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The True Costs of Food Production in Kenya and Viet Nam

Rui Benfica

Marup Hossain

Kristin Davis

Sédi Boukaka

Carlo Azzarri

Natural Resources and Resilience Unit
Innovation Policy and Scaling Unit

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Rui Benfica (r.benfica@cgiar.org) is a Senior Research Fellow in the Innovation Policy and Scaling (IPS) Unit at the International Food Policy Research Institute (IFPRI), Washington, DC.

Marup Hossain (maruphossain@gmail.com) is a Non-resident fellow at the Center for Development Economics and Sustainability, Monash University, Clayton, VIC, Australia.

Kristin Davis (k.davis@cgiar.org) is a Senior Research Fellow in IFPRI's Natural Resources and Resilience Unit, Knysna, South Africa.

Sédi Boukaka (s.boukaka@cgiar.org) is a Research Coordinator in IFPRI's IPS Unit, Nairobi, Kenya.

Carlo Azzarri (c.azzarri@cgiar.org) is a Senior Research Fellow in IFPRI's IPS Unit, Rome, Italy.

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Abstract

Sustainable agrifood systems (AFS) provide food security and nutrition without compromising economic, social, and environmental objectives. However, many AFS generate substantial unaccounted for environmental, social, and health costs. True cost accounting (TCA) is one method that adds direct and external costs to find the “true cost” of food production, which can inform policies to reduce externalities or adjust market prices. We find that for Kenya—considering the entire food system, including crops, livestock, fishing, and value addition sectors at the national level—external costs represent 35 percent of the output value. Social costs account for 73 percent of the total external costs, while environmental costs are 27 percent. In contrast, in Viet Nam, where total external costs represent 15 percent of the output value, the environmental costs (75 percent) dominate social costs. At the subnational level, in the three Kenyan counties (Kisumu, Vihiga, and Kajiado) covered by the CGIAR Research Initiative on Nature-Positive Solutions (NATURE+), external costs (or the true cost gap) represent about 30 percent of all household crop production costs. Those external costs are overwhelmingly dominated by social (84 percent) over environmental (16 percent) externalities. In Viet Nam's Sa Pa and Mai Son districts, external costs represent about 24 percent of all household crop production costs. Environmental externalities (61 percent) are greater than social ones (39 percent). In Kenya, forced labor is the main social (and overall) external impact driven by factors ranging from “less severe” financial coercion to “more severe” forms of physical coercion. Land occupation is the most important environmental impact, resulting from occupation of lands for cultivation rather than conservation, while underpayment (low wages) and low profits are important social costs that are closely associated with the prevailing gender wage gap and occurrence of harassment. Soil degradation is the only other environmental impact, linked with the use of inorganic fertilizers (60 percent of households) and pesticides (36 percent). In Viet Nam, land occupation is the most important external impact, followed by soil degradation and contributions to climate change, primarily due to widespread use of inorganic fertilizers (98 percent of households) and pesticides (93 percent). Underpayment and insufficient income are significant social costs, followed by the gender wage gap and child labor. Crop production systems in Kenya exhibit relatively high labor-related costs compared with nonlabor inputs, with relatively lower intensity in the use of inorganic fertilizer and other chemical inputs and lower crop yields. This production system leads to relatively greater social externalities. Conversely, crop yields in Viet Nam are significantly higher than those in Kenya, likely due to the extensive use of inorganic fertilizers representing the largest direct cost component and leading to a relatively higher level of environmental externalities. Because external costs represent a significant part of the total cost of food production, policy and investments to minimize these costs are essential to a nature-positive AFS that is environmentally sustainable and socially equitable. Strategies to reach this goal include regulatory adjustments, investments in resource-

efficient infrastructure and technologies that minimize costs, and the prudent management of environmentally impactful production inputs and factors.

Keywords: Environment, externalities, food, social equity, sustainability, true cost

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This work was undertaken as part of the CGIAR Research Initiative on Nature-Positive Solutions. Building on the 2021 United Nations Food Systems Summit (UNFSS) recognition of nature-positive production as one of five critical pathways to sustainable food systems, the Nature-Positive Solutions initiative was launched to reimagine, co-create, and implement nature-positive, solutions-based AFS that equitably support local food and livelihoods, while simultaneously ensuring that agriculture is a net positive contributor to nature. Other CGIAR centers participating in Nature-Positive Solutions include the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), the International Potato Center, and the International Water Management Institute. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: www.cgiar.org/funders/. We also thank the CGIAR Nature-Positive Solutions initiative stakeholders who attended ground truthing/validation events in Viet Nam and Kenya and commented on the material. We are thankful for the information and insights provided by the experts from the Impact Institute in the Netherlands with respect to the Global Impact Database (GID) and the monetization factors (MFs). The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of CGIAR.

1. Introduction

Sustainable food systems aim to provide food security and nutrition to all without compromising economic, social, and environmental objectives (United Nations 2023). However, the stark reality is that many countries fail to achieve this goal because their food production system generates substantial and unaccounted for environmental, social, and health costs (FAO et al. 2020). A critical prerequisite for reshaping these flawed food systems is a clear understanding of the extent of these costs to inform policies aimed at reducing these externalities or adjusting market prices to ensure that the true cost of production is reflected (Baker et al. 2020; von Braun and Hendriks 2023).

The links between market activities and the associated social and environmental repercussions remain invisible (UNFSS Scientific Group 2021; von Braun and Hendriks 2023). In this regard, the true cost accounting (TCA) framework emerges as an important tool to overcome the limitations of conventional economic analyses of food systems by offering a comprehensive analysis of the true costs of food.

Conceptually, TCA recognizes the interconnectedness of food systems with broader environmental, health, and societal contexts. It quantifies external costs associated with food production in dimensions such as environmental, social, and health. By incorporating these external costs alongside the direct costs of production, TCA offers a holistic estimation of the true cost of food. Rooted in The Economics of Ecosystems and Biodiversity (TEEB) agrifood evaluation framework (TEEB 2018), this analytical approach provides a structured foundation for evaluating externalities associated with food production (Gundimeda, Markandya, and Bass 2018; TCA Handbook 2022).

Despite notable progress over time, the TCA framework faces data limitations and difficulties in quantifying externalities. The data limitations, especially in low- and middle-income countries, remain at the top of the list. Most of the existing studies are limited to national- or global-level analyses. For instance, the latest *State of Food and Agriculture 2023* report relied on national-level assessments (FAO 2023). Some studies have focused on specific crops, such as coffee in Viet Nam (Verkooijen, Ruiz, and Fobelets 2016) and Kenya (Impact Institute and IFPRI 2023), while

others have concentrated on individual countries, as exemplified by studies in the United Kingdom (Fitzpatrick et al. 2019) and the United States (Rockefeller Foundation 2021).

This study uses multiple sources of data, namely (a) a smallholder household–level primary data survey, (b) a worker-level primary data survey, and (c) national-level data drawn from the Global Impact Database (GID) to measure the true costs of food production in Kenya and Viet Nam. In each country, the true cost estimates are computed at those two levels separately. By quantifying the hidden costs, the research aims to establish a foundation for informed decision-making and the development of sustainable food system policies in both countries. More specifically, the study aims to answer three critical questions. First, what is the true cost of food production systems when considering externalities related to social and environmental costs in Kenya and Viet Nam? What is the contribution of, and the implications for, marginalized groups such as women? Second, how does the cost structure differ by externality type (i.e., social or environmental) and associated factors in each country? Finally, what policy and investment recommendations can inform laws and policies to minimize external costs and promote a more environmentally sustainable and socially equitable food system?

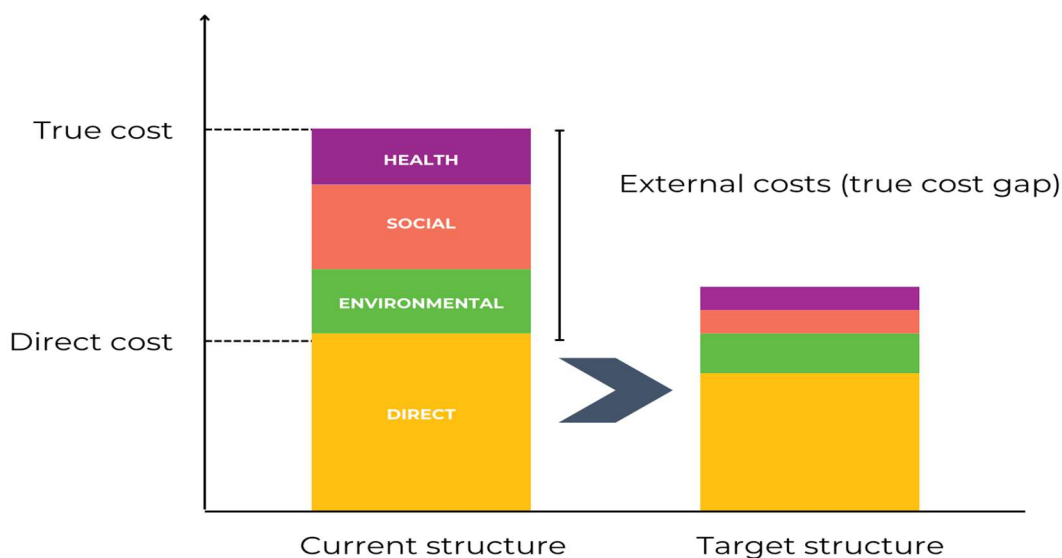
This study is part of a broader research initiative of CGIAR, [Nature-Positive Solutions](#) (NATURE+), which aims to reimagine, co-create, and implement nature-positive, solutions-based agrifood systems (AFS) that equitably support food and livelihoods while ensuring that agriculture is a net positive contributor to biodiversity and nature. While NATURE+ works in five countries in the first phase, Kenya and Viet Nam were selected for TCA due to cost limitations and the need for a suitable policy environment in two diverse countries. The study results will be used to inform priority-setting and investment decision-making in the countries through stakeholder consultations, a country dashboard, and academic and policy outputs.

The rest of the report is structured as follows. Section 2 details the TCA framework. Section 3 analyses the global and household-level data used in this study. Section 4 presents the findings from the GID analysis, and Section 5 provides the results from the household and farm workers survey analysis. Section 6 provides policy implications, and Section 7 closes with the identification of some limitations of the study.

2. TCA framework

TCA emerges as a critical analytical framework, offering a comprehensive approach for measuring direct and external costs of food production. The TCA framework goes beyond traditional economic measures by incorporating environmental, social, health, and economic costs associated with food production. Figure 1 illustrates a hypothetical food system structure, showcasing the incorporation of external costs atop direct production costs. The externalities, consisting of environmental, social, and health impacts, are defined as effects not reflected in the market prices of goods or services. Note that the TCA methodology only accounts for negative impacts induced by economic activity. In fact, for almost all indicators,¹ no positive impacts are included. Although creating positive externalities is desirable, doing so does not offset negative externalities. For instance, extra job creation does not offset forced labor (True Price 2020). The TCA accounting framework for this research is fully detailed in Benfica (2023).

Figure 1. The true costs of food



Source: Adapted from True Price (2021c).

2.1. TCA methodology

The TCA methodology links four types of capital involved in the production system: natural, human, social, and produced. The first three types are the core of the TCA framework, containing

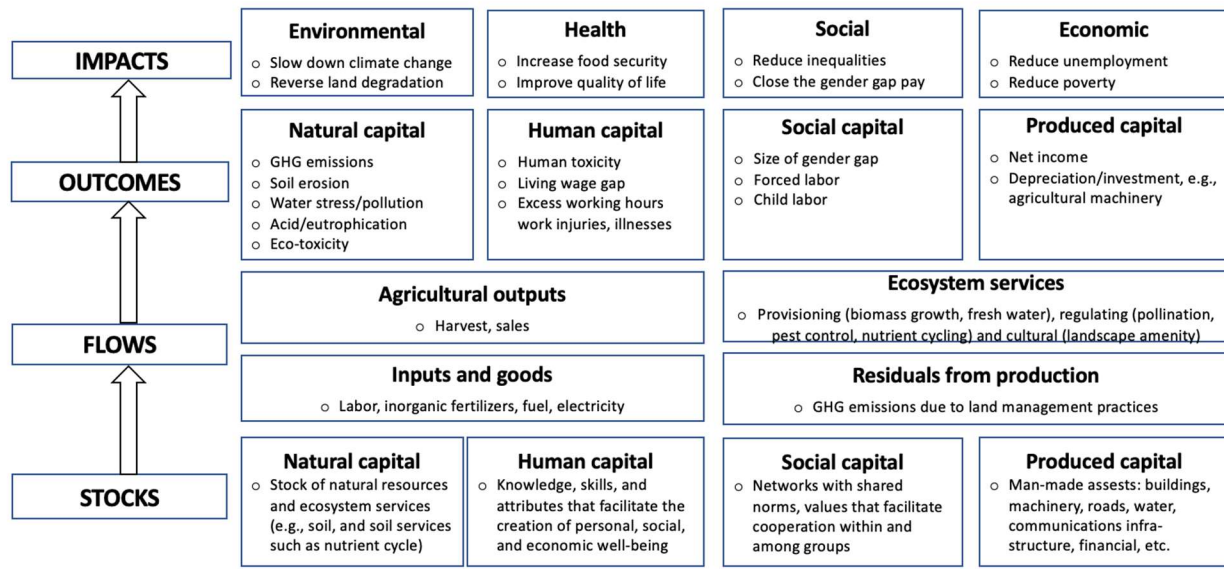
¹ Only two indicators, namely “carbon stock” and “soil organic matter buildup,” account for positive impacts, that is, long-term carbon sequestration in agricultural soil and trees (TCA Handbook 2022).

the AFS's essential externalities. The fourth type, produced capital, corresponds to the direct production costs already incorporated by current accounting standards quantified in monetary units and reflected in the product's market price. The analysis in this study focuses on the external costs related to the first three types of capital. Figure 2 contains a graphical presentation of the elements of the TCA methodology highlighting the breakdowns of the stocks, flows, outcomes, and impacts. These elements are grounded on the TEEB evaluation framework (TCA Handbook 2022; TEEB 2018).

