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True cost of food and land degradation

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Abstract

Achievement of Sustainable Development Goals critically depends on well-functioning food systems which can provide sufficient and healthy food for all in an environmentally sustainable, economically viable and socially equitable manner. However, current food systems are failing on all of these dimensions. In fact, food systems are generating substantial amounts of environmental, health-related, social, and economic externalities negatively affecting the well-being of present and future generations of people, particularly that of the poorest and most vulnerable. True cost accounting approaches, a research frontier in sustainability sciences, seek to comprehensively measure these so far unaccounted externalities from food systems to propose solutions for addressing their negative social welfare effects. Contributing to discussions on true costs of food, this paper traces the environmental costs of ecosystems degradation due to cropland expansion during the period of 2001 to 2009 at the global level. The results show that cropland expansion caused by growing food demands has led to the degradation of 511 million hectares of higher value forest, woodland, shrubland and grassland ecosystems globally, with the total economic costs equaling 435 billion U.S. dollars. This means that each year the global community is incurring 54 billion U.S. dollars of externality costs from food systems because of cropland expansion alone. Addressing this problem requires a flexible government regulation combining incentive mechanisms such as payments for ecosystem services and carbon pricing, with legislative deterrents, e. g., environmentally friendly cadastral planning, fines, and taxes. Current research on true cost accounting is primarily focused on identifying the extent of externalities from food systems. However, knowledge does not always automatically translate into action. The key impetus for future actions for true pricing of food would come from closing knowledge gaps on transaction costs for the implementation of true pricing and the development of innovative solutions for reducing them.

Keywords: true cost accounting, food systems, land degradation.
JEL classification: Q01, Q15, Q18, Q24, Q51, Q57.

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1. Introduction

Achieving sustainable development and eradicating hunger and malnutrition around the world depend on producing sufficient amounts of healthy, nutritious and affordable food without damaging the environment. However, our current food systems are having an immensely negative environmental, social and economic impacts both globally and locally around the world (IPBES, 2019; IPCC, 2019). Food systems are made up of complex value webs of production, processing, distribution, and consumption of food, as well as disposal of food waste (von Braun et al., 2021). All of these components of food systems are generating huge amounts of externalities, i.e., the costs which are not integrated in the market prices of food but still incurred by societies at large and specific individuals. To illustrate, the total amount of annual expenditures on purchasing food by the global population now equals to about 9 trillion U.S. dollars. At the same time, these food expenditures do not reflect the costs associated with externalities generated by food systems. These externalities are primarily linked to damages to the environment during the food production and costs to human health through consuming unhealthy food. Hendriks et al. (2021) estimated that the externalities from food systems equal 19.8 trillion U.S. dollars each year, i.e., twice more than the marketed value of food. About 35% of these external costs are due to environmental damages resulting from food systems, 55% are related to human health and mortality costs, and the remaining 10% are economic costs (Hendriks et al., 2021). These external costs from food systems are invisible in farm or company balance sheets or national gross domestic products (GDPs). Nevertheless, they represent tangible costs reducing the well-being of present and future generations of people.

Accounting for these externalities caused by food systems and reflecting true costs of food in food prices constitute an emerging interdisciplinary science frontier where economics can provide with particularly relevant insights. Various approaches have so far been suggested to shed light on and to integrate these externalities within public policies and business models, including such approaches as life cycle costing, activity-based costing, material flow costing, total economic value, or environmentally balanced scorecards (Sandhu et al., 2021), which can be summarized under the broad category of true cost accounting approaches. Such accounting seeks to quantify monetary values of the externalities generated by food systems.

Contributing to this literature on true cost accounting in food systems, this paper intends, firstly, to assess the opportunities and challenges associated with true cost accounting of food system externalities, and secondly, to provide a focused discussion on one aspect of these externalities: externalities from food systems through land degradation.

2. Conceptual underpinnings

The knowledge that economic activities generate a substantial number of externalities is not new. Already in 1920s, Arthur Pigou highlighted the external costs generated by air pollution to society and suggested what has since then been named as Pigouvian taxes to address these externalities (Pigou, 1920).

