

## The price tag for transforming food systems under climate change

How transforming food systems under climate change will cost trillions, but inaction will cost more

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### KEY MESSAGES

- Transforming food systems so they survive and thrive under climate change demands **USD 1.3 trillion in investment every year over the next three decades**.
- This investment must be channelled through four areas of action set out by a landmark report *Actions to Transform Food Systems Under Climate Change*: (i) **Rerouting** farming and rural livelihoods to new trajectories (ii) **De-risking** livelihoods, farms and value chains (iii) **Reducing** emissions through diets and value chains and (iv) **Realigning** policies, finance, support to social movements, and innovation.
- The transformation investment equates to approximately **15 percent of the estimated USD nine trillion spent on food consumption** around the world every year.
- Critically, the investments needed to make food systems resilient and sustainable are a small fraction, **less than seven percent, of the USD 20 trillion hidden costs generated by current food systems** — costs to the environment, human health, and our social and economic systems.
- The cost of inaction far outweighs the benefits of investment in transforming our food systems.
- **Just over half this entire investment (56%) must be devoted to halting the conversion of land use for agriculture**: 250 million hectares of forest (equivalent to roughly all the agricultural land available in Brazil) and 400 million hectares of peatland (equivalent to the agricultural land of Australia). Both types of land conversion are huge contributing factors to climate change and biodiversity loss.

This brief summarises the estimated costs of implementing high-priority actions for transforming the food system, under four key action areas, as set out in the *Actions to Transform Food Systems under Climate Change* report (Steiner et al. 2020):

- REROUTE farming and rural livelihoods to new trajectories
- DE-RISK livelihoods, farms and value chains
- REDUCE emissions through diets and value chains
- REALIGN policies, finance, support to social movements, and innovation

These four action areas are then broken down into eleven priority actions that support other calls for sustainable development. These actions directly address the policy changes called for by numerous international initiatives that hope to make agriculture and food systems more resilient under a changing climate. These include increasing farmers' resilience to weather shocks and reducing food loss and waste, for example.

The reality is that we must rapidly transform our food systems if we are to feed the world's growing population sustainably under climate change. The emerging evidence of the seriousness of climate change — highlighted by the *Sixth Assessment Report* of the UN Intergovernmental Panel on Climate Change (IPCC) — brings added urgency to these calls. There is no plan B.

This follow-up report to *Actions to Transform Food Systems Under Climate Change* presents an estimate of the investment needed to scale up action in the sectors and countries or regions where the eleven actions will have the most impact and drive the greatest transformation.

Our conclusion is that USD 1.3 trillion of investment is needed annually from now until 2050 across the

four action areas set out in *Actions to Transform Food Systems Under Climate Change*. The largest share of this investment should be directed to actions designed to rerouting food systems towards more intensive yet resilient models that dramatically reduce carbon emissions.

If even more dramatic and positive progress is made in putting food systems on even more sustainable trajectories — exceeding those set out in *Actions to Transform Food Systems Under Climate Change* — it is reasonable to assume that the annual investment needed for future actions would substantially decrease over time.

### ESTIMATING THE COSTS

There is a broad consensus that food system transformation is essential in the face of climate and biodiversity crises. The eleven actions in Steiner et al. (2020) were identified through consultations with over 100 partners, individuals and organisations and through a series of background science papers. In line with several other major reports published since 2019 that provide insights on the challenges faced by global food systems, it stresses the urgency of addressing the effects of global change on food systems and the natural resources on which they depend.

Only limited information is currently available on how much investment must be mobilised for this global transformation. Estimating the cost of the fundamental changes required to move the food systems away from its current trajectory is fraught with challenges. Our approach was to estimate a set of “unit costs” for the eleven actions based on existing literature, such as cost per farmer or cost per hectare, and then apply these unit costs to the target populations and areas in Steiner et al. (2020) for each action. It is worth highlighting that these eleven actions are not all-encompassing but represent a best estimate of what is needed to provide the necessary momentum for systemic transformation to occur.