- *Natural capital* refers to physical and biological resources found on earth, such as air, water, soil, biodiversity, and ecosystems, which benefit people through ecosystem goods and services. The external costs of this type of capital include greenhouse gas (GHG) emissions, soil erosion, water stress/pollution, acid-eutrophication, and eco-toxicity. Actions to counteract those costs result in impacts such as slowing down climate change effects and reducing land and soil degradation.
- *Human capital* includes an individual's health, knowledge, skills, and motivation essential for productive work and to facilitate personal, social, and economic well-being. The associated costs include human toxicity,² prevailing living wage gaps, excessive working hours, injuries, and illnesses. Addressing those effects through policies and investments improves food safety, security, and workers' quality of life.
- *Social capital* encompasses networks, institutions, societal norms, and values facilitating cooperation within and among groups. Changes in conditions resulting from value chain activities relate to costs attributed to resulting gender wage gaps, forced labor, and the use of child labor. Proactive efforts to address these costs result in social impacts such as reduced inequities in pay, preservation of worker rights, and benefits for children in the form of better prospects.
- *Produced capital* refers to all manufactured (buildings, factories), built (roads, water systems), financial, and intellectual capital (technology, software, patents). It includes monetary costs, such as depreciation and profits resulting from productive processes.

² Human toxicity is an impact indicator that considers the potential health risks of cancerous and noncancerous effects of chemicals emitted to the environment (mainly soil and water) (TCA Handbook 2022). Due to data limitations, our analysis did not include this indicator.

Figure 2. Elements of the TCA methodology



Source: Adapted from Müller and Sukhdev (2018) and TCA Handbook (2022).

Note: GHG = greenhouse gas.

Each of the three types of capital critical to our analysis is associated with externality types (environmental and social) that in turn aggregate a set of impact categories and indicators. Table 1 shows the indicator definitions for the different types of capital (stocks) and the associated outcomes — that is, the changes in the condition of their stocks due to value chain activity (TCA Handbook 2022).

Table 1. Capital and externality types, impact categories, and impact indicators

Type of capital	Type of externality	Impact category	Impact/footprint indicator
Natural	Environmental	1. Climate change	Greenhouse gas (GHG) emissions
Natural	Environmental	2. Air pollution	Toxic emissions to air*
Natural	Environmental	3. Water pollution	Toxic emissions to water*
Natural	Environmental	4. Soil pollution	Toxic emissions to soil*
Natural	Environmental	5. Land occupation	Land occupation**
Natural	Environmental	6. Land transformation	Land transformation**
Natural	Environmental	7. Soil degradation	Soil organic carbon loss
Natural	Environmental	8. Fossil fuel depletion	Fossil fuel depletion
Natural	Environmental	9. Other nonrenewables depletion	Other nonrenewable material depletion
Natural	Environmental	10. Scarce water use	Scarce blue water use
Human	Social (working conditions)	11. Workplace health/safety incidents	Occupational health and safety
Human	Social (working conditions)	12. Workload	Excessive working hours
Human	Social	13. Underpayment/work pay	Living wage gap
Social	Social (human rights)	14. Child labor	Child labor (underage work/loss of education)
Social	Social (gender discrimination)	15. Gender wage gap	Gender wage gap
Social	Social (human rights)	16. Forced labor	Forced labor (low and medium severity)

Source: True Price (2021a).

Note: * Human, terrestrial, fresh water, marine. ** Forest, woodland, grassland, inland, coastal.

2.2. Analytical steps in TCA

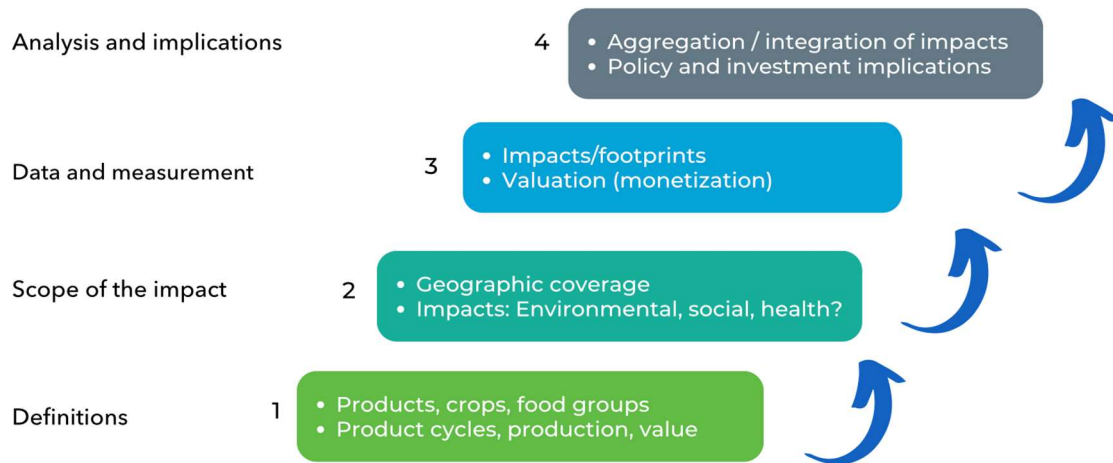
The TCA framework involves several steps (Figure 3). Steps 1 consists of defining the scope of the analysis—that is, identify the products, crops, or food groups under scrutiny, and map the production and value-addition processes. Step 2 defines the geographic and impact boundaries. These initial steps lay the foundation for the TCA assessment.

Step 3 digs into the heart of measurement and valuation, which involves identifying and quantifying externalities and impact footprints and valuing them in monetary terms using monetization factors (MFs) (True Price 2021b). We look at these terms in turn.

Identification and measurement of the impacts/footprints. The impact measurement identifies the impact/footprint indicators (FPI) by impact type. Table 1 presents examples of impact categories/indicators related to environmental and social externalities. Once the indicators are identified, “process data” is collected from economic agents through surveys, for instance with

farmers (predominantly for the environmental domain) and workers (for the social domain). Units of measurement are specific for each indicator.

Figure 3. Key steps in the TCA assessment



Source: Authors.

Valuation (or monetization) of the impacts/footprints. Once the relevant impacts/footprints are identified and measured quantitatively, they need to be valued in monetary terms. To do so, the analysis uses MFs. The MFs are unit cost factors used to value and convert the negative externalities from footprints to monetary terms. The approach to monetize negative externalities includes accounting for restoration and compensation costs (True Price 2021a).³ If externalities cannot be fully restored, which is often the case for social externalities, compensation and/or penalties values are required. The valuation of footprints or the external cost (EC_i) for the specific impact category/indicator is estimated by multiplying FPI_i by MF_i , where i represents impact categories as listed in Table 1, ranging from "1. climate change" to "10. scarce water use" for environmental externalities, and from "11. workplace safety" to "16. forced labor" for social externalities.

The final step consists of the *aggregation and integration of impacts*. To get the costs by externality type—environmental (EC_E) and social (EC_S)—the external costs are then aggregated to that level. Formally, the steps can be represented as:

³ For example, contribution to climate change can be restored by capturing atmospheric carbon. Water pollution can be restored through cleaning. For occupational accidents, covering the medical costs can restore part of the damage.

$$(1) \quad EC_E = \sum_{i=1}^{10} FPI_{Ei} * MF_{Ei}$$

$$(2) \quad EC_S = \sum_{i=11}^{16} FPI_{Si} * MF_{Si}$$

The total value of the externalities (EC_T) is given by $EC_T = EC_E + EC_S$.

At this point, the data can be organized and analyzed to establish and compare the structure and distribution of the costs of food, inclusive of the externalities, and to strategize on what alternative scenarios of policy, programs, and investments would be needed to promote changes toward a more sustainable external cost structure in the food system.

3. Data

This study uses primary and secondary data to estimate the true costs of crop production in Kenya and Viet Nam. The primary data were gathered through two surveys: one at a farming household level and another at the farm-worker level. The secondary data, corresponding to the national level, are contained in the GID (Impact Institute 2024) and the MFs, both compiled by the Impact Institute for a wealth of countries, but extracted only for Kenya and Viet Nam for this study. For the household-/farm-level analysis, we do not consider the livestock sector because the disaggregated livestock cost data in the household survey were not adequate for the TCA analysis. Considerations on the livestock sector are, however, included at the country level using the GID.

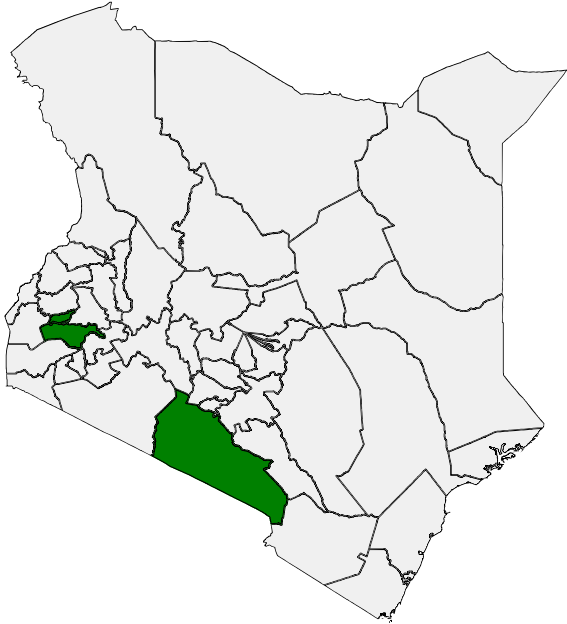
3.1. Primary data

The farming household-level survey captures farm production and cost structure, which enables the calculation of direct and indirect costs associated with farming activities. The population of interest in this study are the small-scale producers in the NATURE+ implementation sites. The farm household-level sample is, therefore, representative of the population of the NATURE+ initiative sites. We determined the total number of households to be surveyed in each country through sample power calculations.

We administered the survey to sampled households in three counties in Kenya—Kisumu, Vihiga, and Kajiado—between May and July 2023. We used a random sampling strategy to identify

approximately 1,500 households across the three counties. NATURE+ implementation partners guided the selection of specific survey sites within the three counties: Alliance of Bioversity International and CIAT for Kisumu and Vihiga, and the World Wildlife Fund for Nature Kenya (WWF–Kenya), for Kajiado. In Viet Nam, we designed the survey to cover the areas concerned with NATURE+ initiatives in two districts: Sa Pa in the North (in Lào Cai province) and Mai Son in the South (in Sơn La province). The survey covered about 1,150 households in 23 villages across the two districts. For more details on the farm-level survey sampling, see Boukaka, Azzari, and Davis (2024a and 2024b). Figure 4 shows the geographical location of the study samples in both countries.

Figure 4. Geographical locations of the field surveys



Kenya



Viet Nam

Source: Authors' elaboration.

Recognizing the limitation of the smallholder household-level survey to capture certain aspects of worker rights and working conditions,⁴ this study implemented a separate survey for the workers who labored in farmers' fields in the past 12 months.

Complementing the household-level data, the worker-level survey covers aspects of indirect costs associated with the work environment of agricultural laborers that relate to social externalities. We drew the sample through a non-probabilistic procedure using snowball sampling, where we recruited workers by exploiting the data collected in the household survey. Specifically, the household survey generated a list of workers who had provided labor to each household over the last year, including their name, location, and phone number. Originally, the plan was to list up to six workers per household and interview one selected randomly. Only those workers that households said could be reached were listed. However, after 10 days of data collection, we reconsidered the plan to interview one worker per household when we realized that the number of successful interviews was very low, so instead we targeted all listed workers to maximize sample size. The worker-level survey covered 1,056 workers in Kenya and 334 workers in Viet Nam (49 in Sa Pa and 285 in Mai Son districts).

The low number of worker-level survey interviews in Viet Nam was because households, especially in Sa Pa district, do not have many workers from the same village, and most households use exchange labor for agricultural activities. The limited number of interviews in Viet Nam limits our ability to generate statistically reliable estimates, particularly for some social impacts in the TCA model. However, it enables us to get a general idea through basic descriptive statistics that help substantiate some of the results. Annex Table A1 provides definitions of the TCA-related indicators calculated from the farm household and workers surveys. For more details on the worker-level survey sampling, see Boukaka, Azzarri, and Davis (2024 and 2024b).

Table 2 maps the content elements of the farming household-level and worker-level surveys to the different TCA capital-type categories.

⁴ It is indeed the case that typical household-level surveys, such as the Living Standards Measurement Study, the Demographic and Health Surveys, and the Labor Force Surveys, rarely engage in topics that involve human rights, working conditions, and entitlements. The workers survey in this study digs into those issues starting from a core survey tested in the context of the true price studies implemented recently in Kenya and Viet Nam (Impact Institute and IFPRI 2023; Verkooijen, Ruiz, and Fobelets 2016).

Table 2. Surveys as sources for TCA impact data

Survey questionnaire content	TCA capital-type categories		
	Natural	Social	Human
Farming household survey			
Crop/livestock outputs	●	●	●
Crop/livestock input use	●		
Water use	●		
Energy use	●		
Fuel use	●		
Transportation of produce	●		
Waste management	●		
Hired labor		●	●
Farm work incidents*			●
Workers survey			
Demographics and education		●	●
Contracts and payments		●	●
Compensation/benefits in the job		●	●
Working times/overtime/drops			●
Relationship with employer			●
Treatment at work		●	
Health and safety in the job			●
On the job training		●	

Source: Compiled by authors.

Note: * Incidents include pesticide and other chemical poisoning and tool-handling injuries, cuts, snakebites, and fire burns. TCA = true cost accounting.

3.2. Secondary data

The secondary data consists of the GID, a standardized compilation produced by the Impact Institute (Impact Institute 2024). The data are quantitative and already monetized, including value chain impacts (VCIs) (economic, social, and environmental) at individual value chain stages and procurement chain impacts (PCIs) for total impact. The data are compiled using different sources, such as global scientific databases, impact literature, trade data, and environmental, social, and governance data. Table 3 provides an overview of the key elements of the GID database used for Kenya and Viet Nam.

