

Most current assessments of agricultural and food systems are partial and ignore a number of important relationships that eco-agri-food systems have with our economy, society, environment, and health. Examples of partial assessments include farm-level assessments of productivity on the basis of yield per hectare only or assessments of environmental efficiency that cover the agricultural production chain but focus only on water or energy use. Such assessments, while clear in scope, omit broader issues of sustainability and equity that are fundamental considerations in assessing food systems.

Thankfully, discussion is growing around new approaches to assessing eco-agri-food systems including the use of sustainability indicator sets, the measurement and valuation of ecosystem services as inputs to food systems, and the assessment of the connections between food and population health. The perspective of the TEEBAgriFood Evaluation Framework is that these types of approaches need to be integrated in order to better inform policy decisions. Assessments that are context specific and that consider a comprehensive set of interactions, as described in the Framework, will ensure that decision-making about food systems captures all material interactions between environment, economy, society, and health and covers interactions from the farm to household consumption.

What does the Framework include?

The Framework includes four elements — stocks, flows, outcomes, and impacts — that capture the set of interactions (see Figure 1). The stocks of eco-agri-food systems comprise the four different "capitals": produced capital, natural capital, human capital, and social capital. These stocks underpin a variety of flows encompassing production and consumption activity, ecosystem services, purchased inputs, and residual flows. The dynamics of an eco-agri-food system lead to outcomes that are reflected in the Framework as changes in the stocks of capitals, both quantitatively and qualitatively. In turn, these outcomes will have impacts on human well-being.

By providing key definitions and associated measurement concepts and boundaries, the TEEBAgriFood Evaluation Framework establishes *what* aspects of eco-agri-food systems may be included within a holistic evaluation. The chapter does not focus on *how* assessments should be undertaken, nor does it prescribe methods for assessments. The choice of methods will depend on the focus and purpose of any given assessment, the availability of data, and the scope of analysis.

