

UNVEILING THE TRUE COST ACCOUNTING (TCA) FOR AGRI-FOOD SYSTEMS IN THE BLACK SEA ECONOMIC COOPERATION REGION: REVEALING HIDDEN ENVIRONMENTAL, SOCIAL, AND HEALTH EXTERNALITIES

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Abstract: *The agri-food systems in the Black Sea Economic Cooperation region have a significant importance not only for the region itself, but also at the global level, due to the presence of ones of the biggest producers and exporters of wheat, maize and sunflower in the world. Taking into account that the usual market prices do not offer a clear view on the hidden costs in the agri-food systems, the True Cost Accounting approach has been used in order to quantify the environmental, social, and health externalities in the BSEC region. Thus, the paper aims to present the first aggregated regional application of TCA to this region, and by revealing the true costs, the paper identifies future possibilities for transforming the agri-food systems into sustainable ones, with reduced food waste, enhanced production practices and resilient to environmental conditions. The findings point on the presence of substantial hidden costs related to environmental aspects, health-related costs and also rural vulnerabilities, that might be addressed through inclusion of the TCA approach into national accounting systems at the local level, and the policy frameworks at the regional one. This will contribute with co-benefits for enhancing the economic resilience in the BSEC region through the increased cross-border cooperation for a sustainable agri-food transformation.*

Key-words: True Cost Accounting (TCA), agri-food systems, Black Sea Economic Cooperation (BSEC), hidden costs, environmental externalities, sustainable transformation.

JEL Classification: Q18, Q56 .

1. Introduction

The agri-food systems in the Black Sea Economic Cooperation (BSEC) region have a significant importance not only for the region itself, but also at the global level, due to the presence of ones of the biggest producers and exporters of wheat, maize and sunflower in the world (Kryvenko, 2022). Taking into account that the usual available market prices do not offer a clear view on the hidden costs in the agri-food systems (FAO, 2024), the True Cost Accounting (TCA) approach has been selected and used in order to quantify the environmental, social, and health externalities (Zhang et al, 2026; UNEP et al, 2021) in the BSEC region. Therefore, the aim of the paper is to present the first aggregated regional application of TCA to BSEC region, and by revealing the true costs, to identify future possibilities for transforming the agri-food systems into sustainable ones, with reduced food waste, enhanced production practices and resilient to environmental conditions.

Representing a holistic (Baker et al, 2020), systemic, based on measure and value approach (Contor et al, 2025), TCA can contribute to more informed decision on behalf of the policymakers, businesses or investors (de Adelhart Toorop et al, 2023; FAO et al, 2024; Scialabba et al, 2025). The global applications of TCA, notably in the FAO's State of Food and Agriculture reports from 2023 and 2024, reveal that hidden costs of agri-food systems in the entire world account for approximately 10–12 trillion USD annually, which is equal to about 10% of the global GDP (FAO, 2023 and FAO, 2024). The health-related externalities dominate at around 70%, followed by environmental costs and social costs. All these

externalities hinder the sustainable development of the agri-food systems (Baltussen et al, 2025) and the fact that businesses avoid to take into account the non-financial impacts (Riemer, 2023), the need of the TCA approach application is increasingly important and significant.

The hypothesis of the paper is based on the fact that the agri-food systems from BSEC region generate important hidden environmental, social, and health-related externalities that are not reflected in conventional market prices, resulting in a significant economic burden, which affects national economies of the respective countries.

2. Methodology and data

Being an in-depth and complex approach aimed at quantifying and revealing the hidden environmental, social, and health costs and taking into account that its applicability is a wide one, with a potential to be used at the farm level, but also at the national one (Gemmill-Herren et al, 2021), TCA is based on the calculation of hidden costs that are perceived as any cost incurred to individuals or society that is not present in the market price of a product or a service (FAO, 2024).

The carried-out analysis is based entirely on the TCA methodology developed in the FAO SOFA 2023/2024 reports (FAO, 2023; FAO, 2024). These reports provide worldwide country-level estimates based on the principle of consistency, due to the use of the 2020 PPP USD as the measurement unit for ensuring the best comparability among countries.

Data has been drawn primarily from the SOFA datasets, covering 154 countries, with the required specific extractions and aggregations for the 13 BSEC member states. The analysed key categories are represented by environmental costs (greenhouse gas emissions, nitrogen pollution, land-use change); social costs (undernourishment and agri-food worker poverty) and health costs including the suboptimal dietary patterns, including high consumption of processed foods/additives (processed meat, sugar-sweetened beverages, sodium, trans-fats), low intake of whole plant foods (grains, legumes, nuts, fruits, vegetables), and insufficient beneficial fatty acids (PUFAs, omega-3).