Table 3. Global impact database: Impacts, sectors, and measurement indicators

Impact categories			Sector categories		
Externality (capital) type	Impact groups	Impact types (12)	Sector groups	Sector types (19)	
Social (human and social)	Labor rights	Workplace health/safety	Rice	Paddy rice	
		Forced labor		Processed rice	
		Child labor	Cereals/grains	Wheat	
	Labor remuneration	Gender wage gap		Cereals/grains	
		Underpayment	Other crops	Vegetables, fruits, nuts	
			Cattle*	Other crops	
Environmental (natural)	Climate	Climate change	Meat and dairy products	Cattle, sheep, goats, horses	
	Air	Air pollution		Raw milk	
					Animal products
	Water	Water pollution			Bovine meat products
		Use of scarce water			Meat products
	Fossil fuels	Fossil fuel depletion		Fish	Dairy products
				Oil	Fishing
	Material	Material depletion		Sugar	Oilseeds
					Vegetable oils and fats
	Land	Land occupation		Sugar	Sugar
			Food products	Sugarcane, sugar beet	
		Beverages and tobacco	Food products	Food products	
			Beverages and tobacco	Beverages and tobacco	

Impact measurement indicators	
Indicator	Definition
Procurement chain impact (PCI) (Int.\$ impact/\$ output)	The PCI reflects the impact of the entire production process of a final (or intermediate) product of a sector. Therefore, the PCI includes impacts occurring throughout the entire production chain.* The data is expressed as monetized impact per dollar output of the sector. This means that it is the impact occurring during the production process of products with a value of \$1.
Value chain impact (VCI) (Int.\$ impact/\$ added value)	The VCI reflects the impact on the global economy of adding value in a sector. As economic activity in a sector stimulates both the supplying sectors and the clients, adding value in a sector leads not only to external costs in that sector, but also to additional externalities in the value chain. The VCI reflects this by providing impact data that aggregates the direct and VCI, both upstream and downstream.
VCI direct	Portion of VCI due to a sector's own impact. This is the part of the impact intensity of a sector that can be attributed to it rather than its value chain partners, based on added value.
VCI upstream	Portion of VCI due to a sector's upstream impact.
VCI downstream	Portion of VCI due to a sector's downstream impact.

Source: Compiled from Global Impact Database documentation (Impact Institute 2024).

Note: * The production chain is estimated based on input output analysis and therefore reflects the economically weighted average production chain of all goods and services produced by the sector.

The full database includes 65 sectors, 42 crops, over 20 impacts, and more than 50 indicators.

This study uses the Kenya and Viet Nam data, which include 19 sectors and 12 impacts. Finally, the MF data are used to convert the footprint indicators from the survey data into monetary

impacts. The MF data contain information for 88 footprint indicators under 21 categories for 2023 (True Price 2021b).

The next two sections look at the analytical results. Section 4 undertakes analysis at the national level using the GID for Kenya and Viet Nam to determine the structure of external costs across sectors and impacts. Section 5 uses the field survey data at the local NATURE+ initiative level to further explore the true costs of food in each country.

4. Findings from the GID Analysis

This part of the analysis is representative at the national level and looks at the entire AFS. It focuses especially on highlights of the crops sector subset of the AFS—that is, the seven crop production sectors (paddy rice, cereals/grains, oilseeds, wheat, sugarcane/sugar beet, vegetables/fruits/nuts, and other crops) to maintain the compatibility with the analysis in Section 4.2 that covers crop production costs at the smallholder level. Results are summarized in Tables 3 and 4.

The analysis starts with the assessment of the structure of external costs and the relative importance of the social and environmental costs across sectors, as well as the main impacts when (a) accounting for the whole agrifood sectors (Table 3), and (b) accounting solely for crop sectors (excludes livestock, livestock-related products, beverages, and tobacco) (Table 4).

4.1. Environmental and social externalities in the AFS

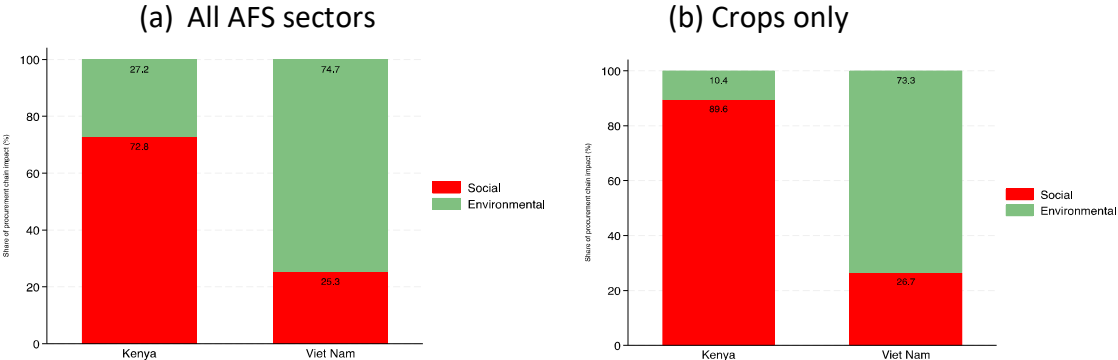
We use the information contained in the GID to assess the importance of externalities in the AFS. First, by looking directly at the PCI that represents the value in US\$ purchasing power parity (\$PPP)⁵ of the externalities per \$ of output (marginal measure). Then, we look at the actual magnitude of the externality accounting for the value of output of the sectors (size) and compare the relative importance of the sectors by looking at the share of the external costs (in \$PPP) in the total output in the AFS (adjusted to \$PPP). As a result, we have three measures: (a) share of total externalities in the AFS output, (b) relative importance of social versus environmental

⁵ *Purchasing power parity (PPP)* is a metric used to compare economic productivity and standards of living between countries. PPP compares different countries' currencies through a "basket of goods" approach. PPP is the exchange rate at which one country's currency is converted into another to purchase the same amounts of a large group of products.

externalities, and (c) ranking of sectors by total externalities while considering the relative importance of the externality types (Figure 5). For the remainder of this analysis, we use the \$ sign to mean \$PPP as defined in footnote 5.

Considering the entire AFS, in Kenya, social and environmental externalities account for 35 percent of the AFS output value (Table 4). A greater share of those costs is social (73 percent) when compared with environmental (27 percent) (Figure 5a). When we isolate the crops sector, the share of all externalities in output falls to 27 percent, and the relative importance of the social externalities is even greater, amounting to about 90 percent of all externalities (Table 5 and Figure 5b).

Figure 5. Structure of externalities by country



Source: Authors' own calculation using the Global Impact Database (GID).
Note: AFS = agrifood system.

Table 4. Key findings from the GID analysis, all agrifood system

Indicator	Kenya	Viet Nam
External cost to output ratio (External cost/output, %)	34.8	15.2
Highest external cost sectors (\$ billions) (influenced by PCI per output and output level)	<ol style="list-style-type: none"> 1. Livestock 2. Cereals and grains 3. Vegetables, fruits, and nuts 4. Food products 5. Other crops 6. Oilseeds 7. Beverages and tobacco 8. Sugar 9. Raw milk 10. Sugarcane, sugar beet 	<ol style="list-style-type: none"> 1. Paddy rice 2. Processed rice 3. Food products 4. Animal products 5. Vegetables, fruits, and nuts 6. Livestock 7. Other crops 8. Beverages and tobacco 9. Raw milk 10. Fishing
External cost structure (%)		
Environmental	27	75
Social	73	25
Major externality impact source* (ranking of PCI impact, \$ billions)	<ol style="list-style-type: none"> 1. Underpayment (S) 2. Land occupation (E) 3. Child labor (S) 4. Climate change (E) 5. Air pollution (E) 	<ol style="list-style-type: none"> 1. Land occupation (E) 2. Air pollution (E) 3. Underpayment (S) 4. Climate change (E) 5. Child labor (S)

Source: Authors' own calculation using the Global Impact Database (GID). **Note:** * E = environmental impact; S = social impact; PCI procurement chain impact. Crop sectors are in boldface type. The ranking of the crop sectors is presented in Table 5.

In Viet Nam AFS, in contrast, total externalities represent only 15 percent of the output value, and environmental externalities (75 percent) dominate social externalities (Table 4 and Figure 5a). Looking at the crops sector alone, we find that total externalities fall to about 11 percent of output, without a significant change in the relative importance of the externality types; that is, environmental externalities continue to represent about three-quarters of all externalities (Table 5 and Figure 5b).

Table 5. Key findings from the GID analysis, crop sectors only

Indicator	Kenya	Viet Nam
External cost to output ratio (External cost/output, %)	27	11
Highest external cost crop sectors (\$ billions)	<ol style="list-style-type: none"> 1. Cereals and grains 2. Vegetables, fruits, and nuts 3. Other crops 4. Oilseeds 5. Sugarcane, sugar beet 6. Paddy rice 7. Wheat 	<ol style="list-style-type: none"> 1. Paddy rice 2. Vegetables, fruits, and nuts 3. Other crops 4. Sugarcane, sugar beet 5. Cereals and grains 6. Oilseeds 7. Wheat
External cost structure (%)		
Environmental	10	73
Social	90	27
Major externality impact source* (ranking of PCI impact, \$ billions)	<ol style="list-style-type: none"> 1. Underpayment (E) 2. Child labor (S) 3. Land occupation (E) 4. Workplace health (S) 5. Air pollution (E) 	<ol style="list-style-type: none"> 1. Air pollution (E) 2. Land occupation (E) 3. Underpayment (S) 4. Child labor (S) 5. Climate change (E)

Source: Authors' own calculation using the Global Impact Database (GID).

Note: * E = environmental impact; S = social impact; PCI = procurement chain impact.

Figure 6 shows the ranking of unit footprints of sectors in part (a) and the ranking of the PCI of the sectors when we account for the sector size to assess its absolute contribution to the externalities in part (b). In both countries, livestock is the sector with the highest footprint per \$1 of output, while food products and beverages and tobacco rank low. When accounting for the size of the sectors, some revealing results emerge.

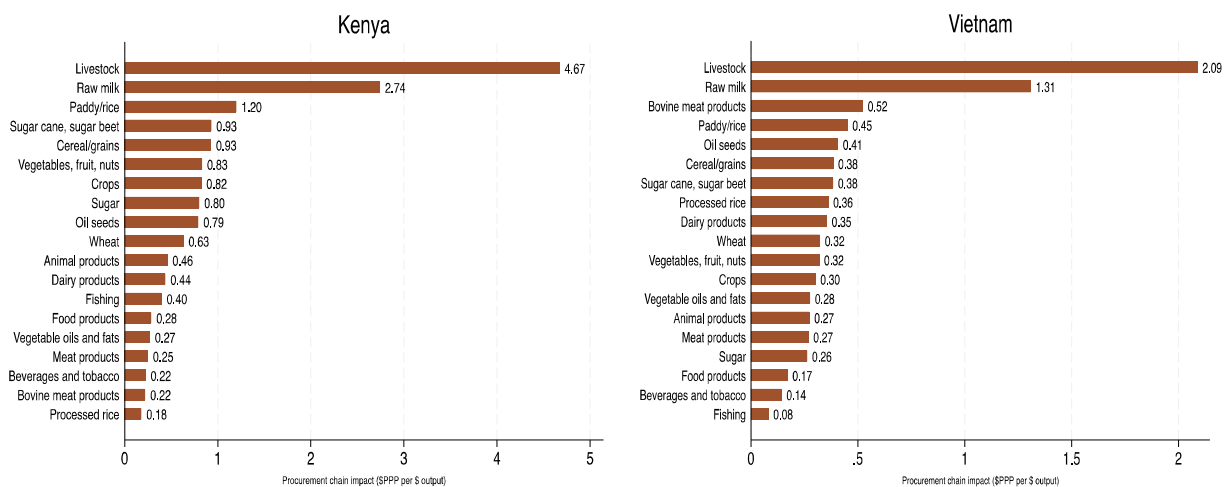
In Kenya, cattle, food products, and noncereal crops stand out. While the cattle sector is important both because of its unit effect and the relative importance in output, food products and cereals/grains are driven by their relatively large contribution to AFS output. In Viet Nam, rice clearly stands out, especially due to the size of the sector in output. Other important contributors to the externalities are food products and other crops. Livestock's relatively less sizable contribution to output relegates it to a less prominent position despite its large marginal impact.

Figure 6b also reveals the relative contribution of the social versus environmental externalities generated by each AFS sector. In Kenya, where social externalities are predominant in the aggregate, we find that, except for the livestock sector, where environmental externalities dominate, every other sector generates significantly more social externalities. The high social

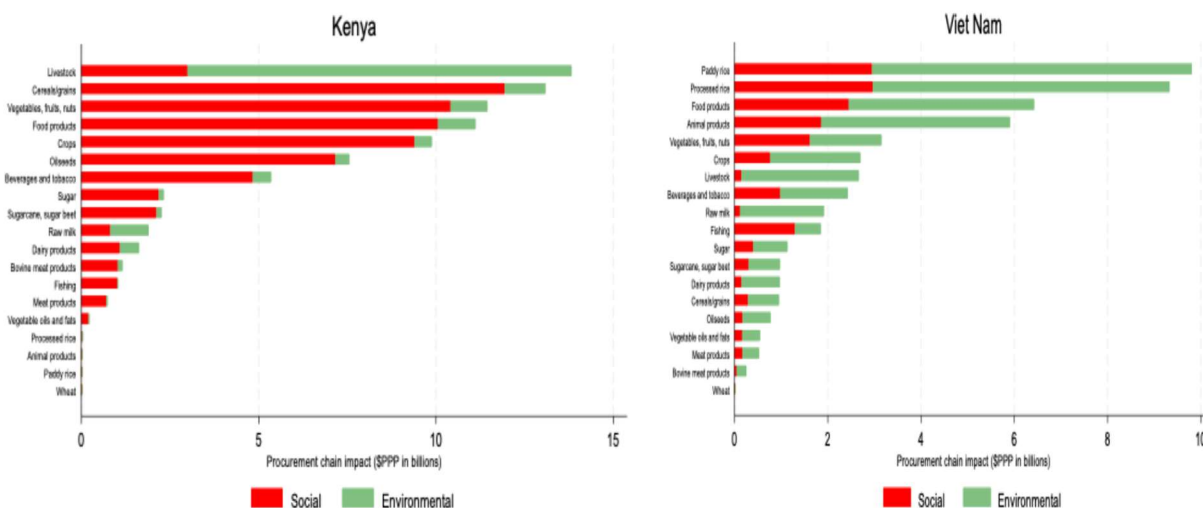
cost number may arise from the intensive labor use and working conditions characteristic of food production in in the country.

Figure 6. Ranking of sectors and composition of externalities, all sectors

(a) External costs per unit of output (marginal footprint), \$ per \$ output



(b) Total external costs (total footprint, \$ billions)



Source: Authors' own calculation using the Global Impact Database.