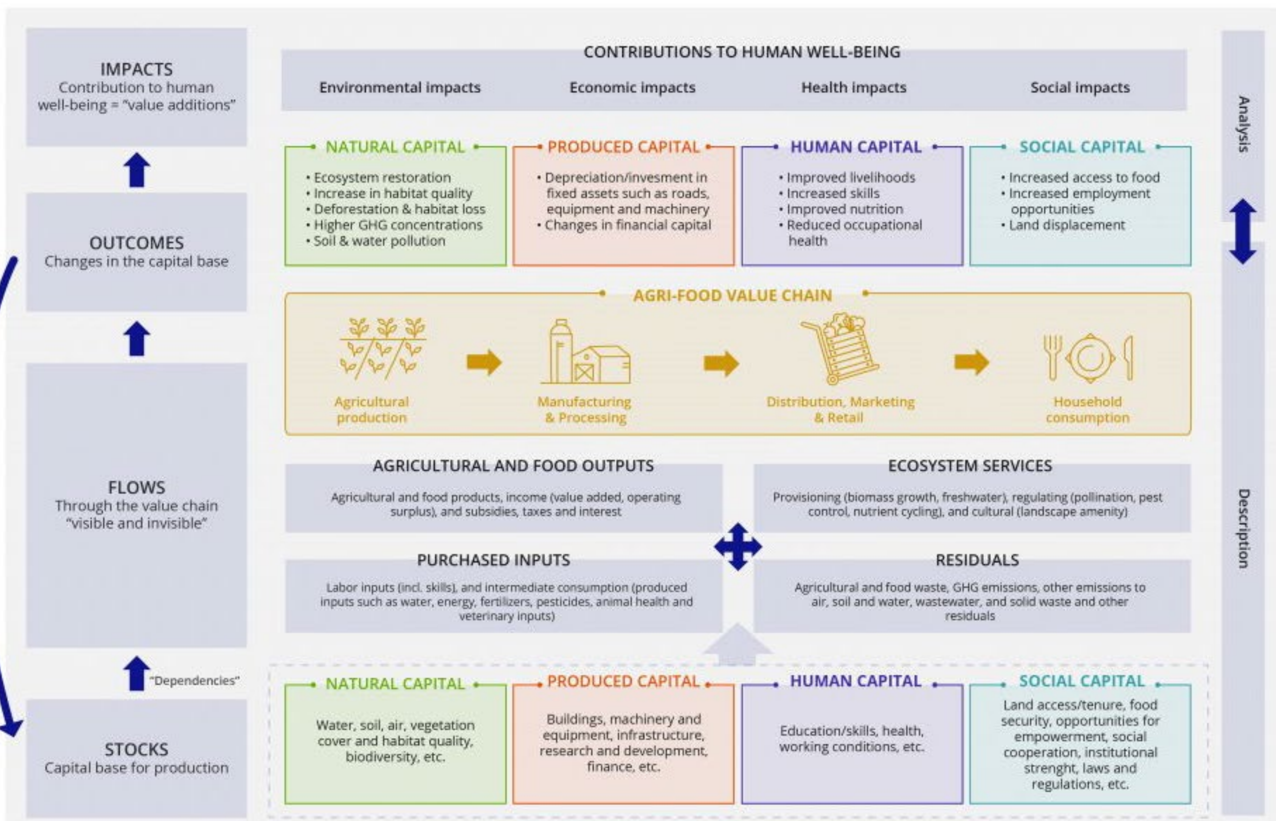


Figure 1: Elements of the TEEBAgriFood Evaluation Framework

What is the purpose and role of the Framework?

With these considerations in mind, the Framework identifies and characterizes *all* relevant elements of our eco-agri-food systems. Of course, eco-agri-food systems are heterogeneous with significant variation in terms of types of outputs, the nature of production systems, and value chains. Further, there will be different purposes and perspectives for each assessment. By way of example, while health impacts at consumption stages for corn produced for corn syrup may be material, this would not be the case for corn produced for ethanol for use in biofuel production. Thus, not every possible combination of elements covered by the Framework will be relevant and material in every assessment.

The Framework has thus been designed to provide broad categories of all interactions that may exist within a given eco-agri-food system. This provides a clear and common starting point for all assessments as they work toward identifying the elements that are most material in their context.

While all assessments will have somewhat different coverage, it is also expected that all TEEBAgriFood based assessments have the following features. They should:

- Be broad and systemic in nature;
- Reflect the contributions of all four capitals; and
- Examine connections along the full value chain, including assessing the impacts of food consumption on human health.

If these three features cannot be demonstrated, then the assessment would be considered a partial assessment and not consistent with the spirit of the TEEBAgriFood project.

How can the Framework be used for an evaluation or a study?
To demonstrate how the Framework may be used, the following steps may be followed:

1. **Determine the purpose of evaluation**. The purpose of the evaluation exercise may differ within and across groups such as researchers, businesses, or consumer groups. A clear articulation of purpose should be used to scope an assessment.
2. **Determine the entry point and spatial scale of analysis**. The entry point would depend on the research interest or focus of the study. Relatedly, appropriate spatial boundaries would need to be defined — within or across regions, countries, etc.
3. **Determine the scope of the value chain under analysis**. This requires the researchers to understand the system and bring together relevant literature and sources to support their description of the value chain — from production to consumption.
4. **Determine the stocks, flows, outcomes, and impacts most relevant for the purpose of the study.** The relevant aspects that should considered through literature review and research are:
    a. At each and every value chain boundary, identify the flows outlined in Figure 1. It is important to understand that these flows can help identify pathways through which the four capitals contribute to agri-food value chains, and how in turn agri-food value chains may impact the capital stocks. These may include waste or emissions generated along the way. This of course requires certain level of knowledge and research of the given system in question.
    b. At each and every value chain boundary, identify the social-, produced-, natural-, and human capital–related outcomes of the system (Table 1 provides some examples). This of course requires certain level of knowledge and research of the given system in question.
    c. Evaluation of these two aspects requires an understanding and mapping of the spatial scales at which these interactions are happening — ecosystem services used at the farm level may be generated beyond the farm, for example. Similarly, health outcomes of a particular food product may happen well beyond the farm, especially if there is international trade.
    d. Given these considerations, the assessment must identify the impacts that it is choosing to address and the ones it is excluding, and provide appropriate reasons.

5. **Select evaluation techniques.** While the first four steps provide the framing and scope of the evaluation, the next step is to choose the techniques that would help one assess and measure the interactions within a given system. For TEEBAgriFood, the focus is on assessing impacts as contributions to human well-being. Other evaluation methodologies may include life cycle assessment and value chain analysis, and various modelling tools and techniques including partial and general equilibrium models and system dynamics.
6. **Collecting data and undertaking the evaluation**. Once the context and methods for evaluation are set, efforts can be made to collect data. While data availability can be an important factor in defining the scope of assessments, by completing steps 1 to 5 prior, the implications of lack of data can be understood and can provide motivations for identifying and filling information gaps.
7. **Reporting and communicating findings**. Communicating the results of the evaluation exercise should be seen as an essential part of the process. Particular note should be taken of the need to develop a range of outputs to suit different audiences, including politicians and business leaders, technical experts, farmers and local communities, and the media.

To support the application and implementation of the Framework and the associated discussions among stakeholders, it may be useful to use the tables and text from Section 6.3 of the chapter that explain the various components of the Framework. With this in mind, the table below provides a stylized version of the Framework in the form of a checklist that can be used by researchers and decision makers to consider the relevant interactions and to ensure awareness of those aspects excluded from an assessment.