The carried-out aggregations include data calculated for the BSEC regional level and the national levels. The descriptive statistics, percentage breakdowns, and comparative tables/figures were developed in order to highlight the existing differences among the analysed countries. The limitations include reliance on secondary aggregated data and the exclusion of certain localized externalities due to data availability.

3. Basic content

The BSEC region that is composed from the countries like Albania, Armenia, Azerbaijan, Bulgaria, Georgia, Greece, Republic of Moldova, North Macedonia, Romania, Russian Federation, Serbia, Turkey, and Ukraine, has a peculiarity based on economies in transition, where the agricultural sector is an important part of the socio-economic life. Even if there are challenges related to the climate change issues, the presence of the phenomenon of depopulation in rural areas together with the insufficient organization of farmers in groups and associations, the BSEC region countries are being characterized by continuously developing agri-food systems. Thus, the current challenges met by these countries are multifaceted and include geopolitical instability in the region due to the Russian-Ukrainian war, logistical disruptions resulting from the previous challenge, high input costs in the energy and agri-food sectors and climate change. All these challenges put an additional

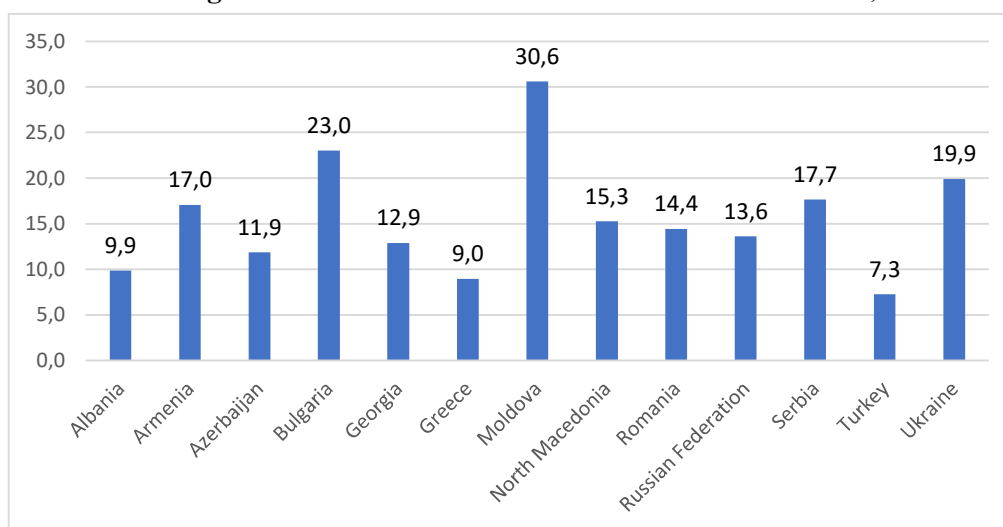
pressure on the economic development, being supported by the hidden costs in the agri-food systems.

Hidden costs in the BSEC region account for about 1.185 billion 2020 PPP dollars, which represents for 10,2% of the global quantified hidden costs of agri-food systems, holding, thus, a significant share.

With respect to the share of total hidden costs in national GDPs, Moldova clearly stands out with the highest share at 30.6%, being followed by Bulgaria with a share of 23.0% and Ukraine with 19.9%. These figures point on the fact that in specifically these economies, the true costs of the food system represent a notable burden for the national economies when being measured against national GDP figures.

On the other side, Turkey has the smallest share of 7.3%, while Greece and Albania also show relatively modest percentages of 9.0% and 9.9%, respectively. Other countries like Armenia (17.0%), Serbia (17.7%), Romania (14.4%) and the Russian Federation (13.6%) have figures close to the region's average. Generally, the noticeable variation among countries presents some existing differences in the absolute amount of hidden costs, but also the size of each nation's economy.