Note: PPP = purchasing power parity.

In Viet Nam, contrary to Kenya, environmental impacts are clearly dominant in all sectors, except for fishing. Rice production incurs the highest external costs, with a relatively lower total social cost (\$2.9 billion) than the environmental component (\$6.6 billion). This could indicate a greater reliance on intensive practices, possibly due to a more mechanized agriculture sector and the high use of inorganic fertilizers and pesticides in food production. The data for other crops also

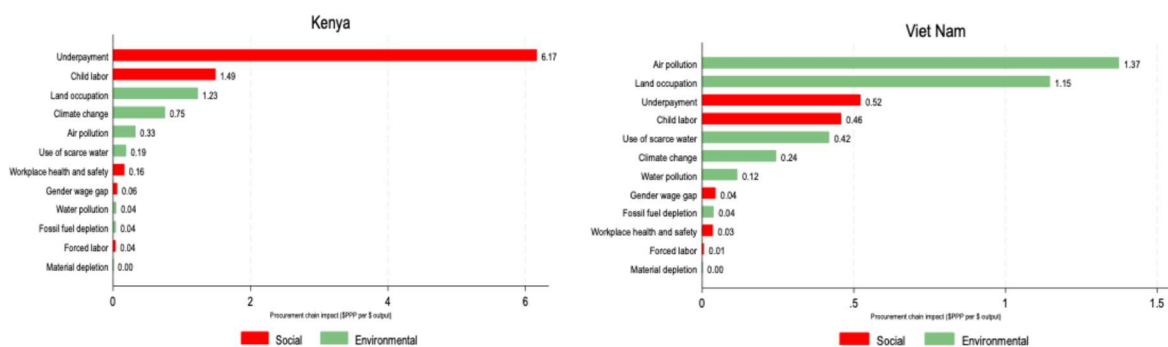
show a similar pattern. As opposed to Kenya, the indirect cost of food production in Viet Nam highlights the need to reduce environmental costs while sustaining and further reducing the social costs and improving benefits to workers within its food production chains.

4.2. The relative importance of external impacts

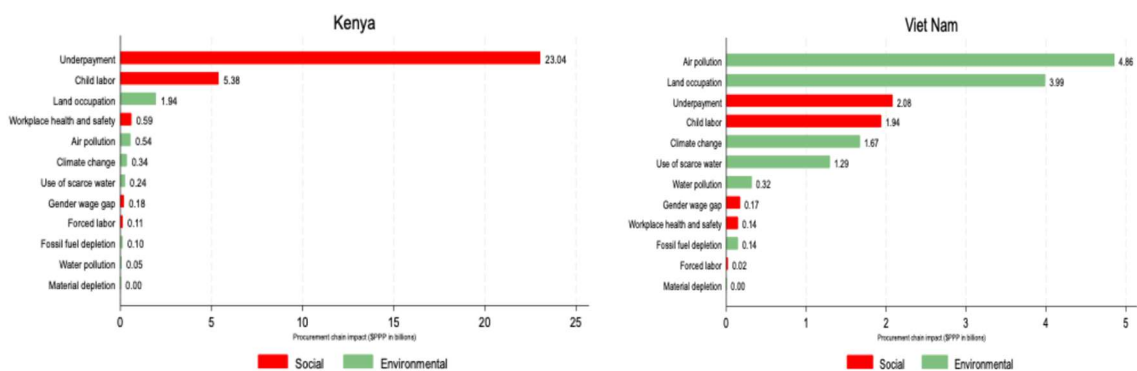
As indicated in Table 1, social and environmental externalities are associated with specific impacts. Figure 7 ranks the different impacts in each country in terms of (a) \$PPP per \$ output and (b) the absolute external costs (total external impacts) associated with them. Impacts associated with social externalities are represented in red, while those related to environmental externalities are in green. To focus the analysis, we highlight the crop sectors only.

Figure 7. Ranking of impacts by externalities, crops only

(a) External costs per unit of output (unit impacts), \$ per \$ output



(b) Absolute external costs (total impacts), \$ (billions)



Source: Authors' own calculation using the Global Impact Database.

Note: PPP = purchasing power parity.

Aligned with the findings in Figure 5, the social footprint of food production casts a long shadow in Kenya. For instance, underpayment stands out at \$6.2 per dollar of output and a total cost of \$23 billion, a stark indicator of the economic challenges faced by workers in food production.

This high value not only underscores the prevalence of low wages but also may reflect the broader socioeconomic disparities within the food production sectors. Child labor, with a PCI of 1.49 and a total burden of \$5.4 billion, further attests to the pressing social costs. On the environmental side, land occupation and climate change are the most significant impacts, though they are considerably less than the social impacts, with PCIs of 1.2 and 0.75, respectively. These environmental costs, though relatively small, reveal the stress placed on natural resources by agricultural food production in Kenya.

In Viet Nam, the footprint-wise results show a different pattern of impacts, again aligned with the findings in Figure 5. Air pollution leads the environmental costs, with a PCI per \$ output of 1.4 and a total cost of \$4.9 billion. Land occupation follows closely, with a significant environmental impact of 1.2, pointing to the intensive use of land in agricultural practices. Socially, the issues of underpayment and child labor are visible, with total external costs of \$2.1 and \$1.9 billion, respectively.

4.3. External costs across value chain stages

Next, we use the VCI data from the GID. The VCI shows the impact (i.e., external cost) of adding a value (i.e., one US\$) to a sector of the global economy. Since economic activity in a sector is linked with other upstream and downstream sectors, adding value can create external costs in that sector (i.e., direct VCI) and other sectors (i.e., upstream and downstream VCI). For instance, rice production can affect upstream sectors, such as seed production, and downstream sectors, such as processed rice. While the analysis is primarily intended for crop sectors, we also introduce noncrop sectors, such as livestock, fishing, and processing sectors, to highlight how they relate to the upstream crop sectors in this context. Crop sectors are the first seven represented in Figure 8.

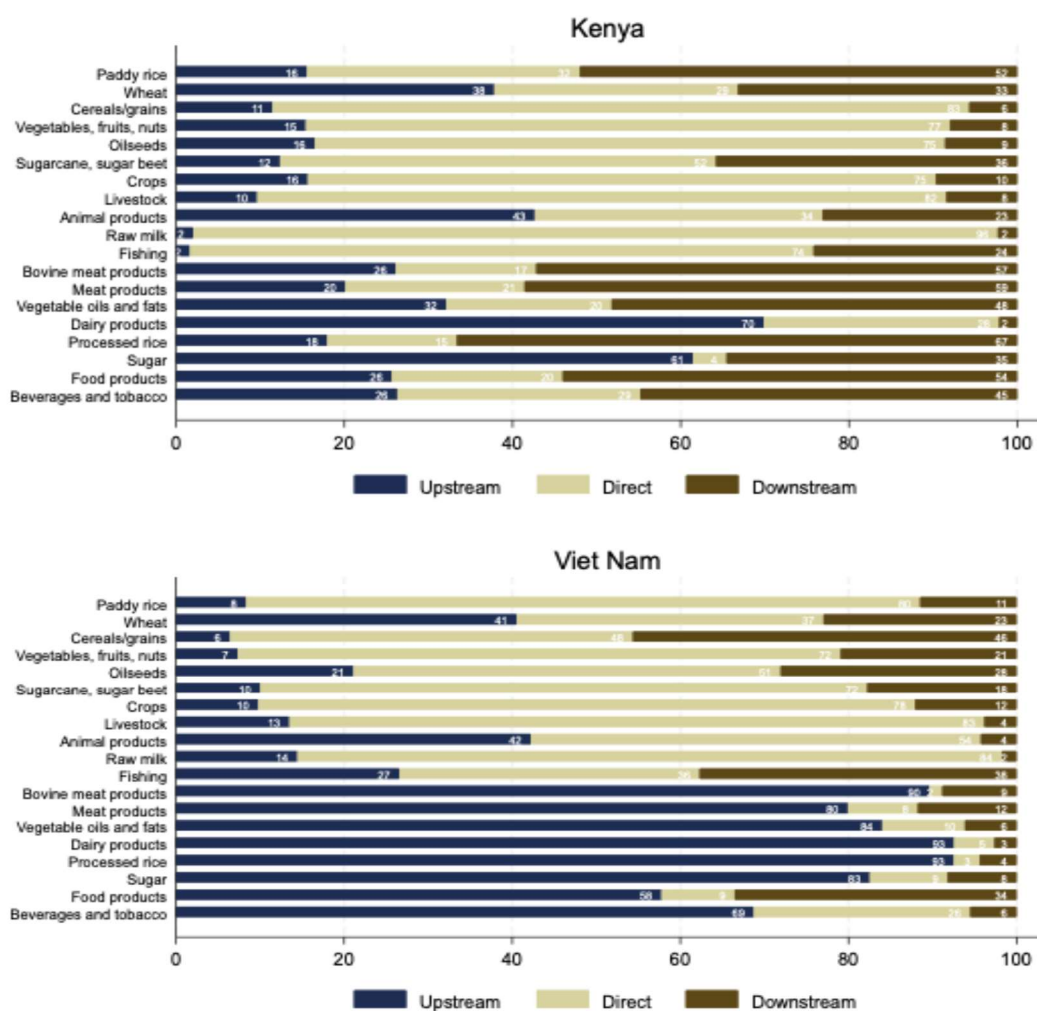
4.3.1. External costs by crops and value chain stages

The VCI data for Kenya reveal a complex interplay between the various stages of the food production chain. Cereals and grains, which are primary food items in Kenya, exhibit a dominant direct VCI at 83 percent, suggesting that these crops' value-addition processes are particularly resource intensive in the on-site production process within Kenya (Figure 8). Vegetables, fruits,

and nuts, as well as oilseeds, show a similar pattern, with a major share of their impacts being direct (77 and 75 percent, respectively). The data suggest the need for strategies that address the production system, potentially through improved efficiency and sustainable practices within the production stages of the value chain, especially for social cost–related practices.

Conversely, the direct VCI for paddy rice—the main crop produced—is notably high at 80 percent in Viet Nam, signifying that the bulk of external costs are generated during the on-site production processes. Cereals/grains and sugarcane/sugar beet follow a similar pattern, with direct impacts of 48 and 72 percent, respectively, indicating the prominence of in situ agricultural practices in the generation of externalities.

Figure 8. Indirect cost by crops and value chain stages (% of \$ per one US\$ addition)
(7 crop sectors + other AFS sectors)



Source: Authors' own calculation using the Global Impact Database (GID).

Note: Results are based on the GID. Only crop farming-related sectors are considered in this analysis (cereals, oilseed, paddy rice, sugarcane, sugar beet, vegetables, fruits, nuts, and wheat). The value chain impact shows the impact of adding a value (i.e., one US\$) to a sector of the global economy by value chain stages. AFS = agrifood system.

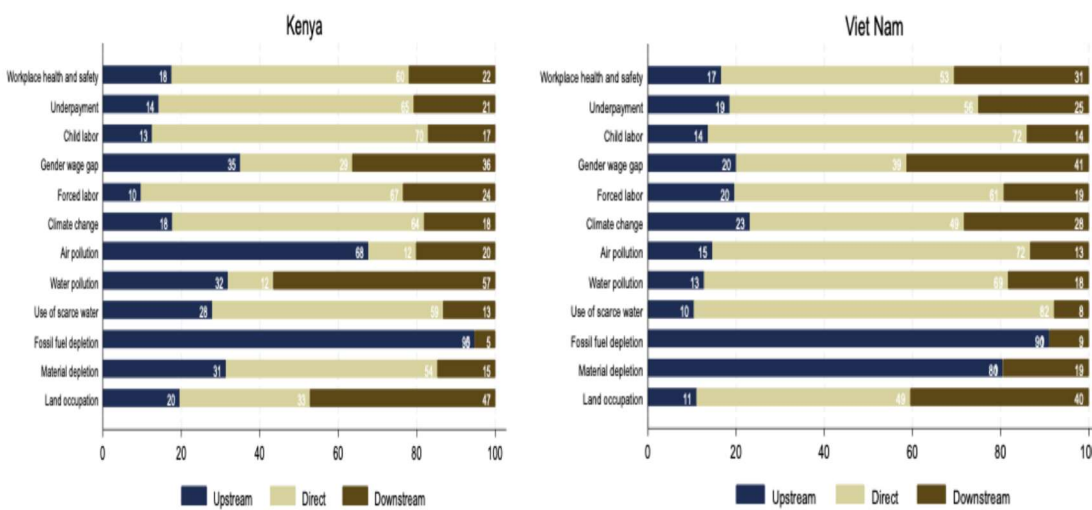
As in Kenya, the VCI patterns observed in Viet Nam point toward a potential to enhance sustainability and reduce external costs by focusing on the direct aspects of the crop production chain. The relative importance of upstream footprints in value addition sectors (see Figure 8) highlights the importance of interventions in the production processes of the crop sectors.

4.3.2. External costs by impact type and value chain stages

Figure 9 shows the indirect cost of food production by impact types across value chain stages. In Kenya, the graph showcases a notable distinction between the stages of the value chain in

relation to different footprints. A considerable portion of the impacts on workplace health and safety (60 percent), underpayment (65 percent), and child labor (70 percent) are direct, suggesting these issues are most prominent during the on-site production activities. Meanwhile, the gender wage gap, water pollution, and land occupation demonstrate significant downstream impacts, implying that these issues become more apparent during or after the product leaves the production site, that is, in the processing or distribution stages.

Figure 9. Indirect cost by impact type and value chain stages (\$ per one US\$ addition), crop sectors only



Source: Authors' own calculation using the Global Impact Database (GID).

Note: Results are based on the GID. Only crop farming–related sectors are considered in this analysis (cereals, oilseed, paddy, sugarcane, sugar beet, vegetables, fruits, nuts, and wheat). The value chain impact shows the impact of adding a value (i.e., one US\$) to a sector of the global economy by value chain stages.

Viet Nam presents a different pattern, with significant direct impacts noted for climate change (49 percent), air pollution (72 percent), and water pollution (69 percent). These suggest that environmental issues are generated predominantly during the production phase. This can be linked to the intensive use of fertilizer and pesticides in cultivation. The gender wage gap displays a balanced impact across all stages, with a notable 39 percent for direct VCI, indicating that the issue is pervasive throughout the value chain. For Viet Nam, addressing the direct environmental impacts of production and the extensive use of water in the upstream stages could significantly reduce the overall external costs in the agriculture sector.