To estimate the costs of food system transformation, we encountered severe challenges and limitations because of lack of data and lack of comparability across different information sources. Some of the proxies we used are not ideal and the uncertainty bounds are likely to be very large.

Nevertheless, we believe that even an approximate order of magnitude of the investment needed for transformation is crucial in planning and catalysing action.

The methods used to estimate each action are briefly described in the Annex, with main sources for data included in Table 1. Overall, our work covered around 320 sources (167 for Reroute, 42 for De-risk, 54 for Reduce, 24 for Realign; as well as 34 global papers). Investments by action are shown in Table 1 and broken down by region in Table 2.

### THE COST OF TRANSFORMATION

We estimate that Action 1.1, avoided conversion of 250 Mha of forests and 400 Mha of peatlands, would require about 56 percent of the total. These costs are spread across all areas of the globe, as there are key areas of forest and peatland in both tropical and temperate zones. Action 1.2, enabling markets and public-sector actions to incentivise climate-resilient, low emission practices would require the next most amount (USD 181 billion), about 15% of the total. This makes Rerouting farming and rural livelihoods to new trajectories the action area with the highest requirements.

Also large are the amounts needed for Action 4.1, implementing policy and institutional changes that enable transformation (USD 177 billion), and Action 1.3, supporting prosperity through mobility and rural reinvigoration (USD 116 billion). Smaller amounts in the order of USD 15–35 billion are needed for each of Action 3.1 — shifting to healthy, sustainable, climate-friendly diets, Action 4.2 — unlocking billions in sustainable finance, Action 4.3 — driving social change for more sustainable decisions, and Action 4.4 — transforming innovation systems to deliver impacts at scale. Even smaller amounts are needed for the remaining actions — USD 2–12 billion each, but as Steiner et al. (2020) argue, action on all elements is required to fully transform the food system.

There are wide regional variations in investment needs for food system transformation. If we exclude Action 1.1 (avoiding agricultural land expansion) for a moment, our estimates indicate massive annual investment needs of USD 165 billion in sub-Saharan Africa, USD 120 billion in South Asia, and USD 109 billion in Southeast Asia and the Pacific.

Table 1. Targets, costs and data sources for the 11 actions

Action area	Action	Target in Steiner et al. (2020)	Proxy targets used in the analysis	Unit cost	Sources	Action cost (USD)
<b>REROUTE</b>	<b>Action 1.1</b> Ensure zero agricultural land expansion in high-carbon landscapes	Globally, avoid conversion of 250 million ha of forests and 400 million ha of peatlands	250 million ha forests 400 million ha peatlands	<b>Forest:</b> USD 1460 per ha per year <b>Peatland:</b> USD 970.5 per ha per year	<b>Forest:</b> Average of the estimates in Crossman et al. (2010), Garcia et al. (2017) and Rai et al. (2017) <b>Peatland:</b> Average of estimates in Glenk et al. (2018), Okumah et al. (2019) and Hansson et al. (2018)	<b>753 billion</b>
	<b>Action 1.2</b> Enable markets and public-sector actions to incentivise climate-resilient, low emission practices	Bring 200 million farmers into appropriate markets by 2030 via increased profitability and market development	185 million farmers in Pathways 2 and 4 (Table 1 in Steiner et al., 2020) adopting new practices	<b>Improved seeds:</b> USD 147.13 per ha per year <b>Fertilizers and soil amendments:</b> USD 379.78 per ha per year <b>Micro-irrigation:</b> USD 273.08 per ha per year	<b>Seeds:</b> Average of Cacho et al. (2018), Harris and Orr (2014) and Sain et al. (2017) <b>Soil amendments:</b> Average of Harris and Orr (2014) and Nowak et al. (2020) (for nutrient and soil amendment) <b>Micro-irrigation:</b> Average of Siderius et al (2021), You (2008) and Xie et al. (2014)	<b>181 billion</b>
	<b>Action 1.3</b> Support prosperity through mobility and rural reinvigoration	Build attractive rural livelihoods, including exits from agriculture, and create 20 million rural jobs by 2030 by investing in infrastructure and youth	Unit costs upscaled to 400 million rural dwellers in low- and lower-middle-income countries	<b>Infrastructural development:</b> USD 286.88 per person per year <b>Safety net policies for facilitating movement out of farming:</b> USD 3.57 per person per year	<b>Infrastructure:</b> Average of ADB (2017), AfDB (2018) and FAO & ZEF (2020) <b>Safety nets:</b> Dinkelman et al. (2018)	<b>116 billion</b>
<b>DE-RISK</b>	<b>Action 2.1</b> Secure resilient livelihoods through early warning systems and adaptive safety nets	End dependence on humanitarian assistance for 40 million rural dwellers by 2030, realigning USD 5 billion per year for adaptive safety nets	Unit costs scaled to 40 million farmers in Pathway 4 (Steiner et al. 2020) in climate risk hotspots	<b>Provision of social safety nets:</b> USD 140.74 per person per year	Average of FAO & ZEF (2018) and World Bank (2018)	<b>5.6 billion</b>
	<b>Action 2.2</b> Help farmers make better choices	Take climate services to scale by connecting 200 million farmers and agribusinesses to ICT-enabled bundled advisory services by 2030	Unit costs applied to 200 million farmers in low- and lower-middle-income countries	<b>Digital climate service provision:</b> USD 12.09 per farmer per year	Average of Ferdinand et al. (2021), Gangopadhyay et al. (2019) and FAO & ZEF (2018)	<b>2.4 billion</b>