Aggregated social utility functions are not maximized in the presence of externalities. Hence, achieving maximum social well-being requires the internalization of these external costs. Environmental externalities arise because it is difficult or practically impossible to assign property rights to the environment (Coase, 1960), with most components of the environment, e.g., atmosphere, oceans, many ecosystem services being collective resources. Moreover, even in cases when property rights can be assigned (e.g., ownership of land), ubiquitous information asymmetries and transaction costs make it impossible for markets themselves to internalize these externalities without government regulation. Hence, ultimately, the only potentially effective mechanism through which these externalities can be addressed is through government regulation (Coase, 1960). The latter, however, also has costs, i.e., transaction costs of enforcement of regulations. In all likelihood, these costs of enforcement of the true cost of food into food systems are substantial.

The understanding of environmental externalities has expanded substantially since the times of Arthur Pigou and Ronald Coase, among many factors, thanks to the emergence of specialized economics disciplines such as environmental economics and ecological economics, and pioneering research on natural capital, inclusive wealth and total economic values of ecosystem services. More recently, externalities generated by food systems were highlighted by several international assessments and initiatives such as IPCC (2019), IPBES (2018) and UN Food Systems Summit (Hendriks et al., 2021; von Braun et al., 2021).

The externalities from food systems are made up of environmental, health-related, social and economic costs (Hendriks et al., 2021). Environmental costs include losses of land ecosystem services, greenhouse gas emissions, air, soil and water pollution, and groundwater depletion. Health related external costs are related to unhealthy diets, which are an outcome of the current structuring of food systems. Socio-economic externalities relate to food waste, poverty and economic inequality resulting from the prevailing organization and political economy of food systems value webs (Hendriks et al., 2021).

The so-called "capitals approach" has emerged as a unifying framework to understand these externalities through the prism of natural, social, human and produced capitals (Sandhu et al., 2021). This framework is an outcome of a long evolution of economics thinking beginning right from its modern origins. For Adam Smith and early economists, land, labor and capital were fundamental inputs to economic value creation. Although early economic thought had a much limited understanding of these factors of production, they were eventually developed to mean natural capital (land) (e.g., more recently, Herman Daly, Robert Costanza, Gretchen Daly), human capital (labor) (e.g., Theodor Schultz, Gary Becker, Amartya Sen), and produced/financial capital (capital). The concept of social capital came about due to the improved understanding and recognition that social norms, trust and networks are key ingredients of productive relationships, and in the historical perspective, owns its origin to the works of such thinkers as Émile Durkheim, Max Weber and Karl Marx, and others (Claridge, 2004), or more recently Elinor Ostrom.

The purpose of true cost accounting is to comprehensively measure the changes in all these capitals due to food system impacts to identify their true social welfare effect.

3. Materials and methods

3.1. Analytical approach

The externalities from food systems are obviously not new; they are likely to have existed throughout the history, at least in localized forms. However, the key difference now is that they are no longer local, but having global implications surpassing the planetary boundaries of sustainability. What is also equally important, with the advancements in scientific methods, new technologies and data collection opportunities, we are now starting to have the necessary data and data processing capacities to quantify at least some of these externalities.

In this paper, we focus on one aspect of these externalities from food systems relating to the losses in natural capital due to food system impacts. The former are represented as losses in ecosystem services resulting from food production activities. Specifically, the paper looks at the externalities generated by cropland expansion leading to the degradation of other ecosystems with higher values of ecosystem services.