Figure 1. Share of total hidden costs in national GDPs, %



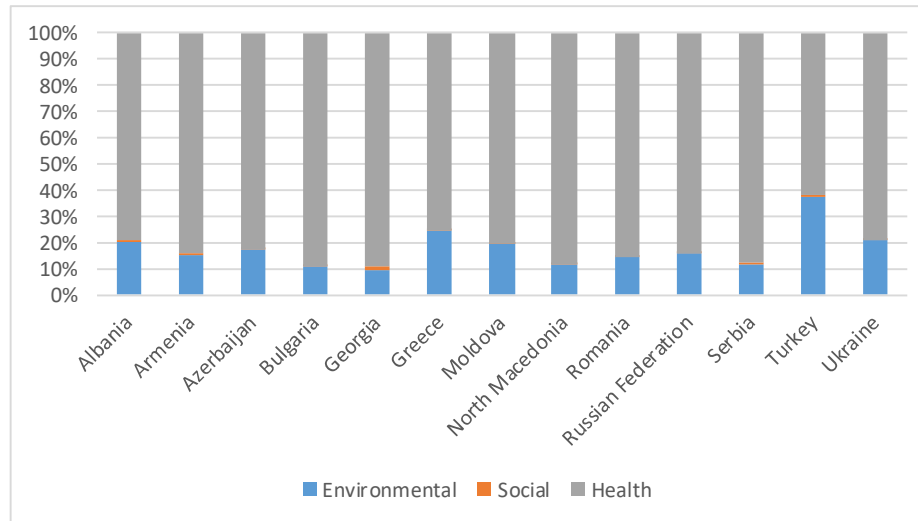
Source: Authors' calculations based on FAO, 2024

When having a look through the main categories of hidden costs, the health costs represent the dominant share across almost all the analysed countries, with a variation from the minimum of 61.6% in Turkey to a high of 88.8% in Bulgaria and Georgia. Environmental costs hold the second place and range from 9.2% to 37.4% of the total hidden costs, being particularly significant in Turkey, Greece, and Ukraine, while the social costs remain very low in all countries, generally under 2%. Only Georgia records the highest relative share at 2.0%.

At the regional level, the total BSEC hidden costs reach 1,184,602 million USD, of which 80.3% are health-related, 19.4% environmental, and only 0.3% are concerning the social aspects. This inequal distribution clearly indicates that health-related externalities and

existing dietary patterns constitute the vast majority of the true costs of the food system in the Black Sea region.

Figure 2. Hidden costs breakdown by main categories for BSEC countries, %



Source: Authors' calculations based on FAO, 2024

With respect to environmental costs, Turkey occupies the first place, with the largest share of 37.4% among all the analysed countries. In terms of absolute terms, other countries with notable environmental burdens are the Russian Federation with 100,096 million USD and Ukraine with 27,290 million USD. In contrast to these countries, smaller economies such as Georgia, Albania and North Macedonia present significantly lower environmental costs in absolute and relative terms.

Table 1. Environmental costs and their share in the total hidden costs in the BSEC region

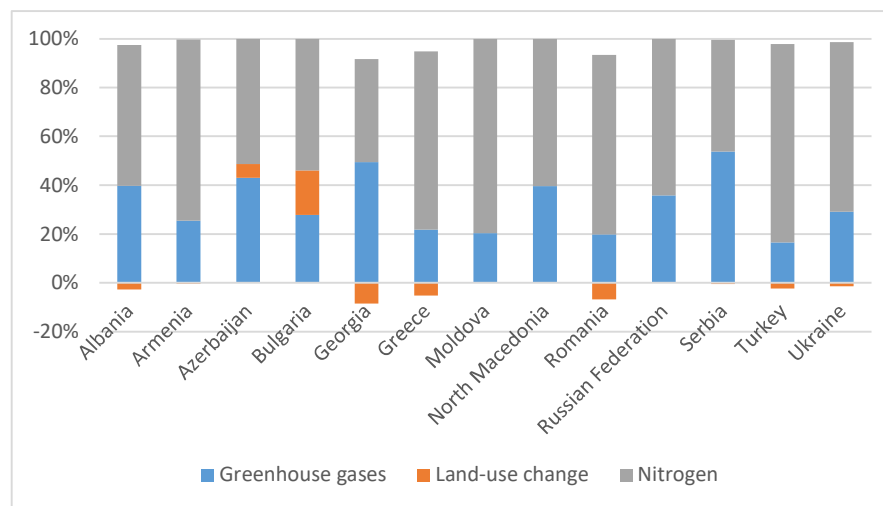
Country	Environmental costs, million USD	Share in total hidden costs, %
Albania	822	20,2
Armenia	1,105	14,9
Azerbaijan	3,11	17,1
Bulgaria	4,573	11,1
Georgia	739	9,2
Greece	6,922	24,5
Moldova	2,126	19,5
North Macedonia	643	11,4
Romania	13,538	14,3
Russian Federation	100,096	15,8
Serbia	3,039	11,9
Turkey	65,964	37,4
Ukraine	27,290	20,9
Total BSEC	229,967	19,4