5. Findings from the farm-level analysis

The farm-level analysis uses data from the household farming survey and the farm workers survey. The sample for this study draws on households actively engaged in agricultural activities, particularly those involved in cultivating land for food. Due to the nature of the data collected, this study's findings apply primarily to crop-farming households in the NATURE+ initiative study areas. Consequently, the characteristics of the sampled households are not consistent with national-level statistics.⁶ The analysis is, therefore, not representative for the country.

While this lack of national representativeness may be seen as a limitation for comparability with the GID analysis, we note that the analyses are complementary and the findings useful for policy.

5.1. Demographic and economic profile of the farming sector

5.1.1. Demographic profile of households and workers

Table 6 provides an overview of the demographic and educational profiles of households and workers surveyed in Kenya and Viet Nam. The average household size in Kenya is 5.4, indicating a relatively large family structure with a balanced gender distribution. Notably, 33 percent of household members beyond the primary education age (14 years) have reportedly no or below a primary education.

The distribution of completed grade levels reveals that another 38 percent of household members beyond the primary education age completed primary education, 22 percent secondary education, and 7 percent tertiary education. Furthermore, 28 percent of households are led by women.

In Viet Nam, the overall household size is 5.0, with a higher prevalence of male members. Vietnamese households surveyed exhibit a similar educational attainment level compared with Kenyan households, with only 30 percent of members above the primary education age (11 years) reporting no or below primary education grade completion. Additionally, about 23 percent completed primary education, 44 percent attained secondary education, and only 3 percent

⁶ In Kenya, according to the Integrated Household Budget Survey 2015-2016 (National Bureau of Statistics 2018), the average household size in rural areas is 4.5 and 3.7 nationally (General Statistics Office 2021), while our study sample indicates an average of 5.4.

pursued tertiary education. In contrast to Kenya, a mere 9 percent of surveyed households in Viet Nam are led by women.

Table 6. Demographic profile of households and workers

	Kenya	Viet Nam
Household profile		
Number of women	2.8	2.4
Number of men	2.7	2.5
Number of children	2.7	1.9
Household size (number of members)	5.4	5.0
HH member with no or below primary education (%)	32.7	30.1
HH member with primary education (%)	37.9	22.5
HH member with secondary education (%)	22.1	43.8
HH member with tertiary education (%)	7.3	3.4
Average years of education (years)	6.5	6.6
HH head age (years)	54.6	46.1
HH head is female (%)	27.9	9.0
HH head education level (years)	7.1	6.6
Worker profile		
Age (years)	39.3	38.6
Female (%)	49.0	59.9
Number of years of education (years)	6.8	7.8
Maximum education: zero or less than primary (%)	44.0	31.1
Maximum education: primary (%)	42.2	19.2
Maximum education: secondary (%)	12.2	47.0
Maximum education: tertiary (%)	1.5	2.7

Note: Authors' own calculation.

Source: Household and workers survey data. N = 1,502 in Kenya and 1,153 in Viet Nam for the household survey. N = 1,056 in Kenya and 334 in Viet Nam for the household survey. HH = household.

The workers survey provides insights into the characteristics of individuals engaged as workers in farming households (bottom panel in Table 6). Workers in both countries have a mean age of about 39 years. In Kenya, around 50 percent of workers are women, while in Viet Nam, the majority, 60 percent, are women. The distribution of maximum education levels varies, with 44 percent of Kenyan workers having no or below a primary education, compared with 31 percent of Vietnamese workers.

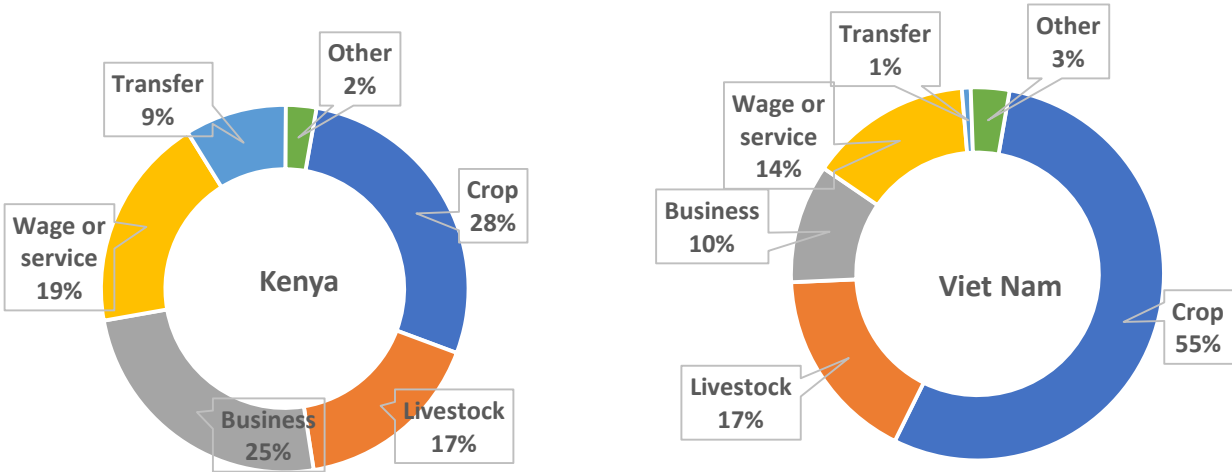
5.1.2. Household economic activities and income composition

All households reported engaging in crop cultivation during the last 12 months, in line with the study's focus on crop-farming households. In addition, 94 percent of households in Kenya and 93 percent in Viet Nam owned or raised some type of livestock in the last 12 months. In contrast, nonagricultural self-employment activities were less prevalent, reported by 40 percent of

households in Kenya and 20 percent in Viet Nam. Finally, about 50 percent of households reported that at least one member is in a wage or service job.

The total household income is \$4,348 in Kenya and \$11,716 in Viet Nam. Figure 10 depicts the contribution of different income streams to total gross income, underscoring notable disparities between the two countries. In Kenya, crop income contributes only 28 percent of total income, although all the sample households are involved in some farming activities. Comparatively, Vietnamese sampled households rely heavily on crop income, contributing 55 percent of the total income. Livestock income maintains a modest share, at 17 percent for both countries. Notably, self-employed enterprise or business income holds a prominent role in Kenya, constituting 25 percent of the total income, while in Viet Nam, it accounts for a comparatively lower share of 10 percent. Wage or service jobs (i.e., employment agriculture and forestry, domestic services, construction, other paid jobs) further diversify the income streams, contributing 19 percent in Kenya and 14 percent in Viet Nam. The share of transfer income is relatively higher in Kenya (9 percent) compared with Viet Nam (only 1 percent).

Figure 10. Composition of household income



Source: Authors' own calculation using NATURE+ Kenya and Viet Nam household surveys. N = 1,502 in Kenya and 1,153 in Viet Nam. All the indicators are measured at the household level, reflecting the share of an individual income stream to the household's total income.

5.1.3. Household farming practices

Average area cultivated is 0.96 hectares per parcel per household in Kenya, and 0.73 in Viet Nam (Table 7). Main crops grown in Kenya are maize, beans, and peanuts, whereas in Viet Nam they are rice, maize, and longan.

Kenyan households demonstrate a more diversified crop farming system, reflected in the higher mean number of crops cultivated per parcel (4.5) compared with Viet Nam's mean of 1.9. This discrepancy underscores the diversification in crop portfolios within Kenyan households, further evidenced by a substantial difference in intercropping practices. For instance, about 84 percent of Kenyan households reported adopting intercropping, whereas this percentage is notably lower at 25 percent in Viet Nam. In Viet Nam, intercropping is more prevalent in male-managed parcels, while in Kenya, it is more likely in jointly managed and female-managed parcels.

Table 7. Land and farming characteristics

	Kenya				Viet Nam			
	Mea- n (All)	Male- manag- ed parcels	Female - manag- ed parcels	Jointly manag- ed parcels	Mea- n (All)	Male- mana- ged parcel s	Female - manag- ed parcels	Jointly manag- ed parcels
Land use								
Area of parcels (in hectares)	0.96	1.10	0.73	1.03	0.73	0.78	0.53	0.70
Number of cultivated parcels per HH	1.91	1.87	1.77	2.05	3.08	3.05	2.28	3.30
HH uses land for animal grazing (%)	4.9	4.6	4.1	5.8	10.8	11.2	10.5	10.3
HH has land left fallow (%)	33.2	30.6	34.6	34.0	10.2	8.1	8.1	14.2
HH has virgin land (%)	0.5	0.2	0.4	0.7	0.6	0.3	0.0	1.3
HH experiences erosion (%)	72.7	68.5	71.5	76.9	54.0	56.1	45.4	52.5
Crops								
Number of crops per parcel	4.52	4.20	4.45	4.83	1.85	1.78	1.85	1.97
HH practices intercropping (%)	84.0	79.5	84.6	87.1	24.6	24.3	20.9	26.1
HH cultivates perennial crops (%)	52.7	48.9	52.6	55.8	56.3	58.2	54.7	53.5
Multi-cropped parcels (%)	96.2	95.4	96.1	96.9	45.7	44.2	39.5	49.9

Source: Authors' calculation using NATURE+ Kenya and Viet Nam baseline household surveys.

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. HH = household.

Interestingly, the cultivation of perennial crops is similar in the two countries, with 53 percent in Kenya and 56 percent in Viet Nam, showcasing a similar inclination toward perennial crop cultivation despite the broader disparities in farming practices and parcel management types.

5.2. True costs of crop production

This section assesses direct costs, gross and net crop income, and the estimation of indirect costs of crop production. Throughout the analysis, cost indicators and all monetary values are expressed in \$PPP. PPI conversion rates—local currency unit (LCU) per international \$—are approximately equal to 43 for Kenya and 7,200 for Viet Nam (World Bank 2023).

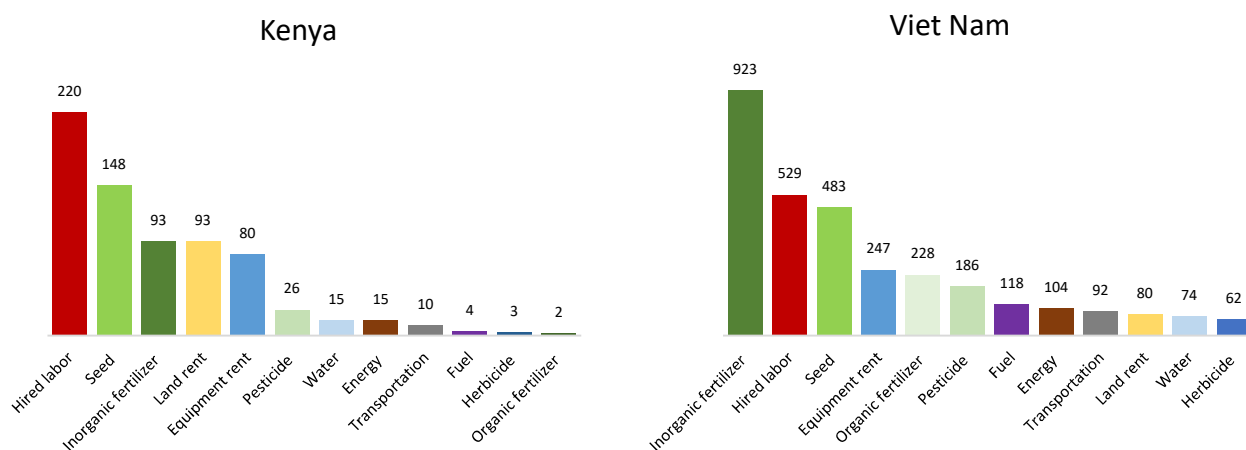
5.2.1. Direct production cost structure and crop income

Figure 11 details the direct cost of crop production at the household level in Kenya and Viet Nam. In Kenya, total direct costs are estimated at \$715. The highest direct cost is attributed to hired labor. Note that the analysis does not account for family labor or free labor costs, which could substantially increase labor costs. Seed costs also contribute substantially, becoming the second-highest cost in Kenyan farming practices. Inorganic fertilizer, land rental, and equipment rental costs follow closely, underscoring the reliance on external inputs for soil enrichment and

mechanized farming operations. The costs of energy, pesticide, and water are comparatively lower.

In Viet Nam, the direct cost composition shows a similar structure; however, cost of food production is much higher, estimated at \$3,148. Inorganic fertilizer is the highest cost heading, indicating a substantial investment in soil nutrients to enhance crop productivity in Viet Nam. Hired labor cost also plays a significant role, the second-highest cost heading. Seed and equipment rental costs follow, reflecting the reliance on human resources and mechanized operations. Pesticide, organic fertilizer, and energy costs are moderate, while water, herbicide, and land rent expenses are comparatively lower.

Figure 11. Direct cost of production (\$ per household)



Source: Authors' own calculation using NATURE+ Kenya and Viet Nam household surveys. N = 1,502 in Kenya and 1,153 in Viet Nam. All the indicators are measured at the household level.

Overall, the crop cost structure shows notable disparities between Kenya and Viet Nam (Table 8).

Table 8. Crop income and direct production costs (\$)

	Kenya	Viet Nam
Gross crop income	1,153	8,981
Total crop production direct costs	715	3,148
Net crop income	438	5,683

Source: Authors using NATURE+ Kenya and Viet Nam household surveys.

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. All the indicators are measured at the household level.

The total gross income from crop farming activities in Kenya amounts to \$1,153, with corresponding total costs totaling \$715. Direct costs represent 62 percent of gross crop income. In stark contrast, Viet Nam's gross crop income and costs are substantially higher, at \$8,980 and \$3,148, respectively, which means that direct costs represent only 35 percent of gross income.

5.2.2. External costs of crop production

5.2.2.1. Factors associated with environmental and social costs

The analysis assesses the extent of use of productivity-enhancing technologies, namely chemical inputs (fertilizers, herbicides, and pesticides) and water resources as factors associated with environmental externalities. While the reliance on chemical inputs suggests a focus on maximizing crop yields, it raises concerns about the potential environmental consequences, including soil degradation, water pollution, and harm to beneficial insects and local biodiversity (Boukaka, Azzarri, and Davis 2024a and 2024b). Results of the analysis (disaggregated by country and parcel management—male, female, joint) are presented in Table 9.