For assessing these losses in ecosystem services, the study adopted the total economic value (TEV) framework previously applied by Nkonya et al. (2016). The TEV framework takes into account monetary values of all ecosystem services, both marketed and non-marketed common pool ones following the nomenclature of ecosystem services based on the Millennium Ecosystem Assessment (MEA, 2005). The Millennium Ecosystem Assessment nomenclature comprises 22 types of ecosystem services classified under provisioning, regulating, habitat, and cultural ecosystem services (Table 1). Provisioning ecosystem services include food production, water provision, the extraction of medicinal, genetic, and ornamental resources that have market prices. On the other hand, regulating, habitat, and cultural ecosystem services are mostly not traded in the markets and do not have market prices, they are rather non-marketed common pool ecosystem services. The TEV analytical approach consists of attaching total economic values to ecosystem services provided by each ecosystem, then calculating economic costs resulting from ecosystem degradation due to land use and land cover changes. The detailed description of the applied methodology is given in Nkonya et al. (2016).

Table 1
The Millennium Ecosystem Assessment nomenclature of ecosystem services.

Provisioning services	Regulating services	Habitat services	Cultural services
Food	Air quality regulation	Nursery service	Esthetic information
Water	Climate regulation	Genetic diversity	Recreation
Raw materials	Disturbance moderation		Inspiration
Genetic resources	Regulation of water flows		Spiritual experience
Medicinal resources	Waste treatment		Cognitive development
Ornamental resources	Erosion prevention		
	Nutrient cycling		
	Pollination		
	Biological control		

Source: MEA (2005).

In particular, firstly, we identify the area of other ecosystems, such as forests, woodlands, shrublands, and grasslands, degraded because of cropland expansion during the period of 2001 and 2009. The total economic values of ecosystem services provided by these ecosystems are usually higher than those provided by croplands (Nkonya et al., 2016). Secondly, we calculate net economic costs from the degradation of these ecosystems after cropland encroachment, so that:

$$\gamma = (\alpha - \lambda) \times \theta, \quad (1)$$

where, γ is the net cost of ecosystem degradation, α is a vector of total economic values of one hectare of degraded ecosystems (forests, woodlands, shrublands, and grasslands), λ is a vector of country-specific total economic values of one hectare of cropland, θ is a vector of areas of cropland expansion on degraded ecosystems.

3.2. Data

The extent of global land use and land cover changes (LUCC) between 2001 and 2009 is identified based on remotely sensed Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data (Friedl et al., 2010). The paper focuses on expansion of croplands on four other higher value ecosystems, namely forest, grassland, shrublands, and woodlands. The MODIS satellite data gives the area of cropland expansion replacing each of these four ecosystems.

The total economic values of ecosystem services provided by forests, grasslands, shrublands, and woodlands were taken from the TEEBAgriFood initiative 2020 database.[1] This is the largest available database of spatially explicit monetary valuations of the total economic values of ecosystem services provided by each type of ecosystems (i.e., value unit/per ha/per year). The database contains over 4000 valuations of ecosystem services from around the world. Country-specific monetary values of each hectare of cropland were calculated using the data on the extent of croplands in each country and their gross production values, both obtained from the FAOSTAT database.[2]

4. Results and discussion

The findings show significant extents of degradation of higher value ecosystems due to cropland expansion. Globally, between 2001 and 2009, croplands expanded on 511 million hectares of what had previously been forest, shrubland, grassland and woodland ecosystems. The latter usually provide higher values of total ecosystem services than croplands, although they provide higher values of food production.

Particularly, high levels of ecosystem degradation affected grasslands in South America, East Asia, Europe, and West Africa. The region with the highest extent of ecosystem degradation was found to be East Asia (Table 2). The corresponding numbers for the Russian Federation are included as part of Europe and repre-

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1 http://teebweb.org/our-work/agrifood/
2 http://www.fao.org/faostat/en/#home

Table 2
Areas of cropland expansion, 2001–2009 (million hectares).

Regions	Cropland expansion on			
	Forest	Shrubland	Grassland	Woodland
Central Africa	2.31	0.32	3.32	4.07
East Africa	1.98	1.51	13.30	4.36
Southern Africa	0.89	5.33	18.39	3.25
West Africa	6.69	3.24	29.00	6.95
Central America	0.52	0.18	0.86	0.69
South America	13.90	4.45	35.90	16.10
North America	3.36	3.17	19.10	6.98
East Asia	21.70	43.30	40.40	80.60
Australia and Oceania	2.67	3.08	7.53	3.16
Europe	11.80	15.80	32.90	7.38
Central Asia	0.28	2.48	6.97	0.83
MENA (Middle East and North Africa)	0.18	10.50	6.86	1.67
The World	66.30	93.30	215.00	136.00

Source: Friedl et al. (2010).