Source: Authors' calculations based on FAO, 2024

Overall, environmental costs account for 229,967 million USD and represent 19.4% of the total hidden costs at the BSEC level. Even if it is not the dominant category, these environmental costs still remain a critical component of hidden costs, especially in larger economies where agricultural and land-use practices contribute significantly to the regional environmental footprint.

Having a look inside the category of environmental costs, one can note that the nitrogen pollution holds a significant share in many countries, especially in Turkey (56,070 million USD), the Russian Federation (64,268 million USD) and Romania (11,491 million USD). Also, greenhouse gas emissions represent one of the largest components across nearly all countries, with high values recorded in the Russian Federation (35,828 million USD), Turkey (11,493 million USD), and Ukraine (8,192 million USD). In contrast, the last component represented by the land-use change shows more variability, including even negative values in several countries such as Greece (-406), Romania (-1,055), Turkey (-1,599), etc. This indicates that carbon sequestration benefits or different programs for land-use improvement offset the emissions in the contexts of these countries.

Figure 3. Environmental costs breakdown by main categories for BSEC countries, %



Source: Authors' calculations based on FAO, 2024

At the regional level, the total BSEC environmental costs are determined primarily by nitrogen (166,234 million USD) and greenhouse gases (66,310 million USD). At the same time, land-use change registers a small negative value of -2,577 million USD on the account of countries with negative values. In total, this results in a net environmental cost of 229,967 million USD for the BSEC region. Carrying out a comparison with the world totals, the BSEC countries show lower, but still substantial contributions, particularly those related to the nitrogen.

As for the social costs, the absolute values for social costs are generally modest across the BSEC region countries, with Turkey recording the highest value at 1,785 million USD, followed by the Russian Federation with 741 million USD and Ukraine with 165 million USD. Most of the countries present social costs below 200 million USD. At the same time, in

relative terms, social costs account for less than 1% of the total hidden costs in the majority of countries, with Georgia representing a notable exception with a share of 2.0%.

Table 2. Social costs and their share in the total hidden costs in the BSEC region

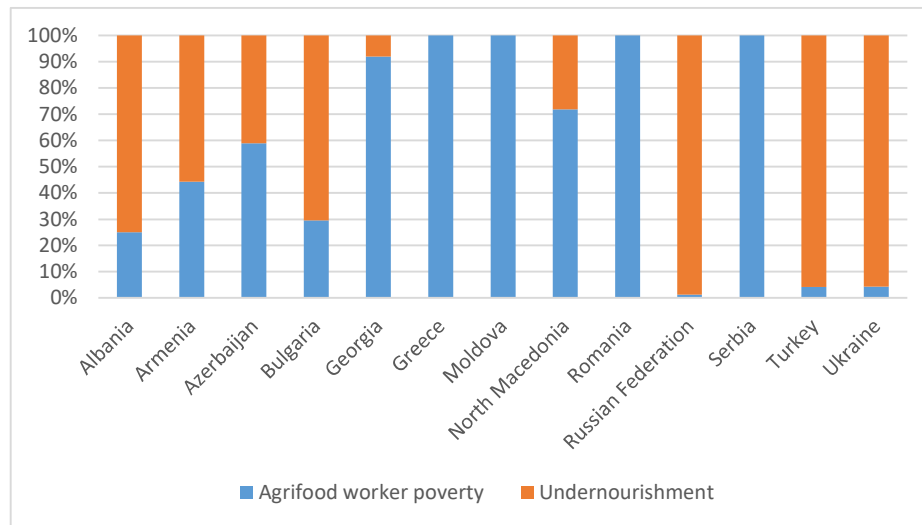
Country	Social costs (mil. USD)	Share in total hidden costs, %
Albania	16	0.4
Armenia	61	0.8
Azerbaijan	56	0.3
Bulgaria	44	0.1
Georgia	161	2.0
Greece	30	0.1
Moldova	2	0.0
North Macedonia	32	0.6
Romania	148	0.2
Russian Federation	741	0.1
Serbia	50	0.2
Turkey	1,785	1.0
Ukraine	165	0.1
Total BSEC	3,291	0.3

Source: Authors' calculations based on FAO, 2024

At the BSEC region aggregate level, the social costs amount to only 3,291 million USD, thus having a share of just 0.3% of the total hidden costs. This low share figure suggests that, within the TCA framework, social externalities are considerably lower compared to environmental and health-related impacts in the BSEC region.