Table 9. Use of productivity-enhancing inputs in agricultural production

	Kenya				Viet Nam			
	Mean (All)	Male-managed parcels	Female-managed parcels	Jointly managed parcels	Mean (All)	Male-managed parcels	Female-managed parcels	Jointly managed parcels
Use of productivity-enhancing inputs								
HH uses organic fertilizer (%)	67.6	60.3	64.8	75.2	54.6	55.2	64.0	51.4
HH uses organic fertilizer (kg/ha)	7,717	9,844	6,540	7,188	54,063	5,048	20,948	146,688
HH uses inorganic fertilizer (%)	59.5	60.1	51.5	65.3	97.5	96.8	96.5	99.2
HH uses inorganic fertilizer (kg/ha)	297	306	314	279	54,579	2,315	2,518	157,030
HH uses herbicides (%)	4.9	4.6	3.0	6.5	55.7	59.5	37.2	53.2
HH uses pesticides (%)	36.0	42.3	25.7	39.3	93.4	92.9	94.2	94.3

Source: Authors using NATURE+ Kenya and Viet Nam household surveys.

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. HH = household.

In Kenya, farmers favor the use of organic fertilizers (68 percent) over inorganic fertilizers (60 percent). About 36 percent of the households use pesticides, and less than 5 percent use herbicides. Jointly managed and male-managed parcels are more likely to use inorganic fertilizers, pesticides, and herbicides. Jointly managed and female-managed parcels are more

likely to use organic fertilizers than are male parcels. In Viet Nam, the use of both organic and inorganic fertilizers is prevalent, but there is a marked preference for inorganic fertilizers (98 percent versus 55 percent for organic), underscoring their importance in farming operations. The same can be observed about pesticides, used by 93 percent of the smallholders. Just over half of smallholders also use herbicides. While there is no significant difference in the proportions of those using fertilizers across the parcel management type, jointly managed parcels use a significantly higher quantity of fertilizers per hectare in Viet Nam.

Table 10 summarizes information on the sources of water used in farms in Kenya and Viet Nam. Rainwater without reservoir emerges as the predominant source of water for irrigation for 97 percent of smallholders in Kenya, which is characteristic of an agricultural system where 83 percent of land area is arid and semiarid (Boukaka, Azzarri, and Davis 2024b). Other sources of water used on farms are surface water (16 percent) and groundwater (7 percent). Overall, there is significant regional variation in sustainable water management (Boukaka, Azzarri, and Davis 2024b). In Viet Nam, the sources of water used on farms is more diverse, with most smallholders relying on rainwater (69 percent), but a significant share also relying on surface water (66 percent), groundwater (21 percent), and rainwater with reservoir (13 percent).

The environmental footprint is also largely influenced during the production and value addition processes, by the level of use of electricity, fuel, water, and transportation. Table 10 shows the proportion of smallholders who had energy, water, and transportation expenses. Viet Nam witnesses a higher prevalence of smallholders incurring expenditures in electricity (18 versus 3 percent in Kenya), fuel (61 versus 4 percent), water (12 versus 7 percent), and transportation (68 versus 30 percent).

Table 10. Sources of water used in farms, and prevalence of expenses in energy, water, and transportation

	Kenya	Viet Nam
Source of water used on farm (%)		
Rainwater (without reservoir)	96.9	67.8
Surface water	15.7	65.7
Groundwater	7.2	21.1
Rainwater (with reservoir)	6.4	12.6
Tap water	2.7	1.6
Prevalence of expenses in electricity, fuel, water, and transportation (%)		
HH has electricity expense	3.2	17.6
HH has fuel expense	3.8	60.9
HH has water expense	7.3	11.5
HH has transport expense	30.0	68.2

Source: Authors using NATURE+ household surveys.

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. HH = household.

Table 11 provides an overview of factors associated with social externalities, namely (a) gender wage gap, (b) children in economic activities, (c) workplace conditions and safety, (d) incidence of harassment, and (e) forced labor. Overall, about 61 percent of smallholders in Kenya and 34 percent in Viet Nam used some hired labor.

About half (49 percent) of the workers interviewed in Kenya were females. In Viet Nam, that figure was approximately 60 percent. The gender wage gap is present in both countries. In Kenya, male workers earn daily wages that are about 10 percent higher than those of their female counterparts. In Viet Nam, the male–female wage differential is 20 percent.

There is a varied degree of children's participation in economic activities across the two countries. In Kenya, about 6 percent of households with children aged between 6 and 17 years reported that at least one of their children had not attended school in the past 12 months of the survey. Furthermore, 35 percent of households reported that their children are involved in light economic activities such as livestock herding or automatic and hose irrigation. Perhaps more alarming is that 54 percent of households reported that their children were engaged in nonlight activities, such as manual weeding, harvesting, lifting heavy loads, bucket irrigation, and other physically demanding tasks. Finally, 34 percent of children were exposed to hazardous activities, such as spraying and inhaling chemicals or facing the risk of injury from agricultural equipment like tractors, sharp plows, or other machinery. In Viet Nam, about 9 percent of children aged between 6 and 16 were reported as not attending school. The engagement of Vietnamese

children in light, nonlight, and hazardous activities is higher, at 35, 33, and 10 percent, respectively.

Table 11. Descriptive statistics on factors associated with social externalities

	Kenya	Viet Nam
Labor use		
HH used hired labor (%)	61.2	33.8
HH has free labor (%)	20.0	65.0
Gender wage gap		
Male–female daily wage ratio	1.1	1.2
Percentage of female workers	49.0	59.9
Children in economic activity*		
Children not attending school	5.9	9.4
Children involved in hazardous activity	33.7	10.4
Children involved in light activity	34.7	35.1
Children involved in nonlight activity	53.7	33.1
Workplace conditions and safety**		
Uninsured nonfatal accidents	0.7	0.9
Insured nonfatal accidents	0.8	0.3
Injured or hurt while working	13.7	2.7
Fatal incidents	0.0	0.1
Worked in nonstandard conditions	39.8	14.2
No social security (public insurance) (%)	5.0	47.4
No maternity leave (%)	99.2	98.0
Illegal overtime at work	37.3	18.3
Harassment		
Experienced nonsexual/nonphysical actions	22.4	3.0
Experienced nonsexual/physical actions	7.8	0.9
Experienced sexual/nonphysical actions	13.5	1.5
Experienced sexual/physical less severe actions	4.9	0.0
Experienced sexual/physical severe actions	2.3	0.0
Forced labor		
Least severe forced work (LSFW) (FTE)	13.8	4.7
Medium severe forced work (MSFW)(FTE)	12.4	3.9
High severe forced work (HSFW)(FTE)	5.7	0.1
Workers are in debt with employer	6.3	3.3

Source: Authors' own calculation using NATURE+ Kenya and Viet Nam household and workers surveys.

Note: * Each indicator shows whether a household has a child with an experience on the respective indicator. Data include households with at least one child. N = 1,152 in Kenya and 789 in Viet Nam. ** The worker-level survey covered 1,056 workers in Kenya and 334 workers in Viet Nam. FTE = full-time equivalent; HH = household.

The workers survey asked all farm workers about their working conditions and safety. The incidence of nonfatal injuries in the workplace is relatively lower in both countries. While about 14 percent of the workers in Kenya and under 3 percent in Viet Nam reported getting insured or hurt while working, fatal incidents were nonexistent among the study sample. About 40 percent of the farm workers in Kenya reported as having worked in substandard conditions, while only

about 14 percent of those in Viet Nam reported having done so. Unpaid overtime (working more hours than agreed without compensation) was reported by about 37 percent of the workers in Kenya and 18 percent in Viet Nam. While about half of the workers in Viet Nam (47 percent) have access to some form of public insurance (social security), only 5 percent of workers in Kenya have such access. In both countries, virtually no maternity leave is granted to workers.

Several types of workplace harassment were reported by workers. In Kenya, 22 percent of workers reported experiencing a situation in which a co-worker, supervisor, or employer has made (nonsexual) comments, threats, or (nonphysical) actions that have made them feel humiliated, offended, intimidated, or discriminated against. Additionally, 8 percent of workers encountered a situation in which a co-worker, supervisor, or employer has made physical but nonsexual contact or aggression that made them feel threatened, unsafe, or uncomfortable. In terms of sexual harassment, 14 percent reported nonphysical comments, threats, or actions, and 5 percent experienced less severe physical actions such as touching, kissing, or hugging. About 2 percent of workers from Kenya reported facing severe sexual and physical actions, such as unwanted or forced violent sexual aggression or sexual intercourse, in return for a favor or favors or to avoid negative consequences at work. In Viet Nam, the incidence of workplace harassment appears relatively lower, with only 3 percent facing nonsexual and nonphysical actions, 1 percent experiencing nonsexual and physical actions, and only 1 percent encountering sexual and nonphysical actions.

The workers survey also inquired about the prevalence of forced labor, defined as “all physical and psychological damage from work or service that is claimed under threat of punishment and for which the person concerned is not autonomously participating” (ILO 2019). In addition, workers were asked about the frequency of the occurrence of (a) instances in which they perform activities requested with which they do not agree, (b) exposure to unfriendly or violent communication by employers, and (c) occurrence of threats or violence from employers in the job. A scale was then created to set two categories: least severe forced work (LSFW), medium severe forced work (MSFW), and high severe forced work (HSFW). Results indicate that in Kenya about 14 percent experience LSF, 12 percent experience MSFW, and only 2 percent HSF. In Viet Nam, the figures are relatively lower at 5, 4, and 0.1 percent, respectively. Relatedly, about 6.3 percent of workers in Kenya and 3.3 percent in Viet Nam are in debt with their employer.

5.2.2.2. Levels and structure of the external costs of crop production

We now turn to a close attention to the relative magnitude of the impacts related to the environmental and social externalities in each country (Figures 12 and 13) and their relevance.

The estimation follows the steps introduced in Section 2 to compute the indirect crop production costs, that is, those related to the environmental and social externalities in this study. The process involves the use of the survey data for the estimation of the footprints of the different impacts associated with those externalities and the subsequent conversion of the footprints to monetary terms using the country specific MFs.

The external costs of food production in Kenya

The total external costs in Kenya are estimated at \$311 per farming household, of which about \$250 are derived from social externalities and the remaining \$51 from environmental impacts.

Figure 12 show the (a) structure and (b) ranking of external impacts in Kenya. As noted earlier, in Kenya, external costs are dominated by social impacts over those related to the environment. Forced labor (24.3 percent) and child labor (17.2 percent) are the main external costs, followed by land occupation (14.6 percent), underpayment (14.3 percent), gender wage gap (12.8 percent), occurrence of harassment (10.8 percent) and workplace health and safety incidents (3.9 percent). Besides land occupation, the only other environmental impact in the top 10 is soil degradation. We group the analysis of impacts by type of externality, starting with those related to social costs.

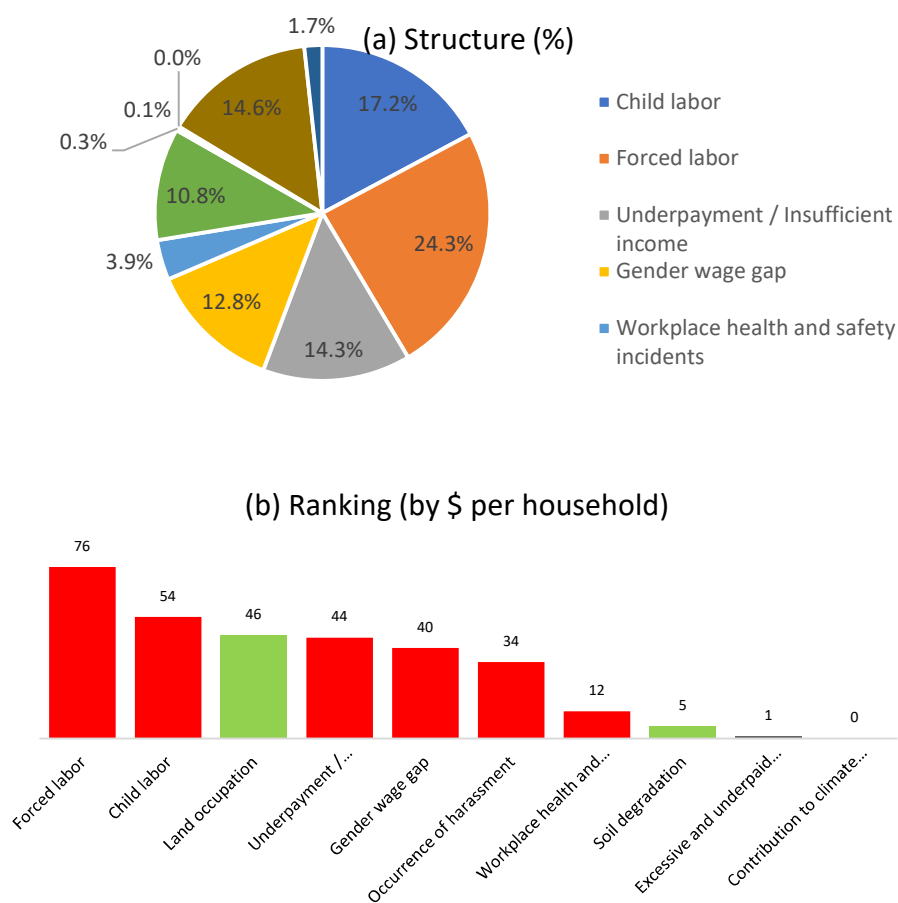
Social costs in Kenya

Forced labor is identified as the main external impact in agriculture in Kenya, about \$76 per household per year, or 24 percent of total external costs and 30 percent of social costs. While virtually no workers reported the most severe (physical coercion) forms of forced labor, about 14 percent reported experiencing some form of least severe (financial coercion) forced labor. About 12 percent reported medium severe (psychological coercion) forced work through some form of restrictions to their movement. The Impact Institute and IFPRI (2023) highlighted forced labor as an important externality in the coffee sector in Kenya. It should be noted that a critical driver of forced labor practices in the agriculture sector is the prevalence of seasonal, temporary

workers without any formal contract, who in some cases move away from their areas of residence and become very dependent on employers, which makes them vulnerable to coercion through holding wages or personal documents (Rainforest Alliance 2020; Verité 2022).