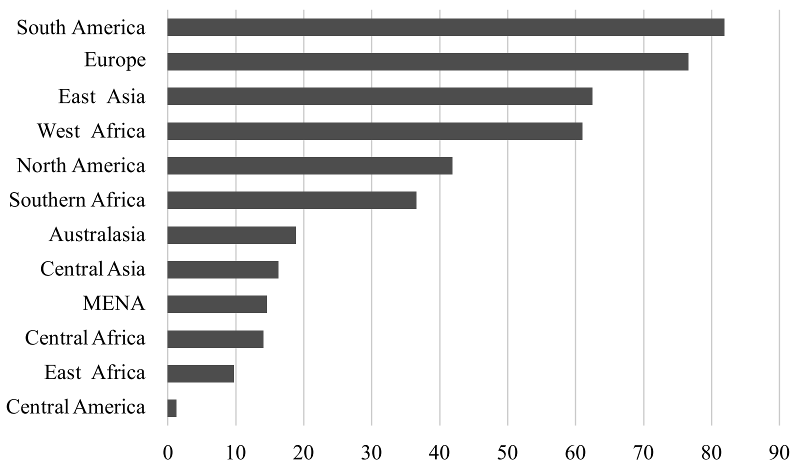

Fig. 1. Value of losses in ecosystem services due to crop encroachment between 2001–2009 (billion U.S. dollars).

Source: Authors' calculations based on Friedl et al. (2010) and TEEBAgriFood initiative 2020 database. http://teebweb.org/our-work/agrifood/

sent a significant share of its ecosystem degradation extent, namely, for grasslands — 12.3 million ha, forests — 6.4 million ha, shrublands — 5.6 million ha, and woodlands — 2.0 million ha.

Globally, economic externalities from the expansion of croplands made up 435 billion U.S. dollars between 2001 and 2009, which signifies annual losses of 54 billion U.S. dollars on average (Fig. 1). For the Russian Federation, total losses of ecosystem services due to the expansion of croplands between 2001–2009 constituted about 56 billion U.S. dollars, i.e., annually about 7 billion U.S. dollars (Table 3).

An important part of this cropland expansion for the Russian Federation is related to the recovery of previously abandoned cropland areas. The collapse of the Soviet Union has led to the abandonment of significant areas of cultivated croplands in

Table 3
Selective country examples of costs of cropland expansion.

Countries	Total costs of cropland degradation, 2001–2009, billion U.S. dollars	Cropland expansion (million hectares) on				Cost per hectare of cropland expansion, U.S. dollars
		Forest	Shrubland	Grassland	Woodland	
Brazil	31	4.8	0.4	20.0	5.0	1,013
Germany	2	0.5	0.0	0.9	0.2	891
India	22	1.0	6.8	4.0	15.0	816
Russia	56	6.4	5.6	12.3	2.0	2,151
South Africa	28	0.2	5.2	15.2	1.7	1,247
USA	33	2.8	2.8	14.8	6.8	1,208

Source: Authors' calculations based on Friedl et al. (2010) and TEEBAgriFood initiative 2020 database. http://teebweb.org/our-work/agrifood/

Russia throughout the 1990s (Lesiv et al., 2018). These abandoned croplands turned into grasslands, woodlands, shrublands and forests in the intervening time. Since the 2000s, a growing extent of these lands was brought back to food production. Schierhorn et al. (2013) estimated that this cropland abandonment resulted in a net carbon sink of 0.47 gigatons of carbon from 1990 to 2009, while the return of these areas into cultivation would mean the loss of this carbon sink.