Having a look inside the category of social costs, undernourishment appears as the dominant component of social costs in most countries. Turkey records the highest undernourishment cost at 1,711 million USD, followed by the Russian Federation with 732 million USD. In contrast to these figures, agri-food worker poverty remains relatively low across the region, with Georgia and Romania showing the highest value of 148 million USD each. Several countries, like Greece, Moldova, Romania, and Serbia, report zero or values close to zero related to undernourishment component.

Figure 4. Social costs breakdown by main categories for BSEC countries, %



Source: Authors' calculations based on FAO, 2024

Overall, at the regional level, the total BSEC social hidden costs amount to 3,291 million USD, of which undernourishment accounts for 2,723 million USD and agri-food worker poverty for 568 million USD. Compared to the total figures for all the countries, in the BSEC region there are present significantly lower absolute social costs, while the distribution of these costs still places undernourishment as the primary social concern in countries like Turkey and the Russian Federation.

When analysing the health costs, one can note that they exceed 80% of the total hidden costs in most of the BSEC countries, reaching high shares of up to 88.8% in Bulgaria, Georgia and Serbia. In absolute terms, the Russian Federation and Turkey have the largest health burdens with 532,356 million USD and 108,848 million USD, respectively, mainly due to larger economies and a higher number of populations. But even smaller economies such as Moldova and North Macedonia have the health costs accounting for over 80% of their total hidden costs.

At the regional level, health costs amount to 951,347 million USD, having an 80.3% share in the total of hidden costs in the BSEC area. This considerable dominance reflects that suboptimal dietary pattern like high consumption of processed foods and low intake of whole plant foods and beneficial fatty acids represent the most significant externality of the current food system in the region.

Table 3. Health costs and their share in the total hidden costs in the BSEC region

Country	Health costs (mil. USD)	Share in total hidden costs, %
Albania	3,225	79.4
Armenia	6,251	84.3
Azerbaijan	14,982	82.6
Bulgaria	36,634	88.8
Georgia	7,163	88.8
Greece	21,345	75.4
Moldova	8,786	80.5
North Macedonia	4,976	88.0
Romania	81,133	85.6
Russian Federation	532,356	84.1
Serbia	22,543	88.0
Turkey	108,848	61.6
Ukraine	103,105	79.0
Total BSEC	951,347	80.3

Source: Authors' calculations based on FAO, 2024

The largest share of health costs in most countries result mainly from the diets that are high in processed foods and different additives (including processed meat, sugar-sweetened beverages, sodium, and trans-fatty acids) as well as from insufficient consumption of plant-based whole foods like whole grains, legumes, nuts and seeds, fruits, and vegetables. The low intake of beneficial fatty acids (polyunsaturated fatty acids and seafood omega-3) also contributes significantly to the burden on the agri-food systems and national economies.

At the regional level, taking into account that the total BSEC health hidden costs reach 951,347 million USD, within this category, the high consumption of processed foods and additives accounts for approximately 210,224 million USD (about 22%), while low consumption of plant whole foods represents the largest subcategory reaching 528,296 million USD. The low intake of beneficial fatty acids adds another 149,392 million USD to costs mentioned above. These figures demonstrate that suboptimal dietary patterns based on the insufficient intake of whole plant foods and healthy fats contribute to the emergence of the majority of health-related externalities in the BSEC region.

At the country level, Bulgaria, Serbia and North Macedonia present high proportions of costs linked to processed foods, while countries like Greece and Turkey have notable contributions from excessive red meat consumption and low plant food intake. Overall, the health costs have a dominant component in the TCA, representing around 80% of all hidden costs at the BSEC level.