Child labor represents 17 percent of total external costs and 21 percent of the social externalities in Kenya. The impact of child labor on costs is driven by the significant number of children performing hazardous activity (about 34 percent) and others involved in other light and nonlight activities. The analysis shows that the share of school-aged children not attending school is relatively small, about 6 percent. Earlier studies in Kenya have highlighted that the highest risks of child labor are in cash cropping (such as coffee) or market-oriented sectors (Bureau of International Labor Affairs 2018; 2022), where a strong correlation is found between low prices and the increased child labor use.

Figure 12. Structure and ranking of external costs, Kenya



Source: Authors' own calculation using NATURE+ Kenya and Viet Nam household and workers surveys and monetization factors (Impact Institute 2021).

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. All the indicators are measured at the household level.

Underpayment/underearning/insufficient income is an important social impact, representing 14 percent of total external costs and 17 percent of social externalities. As highlighted earlier in this analysis, about 61 percent of the smallholders in Kenya hire labor (Table 11). Also, hired labor cost is the top-ranked direct cost in Kenya (Figure 11a), making it the main target for reducing input cost among farmers, therefore resulting in consistently low wages. As a result, a high incidence of workers earn below the minimum wage. In general, these wages are lower among female workers. Likewise, female-headed smallholders generate lower profits. This reflects the prevalence of gender wage/income gaps. It should also be noted that the prevalence of high input costs and other factors associated with low productivity and profitability in agriculture results in a significant number of farmers earning insufficient incomes. Earlier research of true prices in

Kenya has highlighted the prevalence of low prices to producers, small land area sizes, and low productivity, which deepen the struggle of farmers to achieve living incomes (Solidaridad 2022).

Occurrence of harassment is another important impact, representing 11 percent of the total external costs and 13 percent of the social externalities. In Kenya, 22 percent of workers experienced nonsexual/nonphysical threats that were humiliating, offending, intimidating, or discriminating. Additionally, 8 percent of workers experienced physical but nonsexual contact or aggression that made them feel threatened, unsafe, or uncomfortable. Furthermore, in terms of sexual harassment, 14 percent reported nonphysical comments, threats, or actions, and 5 percent experienced less severe physical actions such as touching, kissing, or hugging. About 2 percent of workers reported facing severe sexual and physical actions. These results are consistent with findings from other studies across different value chains in Kenya (Impact Institute and IFPRI 2023; International Labor Rights Fund 2002; Ministry of Agriculture 2022; Rainforest Alliance 2023).

Environmental costs in Kenya

Land occupation/land use is the single most important environmental impact in Kenya. While it represents only 15 percent of all externalities, it represents over 90 percent of the environmental costs. Land occupation represents the decreased availability of land for purposes other than the one for which it is being used currently. It is a cost because the use of land for agricultural purposes displaces habitats and ecosystems, leading to the loss in biodiversity and ecosystem services (De Groot et al. 2012).

Beside land occupation, soil degradation is the only other (related) environmental impact in Kenya. It is estimated at \$5 per household, representing only 2 percent of all externalities and 10 percent of the environmental costs. Soil degradation, which is defined as the physical, chemical, and biological decline in soil quality, can be caused by the reliance on chemical inputs and excessive water use during the crop production process. The use of such inputs in Kenya is relatively low; that is, while 60 percent of the households use inorganic fertilizer, the level of intensity or quantity used is very limited (0.1 kg/ha). Similarly, only 36 percent of the households use pesticides, and less than 5 percent use herbicides. It is worth noting that about 73 percent of smallholders in Kenya report having experienced some form of soil erosion, which raises an

important concern about soil degradation, with possibly severe negative consequences to sustainable crop production performance.

The external costs of food production in Viet Nam

The total external costs in Viet Nam are estimated at \$988 per household, of which about \$603 are environmental and the remainder are social. Figure 13 shows the (a) structure and (b) ranking of external impacts in Viet Nam. External costs are dominated by environmental impacts over those related social aspects. Land occupation/use is the dominant impact (27.8 percent), followed by soil degradation (14.5 percent) and underpayment/insufficient income (14.3 percent). Other prominent environmental impacts are climate change (11 percent) and the use of scarce water (8.0 percent). Relatively small social impacts related to child labor (6.5 percent), forced labor (5.7 percent), occurrence of harassment (3.1 percent), workplace health and safety (1.4 percent), and excessive underpaid overtime (0.4 percent) are also observed in Viet Nam. We group the analysis of impacts by type of externality, starting with those related to environmental costs.

Environmental costs in Viet Nam

To understand the dominance of environmental impacts in Viet Nam, it is important to recall that farming is relatively more input-intensive. As indicated in the *2022 Nature+ Vietnam Assessment Report* (Nguyen Thi Tan Loc 2022), the intensive use of chemicals negatively affects environmental health and biodiversity. The report highlights that the overuse of pesticides in cultivating crops such as rice and maize have a profound impact on the environment and how floods contribute to landslides and soil erosion, exacerbating environmental degradation (Boukaka, Azzarri, and Davis 2024a).

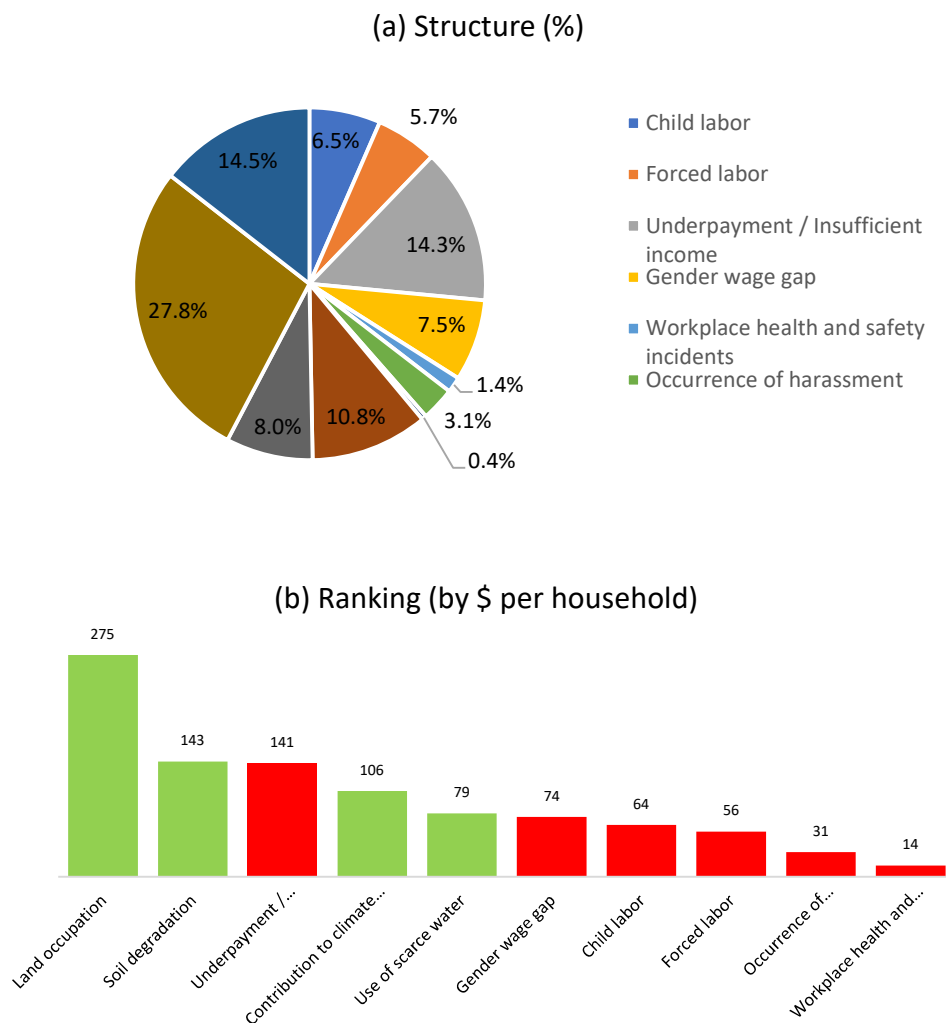
Land occupation is the single most important impact in Viet Nam (\$275 per household), representing 28 percent of total externalities and 46 percent of the environmental costs. This indicates that the occupation of lands for cultivation—rather than the conservation in its natural state as woodlands or grassland—is imposing a cost in the food production system over time. As indicated earlier, smallholders in Viet Nam cultivate relatively smaller areas (0.7 versus 1.1 in Kenya), but each smallholder has relatively more parcels (2.9 versus 1.7 in Kenya). It is critical to

slow down the process of land expansion to minimize the loss of biodiversity and ecosystem services.

Soil degradation is the second most important external impact, estimated at \$143 per household (about 14 percent of the overall externalities and 24 percent of the environmental cost). The widespread use of inorganic fertilizers (98 percent of households), alongside significant use of pesticides (93 percent of households), points to an intensive approach to agricultural management in Viet Nam. In some regions of the study area, the high usage is due to the terraced landscapes, where the difficulty of maintaining productivity on steep slopes (Tarolli and Straffelini 2020) may drive the need for such inputs (Boukaka, Azzarri, and Davis 2024a), with consequences to soil quality.

The costs derived from contributions to climate change are estimated at \$106 per household (about 11 percent of the overall externalities and 18 percent of the environmental costs). This indicator refers to the quantity of GHG emissions in CO₂ equivalents derived from the crop production processes. The exclusion of livestock from the analysis results in relatively lower impact. Nonetheless, the relatively high level of the use of fertilizers and other chemical inputs is a significant factor driving this environmental impact, exacerbating the negative environmental implications in Viet Nam.

Figure 13. Structure and ranking of external costs, Viet Nam



Source: Authors' own calculation using NATURE+ Kenya and Viet Nam household and workers surveys and monetization factors (Impact Institute 2021).

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. All the indicators are measured at the household level.

Technically, scarce water use refers to the use of blue water that is evaporated, incorporated into products, and transferred to other watersheds in areas where water is scarce (Falkenmark and Rockström 2004). In Viet Nam, the sources of water used on farms is more diverse than in Kenya, with most smallholders relying on rainwater (69 percent), but a significant number also relying on surface water (66 percent), groundwater (21 percent), and rainwater with reservoir (13 percent). Scarce water costs are estimated at \$79 per household, which represents 8 percent of the total external costs and 13 percent of the environmental externalities.

Social costs in Viet Nam

Social externalities in Viet Nam are largely smaller than those related to the environment. Given the relatively small sample of workers in Viet Nam, this result on social costs needs to be considered with caution.

Underpayment/insufficient income is the most significant social cost in Viet Nam. It is estimated at \$141 per household, representing more than 14 percent of the total external impacts and a significant share of the social impacts (37 percent). From earlier analysis, we found that 34 percent of smallholders in Viet Nam hire labor (Table 11). Hired labor cost is the second-ranked direct cost in Viet Nam (Figure 11b), making it an important target for reducing input cost among farmers, therefore resulting in lower wages. Associated with this result is the prevalence of gender wage/income gaps, reflected in the relative position of the wage gender gap in the ranking. Relatively low profits are generated by some farming households, especially those headed by females.

Child labor–related external costs are estimated at \$64 per household, representing only 6 percent of the total external impacts and 17 percent of the social impacts. While a relatively small proportion of households have children engaged in hazardous activity (10 percent), and a relatively small number of households have children not attending school (10 percent), about a third of the households have kids engaging in light activities and other nonlight activities, which makes the relevance of this cost relatively low.

The occurrence of harassment is much less prevalent in Viet Nam, representing only \$31 per household (about 3 percent of the overall externalities and 8 percent of social costs). As per the survey statistics, only about 3 percent of households reported experiencing nonsexual/nonphysical harassment and 2 percent as having experienced sexual/nonphysical harassment. So, this is a less pressing issue for Viet Nam.

Like the occurrence of harassment, workplace safety conditions in Viet Nam are relatively good. This cost is estimated at \$14 per household (less than 1.4 percent of total external impacts and 4 percent of the social costs). In fact, the occurrence of fatal and nonfatal accidents is negligible, with about 14 percent report working in nonstandard conditions, which is significantly lower than the 37 percent in Kenya.

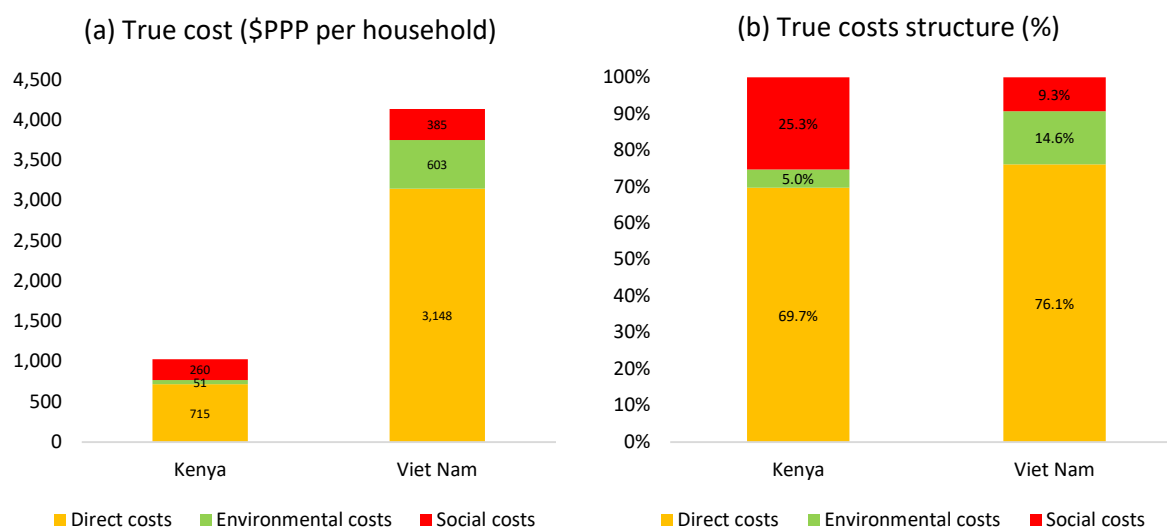
5.2.3. Estimation of the true costs of crop production

The estimates of the true costs of production are generated in \$ per sample household and are computed as the sum of the direct (Section 5.2.1) and indirect (5.2.2) costs per household in each country.