The region with the biggest losses in monetary values of provided ecosystem services because of cropland expansion is South America. This is primarily related to the deforestation of the biodiversity rich Amazon Forest and the expansion of crop production into grassland areas, for example, into the Cerrado area in Brazil. Although the area of ecosystem degradation is larger in East Asia, economic externalities from cropland expansion in this region are ranked only in the third place globally due to higher cropland productivity. The amount of externality costs is smaller if degraded ecosystems are being replaced by high value and high productive crop production rather than by low productive agricultural activities.

The annual externalities from cropland expansion amounting to 54 billion U.S. dollars in terms of lost ecosystem services represent a significant economic cost to the global community. Governments can reduce negative externalities through a variety of policy tools. Regulations providing disincentives for ecosystem degradation could be summarized under the umbrella of the so-called "polluter pays" principle, where the original polluter is required to compensate the affected parties for the cost of incurred externalities. As discussed earlier, the economics literature also refers to them as Pigouvian taxes (Pigou, 1920). Ideally, the tax would be equal to the amount of the negative externality to internalize social costs of the pollution. The major practical shortcomings of Pigouvian taxes include the difficulty for measuring the amount of the negative externality involved and identifying the appropriate tax base. An alternative taxing approach, Ramsey rule, seeks to incorporate both the elasticity of demand for polluting activities and internalization of social costs (Eurostat, 2013). According to the Ramsey rule, the more inelastic the demand for a polluting activity, the higher the environmental tax.

In previous discussions of potential policy tools, it was argued that smallholder farmers causing ecosystem degradation are too poor to compensate the society for negative externalities they cause through cropland expansion or unsustainable land management practices, e.g., shifting slash-and-burn system in West Africa (Mirzabaev et al., 2015). In such cases, incentivizing policies (e.g., payments for ecosystem services) could be applied to avoid externalities. Although no similar constraints apply to large scale agricultural enterprises that are sources of ecosystem degradation in high- and middle-income countries, government intervention could be hindered by lobbying and other political economy considerations. Therefore, avoiding externalities from ecosystem degradation in these cases may require active civil society participation calling for stringent environmentally friendly regulation and its enforcement.

Enforcement of standards and regulations requires significant resources from governments to collect data, monitor sites, identify infringers, and enforce punishment, i.e., the transaction costs for true cost pricing of food. In many developing country settings, allocating such vast amounts of resources will be impossible. In this context, economic policy tools such as environmental taxes and subsidies could be more efficient in promoting true cost accounting in the food system than standard-setting based approaches. When faced with environmental taxes, farming enterprises will choose to self-limit their ecosystem degrading activities as long as marginal degradation abatement costs are lower than the amount of the tax, i.e., no ecosystem degradation for expanding low value crop production. The advantage for the government is that they do not need to know about the costs of ecosystem degradation abatement. However, the challenges remain in the form of identifying the proper taxing base and identifying the amount of the tax. Governments would also need to have substantial capacities for data collection on ecosystems degradation to assess the impact of taxing.

The extent of these transaction costs will serve as a serious impediment for the implementation of true cost accounting in food systems. Current research is primarily focused on identifying the extent of these externalities. With the ongoing exponential growth in the related literature, any knowledge gaps about food system externalities are likely to be soon closed. However, knowledge does not always automatically translate into action. The key impetus for future actions in terms of true pricing of food would come from closing knowledge gaps on transaction costs for the implementation and development of innovative solutions for reducing them.

5. Conclusions

Food systems are currently having an enormous negative environmental, social, and economic impacts at the global and local levels. True cost accounting seeks to quantify monetary values of these negative externalities. This study found that only cropland expansion resulted in negative externalities equaling 435 billion U.S. dollars between 2001 and 2009 at the global level. Addressing these externalities requires a flexible government regulation combining incentive mechanisms such as payments for ecosystem services and carbon pricing with legislative deterrents — environmentally friendly cadastral planning, fines, and taxes. More research is needed on transaction costs related to the implementation of true pricing of food.

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