Table 4. Health costs breakdown by main categories for BSEC countries, million USD

	High in processed foods and additives					Consumption of animal source whole foods			Low in plant whole foods						Low in beneficial fatty acids		
	of Total, which:	Processed meat	sweetened beverages	Sodium Trans-fatty acids	of Total, which:	Low in milk	High in red meat	of Total, which:	Whole grains	Legumes	Nuts and seeds	Fruits	Vegetables	of Total, which:	Polysaturated fatty acids	Seafood omega-3 fatty acids	
Albania	1310	369	52	885	5	95	6	89	1231	737	145	213	116	19	589	269	321
Armenia	876	202	21	644	9	403	41	362	3595	1773	663	831	317	11	1377	571	806
Azerbaijan	2924	653	121	1405	745	490	93	397	8207	4063	1629	1311	1078	125	3361	1456	1905
Bulgaria	13531	2027	543	10944	17	2868	575	2293	16308	5490	1077	1844	6788	1110	3927	1510	2418
Georgia	1388	338	52	986	13	239	63	176	4494	1622	521	460	1286	606	1042	448	594
Greece	4923	2150	514	2203	56	3390	557	2832	9736	6599	888	542	1210	497	3296	1879	1418
Moldova	1160	583	19	535	23	358	115	243	5574	1527	917	1127	1346	657	1694	788	906
North Macedonia	2029	397	120	1509	3	217	64	153	1974	1211	167	134	403	58	756	317	440
Romania	30408	5433	1604	23260	111	6366	550	5816	32602	11780	4144	7478	8864	334	11757	5619	6138
Russian Federation	121564	47525	3665	69947	427	34708	5193	29515	303878	117213	38830	57260	63269	27306	72206	49731	22475
Serbia	8265	1332	384	6532	17	1419	369	1050	9367	4589	713	1375	1365	1325	3492	1572	1919
Turkey	13352	3785	5085	4473	9	7891	2103	5788	62976	54581	947	1519	5630	299	24629	14356	10273
Ukraine	8494	2415	153	5923	3	4991	956	4035	68354	26873	8057	14987	16112	2326	21266	11470	9796
Total BSEC	210224	67209	12333	129246	1438	63435	10685	52749	528296	238058	58698	89081	107784	34673	149392	89986	59409

Source: Authors' calculations based on FAO, 2024

4. Conclusions

The carried-out TCA analysis reveals that hidden costs of agri-food systems in the BSEC region reach the figure of 1.185 billion USD (in 2020 PPP), representing approximately 10.2% of the global quantified hidden costs.

The health externalities dominate the hidden costs, having a share of 80.3% of the regional total hidden costs, being followed by environmental costs with a share of 19.4%, and social costs with a low value of only 0.3%. The Russian Federation, Turkey, and Ukraine have the largest absolute hidden costs, while smaller economies such as Moldova and Bulgaria face the highest burden with respect to their GDPs.

Diets high in processed foods and additives, being combined with low consumption of whole plant foods and beneficial fatty acids, represent the main drivers of health-related hidden costs across the region. At the same time, the existing differences between the countries present the BSEC region as a distinct one, as Turkey shows the highest environmental share (37.4%), Georgia records the highest relative social costs, and several countries like Bulgaria, Serbia and North Macedonia have the health costs exceeding 88% of their total hidden costs.

Overall, these findings highlight that the current agri-food systems in the BSEC region generate substantial unaccounted externalities, particularly linked to dietary patterns and environmental pressures, which requires urgent transformation toward the development of more sustainable and healthier food systems.

Therefore, in terms of recommendations, the following directions can be proposed:

- Promotion of the dietary shifts across the BSEC region by reducing consumption of ultra-processed foods, red meat, and sugar-sweetened beverages, but, at the same time, increasing the intake of whole grains, fruits, vegetables, legumes, nuts, and seafood rich in omega-3 fatty acids. The development of country-specific nutrition education campaigns should be liked mandatory to the local dietary habits.
- Strengthening the environmental sustainability in the agricultural sector, with an accent on reducing greenhouse gas emissions and nitrogen pollution in high-impact countries such as Turkey, the Russian Federation, Ukraine, and Romania.
- Addressing the country-specific challenges like the implementation of targeted interventions in Turkey in order to lower the environmental costs, in Georgia for tackling social issues, and in Moldova, Bulgaria, and Ukraine to mitigate the effects of the high relative burden of hidden costs on national GDP.

The further research questions in the analysis of the TCA approach for the BSEC region, or any other regions or particular countries, should be focused on the ways how to integrate the TCA into national policy frameworks in order to internalize hidden costs and make smoother the transition toward resilient, low-externalities agri-food systems. For this purpose, will be needed to foster the regional cooperation among BSEC countries to share their specific best practices, harmonization of the data collection process and development of joint initiatives for sustainable food production and consumption that will enhance the resilience of the agri-food systems.

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