In Kenya, the calculated true cost of crop production is \$1,026 per household, which is the sum of the direct production cost (\$715 per household) and the external costs estimated at \$311 per household. The latter is also called the true cost gap, which in this case represents 30 percent of the true cost. The breakdown of externalities indicates that social costs (25 percent of true cost and 84 percent of the external costs) dominate those related to environmental impacts that are only 5 percent of the true costs or 16 percent of the external costs (Figure 14).

In Viet Nam, the true cost of crop production is estimated at \$4,136 per household, which is the sum of the direct production cost (\$3,148 per household) and the external costs estimated at \$988 per household, which represents about 24 percent of the true cost, a percentage that is relatively lower than in Kenya. The breakdown of externalities indicates that environmental costs (15 percent of true cost and 61 percent of the external costs) dominate those related to social impacts that are only 9 percent of the true costs or 39 percent of the external costs (Figure 14). So, while both countries reveal the presence of both types of external impacts in their crop production systems, environmental issues are relatively more severe in Viet Nam, and social issues are relatively more relevant for Kenya.

Figure 14. True costs of food production



Source: Authors' own calculation using NATURE+ household and workers surveys and monetization factors.

We finish by revisiting the importance of the production costs on crop income, now looking at the external costs. Table 12 (which builds on Table 8 in Section 5.2.1) shows that there are notable differences between Kenya and Viet Nam.

Table 12. Crop income and direct and external production costs (\$)

	Kenya	Viet Nam
Gross crop income	1,153	8,981
Direct crop production costs	715	3,148
Net (of direct costs) crop income	438	5,683
Indirect/external production costs	311	988
Environmental	51	603
Social	260	385
Net (of externalities and direct costs) crop income	127	4,695

Source: Authors using NATURE+ Kenya and Viet Nam household surveys.

Note: N = 1,502 in Kenya and 1,153 in Viet Nam. All indicators are measured at the household level.

In Kenya, external costs (\$311) represent just over 25 percent of the gross crop income. These external costs represent more than 70 percent of the net (of direct costs) crop income, resulting in a significantly lower full net (of direct costs and externalities) crop income (\$127). So, when accounting for all direct and external costs, final farm crop profits represent only 11 percent of the original gross crop income.

In Viet Nam, external costs (\$988) represent just over 11 percent of the gross crop income. These external costs represent only 17 percent of the net (of direct costs) crop income, resulting in a

still reasonable full net (of direct costs and externalities) crop income (\$4,695). In this case, when accounting for all direct and external costs, final farm crop profits represent more than 52 percent of the gross crop income.

6. Conclusions and implications

Overall, our data analysis shows stark differences in the food production systems of Kenya and Viet Nam. In Kenya, cereal crops and other non-rice crops dominate food production, whereas in Viet Nam, rice production is dominant. Crop production systems in Kenya exhibit relatively high labor-related costs compared to nonlabor inputs, with relatively low crop yields. This production system leads to the relatively greater social externalities (compared to environmental). Conversely, crop yields in Viet Nam are significantly higher than those in Kenya, likely due to the extensive use of inorganic fertilizers representing the largest direct cost component and leading to a relatively higher level of environmental externalities than in Kenya.

Because external costs represent a significant part of the final cost, policy and investments leading to minimizing those costs are essential to building a more environmentally sustainable and socially equitable food system. Overall, strategies may encompass (a) regulatory adjustments for economic actors, (b) investments in resource-efficient infrastructure and technologies, and (c) prudent management of environmentally impactful production inputs and factors. Applying this policy would involve navigating the limitations and quality aspects of scarce resources such as land and water and addressing labor-related issues such as remuneration, harassment, child labor, forced labor, working conditions, and gender discrimination.

High social costs, that is, social externalities, are rooted in low prices of agricultural commodities, rising costs of production, and high levels of informality in the sector. Low market prices pressing producers to cut costs lead to downward pressure on farm workers' wages (underpayment) and the reduction of profits, resulting in insufficient income for producers. Low prices also lead to the deterioration of working conditions. The high prevalence of informal relationships, or the lack of formal contracts, increases farm workers' vulnerability and exposure to social impacts, particularly forced labor, and to different forms of harassment. Furthermore, the high costs of hired labor lead farmers to increase the use of family labor, which in turn increases the

prevalence of child labor. Additionally, widespread informality and relatively low presence of farmer organizations make it costly for governments to monitor and enforce regulations.

Smallholder farmers are disproportionately affected by the threats of climate change and are generally less able to strengthen their resilience and adaptive capacity to reduce environmental impacts, due to financial and technical constraints (Dzebo and Adams 2022), leading to quite substantial environmental externalities. Especially in Viet Nam, generally unsustainable production practices make it critical to promote actions aimed at minimizing the loss of biodiversity and ecosystem services, soil degradation, and the use of scarce water. However, smallholders' economic vulnerability limits their ability to make the necessary investments in sustainable practices. The low profit margins put pressure on smallholders to increase productivity through the increased use of chemical inputs such as fertilizers and pesticides, which further aggravates the negative environmental impacts.

We suggest the following interventions to overcome the challenges of farmers and workers in the environmental and social areas.

First, strengthen smallholder farmers' performance. Since actions are needed to increase farm-level productivity, resilience, and sustainability and improve farmers' livelihoods, efforts should focus on the efficient use of resources that leads to higher yield, lower production costs, and the effective prevention of, mitigation of, and adaptation to the threats of climate change (Impact Institute and IFPRI 2023). Specifically, (a) promote, possibly in collaboration with farmers' organizations, the capacity and training of farmers in sustainable agricultural practices and adaptive strategies. This will enable farmers to access important actionable information that brings sustainable economic benefits while minimizing environmental costs; (b) promote sustainable farming practices grounded on regenerative farming principles where appropriate. This strategy will enable increased functioning and resilience of ecosystems, minimizing the need for inorganic inputs that lead to lower costs and environmental impacts; (c) encourage contract farming to enable technology transfer and input credit schemes to farmers and support government-funded programs that enable access to sustainable technologies and markets; and (d) encourage crop and overall income diversification among farmers to ensure they can cope with risks, be able to invest in sustainable farm production, and maximize overall income.

Second, capacitate and empower farm workers. A key limitation of farm workers lies in their incapacity to advocate and safeguard/protect their rights, particularly with respect to the violations related to forced labor, harassment, unfairness in remuneration, and health and safety. Specifically, (a) promote the development and strengthening of worker associations and unions. The opportunities arising from worker organizations include the benefits of collective bargaining, which strengthens participants' ability to negotiate for fair wages, better working conditions, and other benefits. Unions open the doors for a broader geographic scope; (b) promote the capacity and training of farmers/workers, preferably organized in groups or unions, on the fundamental national labor rights, including health and safety standards. This will enable farm workers to know, advocate for, and claim their labor rights more effectively; and (c) develop local grievance mechanisms for workers, which is best done in the context of worker organizations and the local community.

7. Study limitations

The study was subject to several limitations. First, the local-level analysis focuses on the direct production stage, capturing the external costs associated with the production phase only. This approach omits the external costs in upstream and downstream segments of the production value chain, such as raw material sourcing, transportation, processing, distribution, consumption, and waste disposal. To overcome this limitation, this study used the GID, which measures the cost structure across different value chain stages by crop types and impacts.

Second, our analysis aims to understand food production's social and environmental costs. However, this means that we did not consider the health-related costs that arise from food production, such as diet-related diseases or the health impacts of pesticide exposure. Relatedly, the study does not consider the health and social benefits of an adequate, diverse, and good-quality diet, which could eventually justify and potentially offset the associated externalities. This omission is primarily due to the lack of comprehensive health-related data and the associated difficulty in collecting these data in household-level surveys.

Third, in estimating environmental externalities at the household level, the study does not account for certain impact factors such as air, water, and soil pollution because of limitations in the household data. These elements are important to understanding the environmental footprint

of food production, as they relate directly to key issues such as climate change, biodiversity loss, and ecosystem degradation. We report external costs on GHG emissions and soil degradation, offering a partial assessment of the environmental costs of food production at the micro level.

Fourth, this analysis is an accounting exercise, and as such it does not consider any household behavioral response and feedback mechanisms at play when social and environmental costs reach specific thresholds.

Fifth, some indicators rely on subjective data from respondents, particularly on social externalities. This may introduce the potential for social desirability bias, in which respondents might underreport or overreport certain behaviors or impacts to align with perceived societal norms or expectations. Such biases can skew our understanding of the social costs associated with food production, either minimizing or exaggerating the real impacts. In Viet Nam, this is further aggravated by the relatively small sample size in the workers survey, which also affects the reliability of the estimates.

Finally, our study had a limitation in the methodological approach. In aggregating the individual impact categories associated with the environmental and social externalities, it considers the effects of the different external impacts partially, not accounting for any simultaneity or how one may exacerbate the other by complementing or reinforcing its effects. While it serves the purpose of accessing the relative importance of each and gives a first-order estimation of the total and individual impacts, it suffers from this weakness. Therefore, future research should address this limitation to improve the measurement of the total external impact.

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Annex

Table A1. Definition of TCA indicators computed from the farm and workers surveys

Externality type	Impact type	Description indicator	Measurement	Indicator type
Environmental	Contribution to climate change	Contribution to climate change	Total CO ₂ emitted from the quantity of fertilizer used in production	Continuous
	Land occupation	Land occupation	Cultivated land in last 12 months (hectare)	Continuous
	Use of scarce water	Scarce blue water use	Total water used in production	Continuous
	Soil Degradation	Soil loss from water erosion	Total soil degraded for cultivated land due to water erosion	Continuous
		Soil loss from wind erosion	Total soil degraded for cultivated land due to wind erosion	Continuous
Social	Child labor	Underage workers who are not attending school	Children aged between 6 and 17 in Kenya (6 and 16 in Viet Nam) not attending school	Binary
		Underage workers below minimum age involved in hazardous work	Children aged between 6 and 13 involved in hazardous work (such as manual application of spraying and use of machete), with FTE estimated based on 40 hours of work per week	Continuous
		Workers above minimum age and below 18 involved in hazardous work	Children aged between 14 and 17 in Kenya (14 and 16 in Viet Nam) involved in hazardous work (such as manual application of spraying and use of machete), with FTE estimation based on 40 hours of work per week.	Continuous
		Underage workers below minimum age for light work involved in nonhazardous economic work	Children aged between 6 and 13 involved in nonhazardous work (work other than manual application of spraying and use of machete), with FTE estimation based on 40 hours of work per week	Continuous
		Underage workers above minimum age for light work and below minimum age involved in nonhazardous, nonlight economic work	Children aged between 14 and 17 (14 and 16 in Viet Nam) involved in nonhazardous work, nonlight work such as manual weeding, manual harvesting, lifting, carrying heavy bags/cans, bucket irrigation, and other physically intense activities (work other than manual application of spraying and use of machete), with FTE estimation based on 40 hours of work per week	Continuous
	Forced labor	Forced labor	Household member forced into a labor activity against their will in the last 12 months	Binary
	Underpayment	Wage gap workers earning below minimum wage	Gap between daily minimum wage (\$11.74 in Kenya and \$21.67 in Viet Nam) and	Continuous

Externality type	Impact type	Description indicator	Measurement	Indicator type
			actual wages received by hired labor for the days worked for a household	
	Gender wage gap	Gender wage gap	Gap in female worker wages compared with the average male worker wages from the local area	Continuous
		Denied maternity leave	Value of denied maternity leave payment for women aged between 15 to 49 years. 12 weeks' leave provision for women in Kenya and 24 weeks in Viet Nam.	Continuous
	Insufficient income	Insufficient income	The gap between poverty line equivalent minimum income (\$3,760.80 in Kenya and \$4,870.42 in Viet Nam) and actual household income; World Bank poverty and equity brief used for the poverty cut-off value	Continuous
	Workplace health and safety (H & S) incidents	Work performed in violation of H & S standards	Worker applies pesticide or machete manually. FTE estimation: all the time = 1, less than half of the time = 0.25, about half of the time = 0.50, more than half of the time = 0.75, and never = 0. Final measure as the average of the two variables (pesticide and machete).	Continuous
		Occupational injuries with breach of H & S standards	Injured or hurt while working in the last 12 months and no H & S training	Binary
		Uninsured nonfatal occupational incidents	Injured or hurt while working in the last 12 months and no injury payment by firm or public funds	Binary
		Insured nonfatal occupational incidents	Injured or hurt while working in the last 12 months but received payment from firm or public funds	Binary
		Fatal occupational incidents	Worker knows if someone lost their lives because of their work at this workplace in the last 12 months	Binary
	Occurrence of harassment	Nonphysical harassment (nonsexual)	Ever been in a situation where a co-worker, supervisor, or employer has made (nonsexual) comments, threats, or (nonphysical) actions that have made you feel humiliated, offended, intimidated, or discriminated against	Binary
		Physical harassment (nonsexual)	Ever been in a situation where a co-worker, supervisor, or employer has made physical (nonsexual) contact or aggression that made you feel threatened, unsafe, or uncomfortable	Binary
		Nonphysical sexual harassment	Ever been in a situation where a co-worker, supervisor, employer has made unwanted sexual comments or threats or (nonphysical) actions that have made you feel uncomfortable, humiliated,	Binary

Externality type	Impact type	Description indicator	Measurement	Indicator type
			intimidated, discriminated against, or offended	
		Physical sexual harassment (nonsevere)	Ever been in a situation where a co-worker, supervisor, or employer has made unwanted physical contact of a sexual nature, such as touching, kissing, or hugging, that has made you feel uncomfortable, unsafe, humiliated, intimidated, discriminated against, or offended	Binary
		Severe physical sexual harassment	Ever been in a situation where a co-worker, supervisor, or employer has made you feel unwanted or forced violent sexual aggression or sexual intercourse in return for a favor or favors or to avoid negative consequences at work	Binary
	Excessive and underpaid overtime	Illegal overtime	Weekly total overtime hours more than 40 hours	Binary
		Underpaid overtime	Gap in worker overtime wages compared with the average worker wages from the local area	Continuous

Source: Based on True Price (2021b).

Note: FTE = full-time equivalent.

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IFPRI HEADQUARTERS

1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org