Table 1. Targets, costs and data sources for the 11 actions (continued)

Action area	Action	Target in Steiner et al. (2020)	Proxy targets used in the analysis	Unit cost	Sources	Action cost (USD)
<b>REDUCE</b>	<b>Action 3.1</b> Shift to healthy, sustainable, climate-friendly diets	Incentivize substantial reductions in beef and dairy consumption in 15 higher-income countries and all C40 cities by 2030	Unit cost applied to the population of the 15 highest-income countries and all the C40 cities	<b>Cost differential between current diet and recommended diet:</b> USD 380.88 per person per year	Average of Herforth et al. (2020), Hirvonen et al. (2019) and Temple et al. (2011)	<b>35 billion</b>
	<b>Action 3.2</b> Reduce food loss and waste	By 2030, target 50% reductions in food loss and waste in five major supply chains where both greenhouse gasses and loss or waste are high	Unit costs allocated across six supply chains and all countries based on their share of the food supply	<b>Unit cost:</b> total investment per year, broken down by supply chain (meat, dairy, roots and tubers, fruits, vegetables, others)	<b>Investment cost:</b> Average of FAO / IFAD (2015) and Rosegrant et al. (2018) <b>Supply chain proportion data:</b> Rosegrant et al. (2018)	<b>12.6 billion</b>
<b>REALIGN</b>	<b>Action 4.1</b> Implement policy and institutional changes that enable transformation	By 2025, realign USD 300 billion of agricultural subsidies to a climate change agenda in 16 countries, improve the “ease of doing business” in 24 sub-Saharan African countries, and significantly improve the readiness score of the ND-GAIN Index in 49 countries	Not applicable	Cost of climate-proofing regional investments adds 16%. As a proxy for this action, we used 16% of the costs of Actions 1.1–3.2	ADB (2017)	<b>177 billion</b>
	<b>Action 4.2</b> Unlock billions in sustainable finance	Unlock USD 320 billion in public and private capital per year to realize business opportunities in the implementation of the SDGs	Regionally-specific unit costs allocated to the 154 million farmers in Pathway 5 (lower-endowment small-scale farmers, Steiner et al. 2020)	<b>Cost of de-risking public investment:</b> USD 15.6 billion per year <b>Cost of de-risking private investment:</b> USD 2.95 per person per year (E Asia & Pacific; S Asia; SE Asia); USD 2.31 per person per year (sub-Saharan Africa); USD 2.22 per person per year (Middle East-N Africa); USD 9.12 per person per year (Latin America and Caribbean)	<b>Public sector:</b> Buhr et al. (2018) <b>Private sector:</b> Ferrarese et al. (2016)	<b>19.7 billion</b>

Table 1. Targets, costs and data sources for the 11 actions (continued)