Table 1 comprises two main sections: 1) stocks/outcomes (changes in capital stocks), and 2) flows. Several of these elements may be measured differently — for example, in qualitative, quantitative, or monetary terms. Impacts (value addition) elements are excluded from this table since the scope of measured impacts will relate directly to the scope of capital stocks, outcomes, and flows that are included in an assessment. The methodologies for assessing impacts are presented in the TEEBAgriFood "Scientific and Economic Foundations" report, Chapter 7.

It is important to note that several of these elements would require a more detailed description and measurement depending on the scope and context of the assessment being conducted. For example, depending on the assessment, water may include coverage of both surface and ground water resources. Furthermore, quality indicators of water may include several other elements such as habitat quality or nutrient profile. Finally, it is not always the case that all components receive the same type of evaluation and measurement. Thus, in using the table to assess the coverage of an assessment, it will be relevant to distinguish as to whether a component is being assessed descriptively, quantitatively, or in monetary terms.

EXAMPLE OF A CHECKLIST TO ASSESS COVERAGE OF A GIVEN TEEBAGRIFOOD FRAMEWORK APPLICATION		Value chain			
		Agricultural production	Manufacturing & processing	Distribution & marketing	Household consumption
Stocks / Outcomes (change in capital stock)					
Natural capital	Water (incl. quality, quantity)				
	Soil (incl. quality, quantity)				
	Air				
	Vegetation cover and habitat quality				
	Biodiversity				
	Other				
Produced capital	Buildings				
	Machinery and equipment				
	Infrastructure				
	Research and development				
	Finance				
	Other				
Human capital	Education / skills				
	Health				
	Working conditions (decent work)				
	Other				
Social capital	Land access/tenure (private, public and communal)				
	Food security (access, distribution)				
	Opportunities for empowerment (gender and minority)				
	Social cooperation (incl networks/unions)				
	Institutions				
	Laws and regulations (e.g. child labor)				
	Other				
Flows					
Agricultural and food outputs	Agricultural and food products				
	Income: value added, operating surplus				
	Subsidies, taxes and interest				
Purchased inputs	Labour inputs (incl skills)				
	Intermediate consumption (produced inputs such as water, energy, fertilizers, pesticides, animal health and veterinary inputs)				
Ecosystem services	Provisioning (e.g. biomass growth, freshwater)				
	Regulating (e.g. pollination, pest control, nutrient cycling)				
	Cultural (e.g. landscape amenity)				
Residuals	Agricultural and food waste				
	GHG emissions				
	Other emissions to air, soil and water				
	Wastewater				
	Solid waste and other residuals				

Legend	
	Descriptive information available
	Quantitative information available
	Monetised information available
	Not included in study

Table 1: Sample checklist to assess coverage of a given eco-agri-food system application

How does the Framework guide researchers, decision makers (public or private), local communities, farmer groups, and other users?

Utilizing a comprehensive and universal Framework provides a common basis to compare assessments, a tool for decision makers to understand what information is missing, and a means to identify areas of further research.

Since it includes all categories of material interactions in a given food system, the Framework can offer entry points to many people — for example, researchers focusing on social impacts of food systems can use social capital related outcomes as a starting point, and then make linkages to the other three capitals. Similarly, decision makers can start at the economic elements but then identify how these may be related to other capital stocks and flows. The Framework can also help decision makers quickly identify any blind spots in the information base used to support decision-making. In essence, no matter what the starting point or purpose, the Framework can allow researchers to contextualize their assessments within the broader set of interactions of their food system. This not only brings transparency to their assessments but also highlights the opportunities to link their work with other research.

The TEEBAgriFood Framework can also be a starting point for identifying the material elements of particular systems and thus can lead to the development of guidelines on comparable assessments. For example, similar firms, in terms of size and products, in the food and beverage sector could use this Framework to identify the main impacts and dependencies of their sector's operations. Similarly, organizations such as farmer cooperatives, consumer protection groups, and local governments could elaborate on the impacts and dependencies most relevant from their perspective. We encourage the adoption and adaptation of the Framework by diverse groups, and hope that over time, sector-specific guidelines can emerge from the Framework.

Further, the Framework is intended for use in an interdisciplinary manner, where the questions to be analyzed, the options to be compared, and the scale, scope, and relevant variables included are determined in an open and participatory way. This engagement should occur before the appropriate assessment and valuation methods are implemented.

Overall, the Framework allows for a broadening of our understanding and conversations around agricultural and food systems. Our aim is that international policies and targets increasingly begin to recognize the interlinkages, in terms of impacts and dependencies that food systems have with our economies, societies, health, and environment. In this task, using the Framework and its language can allow for the next generation of agricultural and food research to provide a more comprehensive basis for decision-making.