Action area	Action	Target in Steiner et al. (2020)	Proxy targets used in the analysis	Unit cost	Sources	Action cost (USD)
<b>REALIGN</b>	<b>Action 4.3</b> Drive social change for more sustainable decisions	Reach 10 million young people by 2025 through science-based social movements to catalyze climate action in food systems	Unit costs applied to 10 million young people	<b>Education cost per student that is climate related:</b> USD 2000 per student	<b>Total cost per student:</b> OECD (2020) <b>Percentage of expenditure that is climate related:</b> OECD (n.d.)	<b>20 billion</b>
	<b>Action 4.4</b> Transform innovation systems to deliver impacts at scale	By 2025, significantly change the approach of public agricultural research for development, with at least 50% of public investment in this research providing end-to-end solutions that support meeting the SDGs related to food	Unit costs allocated to all countries proportionally to the number of farmers in all five pathways (Steiner et al. 2020)	<b>Cost of improving innovation:</b> USD 10.1 billion per year <b>Cost of transforming approaches to gender, including improving female literacy:</b> USD 5.2 billion per year	<b>Innovation:</b> average of Beintema et al. (2020), CoSAI (2021), FAO / IFAD (2015), FAO and ZEF (2020) <b>Gender:</b> FAO and ZEF (2020), FOLU (2019), World Bank (2018b)	<b>15.3 billion</b>

## CONCLUSIONS

The overarching message from a wealth of literature is that our food systems are failing us. In addition, climate change is increasingly having severe negative impacts on food systems, while food systems themselves are part of the problem through direct and indirect emissions.

We estimate that investment costs of USD 1.3 trillion per year from now until 2050 are needed to achieve systemic food system transformation. Most of this — USD 1 trillion — would be for Rerouting, with the remainder for De-risking, Reducing, and Realigning aspects of food systems. The total is equivalent to about 15 percent of the estimated USD 9 trillion yearly monetary value of global food consumption (van Nieuwkoop 2019). However, it amounts to less than 7 percent of the hidden externalities generated by the current food system (Hendriks et al., 2021) and to less than 4 percent of what has been mobilised globally, and in a short time period, to respond to the COVID-19 pandemic.

Food system transformation promises major benefits, not just through increased food system

resilience but also via improvements in global human health that have been valued at more than USD 1 trillion per year (FOLU 2019). Major savings could also be achieved by reducing food loss and waste, estimated to cost USD 2.6 trillion per year (FAO 2021). These costs could be substantially reduced at a cost of USD 12.6 billion per year, from our analysis of Action 3.2.

The total cost may seem high, but we can be sure that the cost to future populations of doing nothing will be far higher.

Table 2. Action costs by region (USD billion, rounded off)

Region	REROUTE			DE-RISK		REDUCE		REALIGN				Total (Total actions 1.2 through 4.4)
	1.1	1.2	1.3	2.1	2.2	3.1	3.2	4.1	4.2	4.3	4.4	
South Asia	0.4	27.5	52.5	1.5	1.4	-	0.2	13.4	13.2	4.9	5.3	120.3 (119.9)
Sub-Saharan Africa	96.4	62.2	50.4	3.4	0.5	2.7	2.8	35.0	3.4	3.0	1.9	261.7 (165.3)
Europe & Central Asia	177.0	6.4	0.6	-	<0.1	7.8	4.8	31.5	-	2.3	1.5	232.0 (55.0)
Middle East & North Africa	0.3	3.2	3.7	0.2	0.1	0.1	1.1	1.4	1.3	1.2	0.7	13.3 (13.0)
Latin America & Caribbean	185.6	24.4	0.9	0.1	<0.1	2.3	2.3	34.5	0.4	1.7	0.7	253.1 (67.5)
Southeast Asia & Pacific	151.6	57.5	8.0	0.4	0.3	2.5	0.8	35.4	1.3	1.8	1.5	261.1 (109.5)
East Asia	8.5	-	-	-	-	6.9	0.4	2.5	-	4.1	3.2	25.6 (17.1)
North America	133.4	-	-	-	-	12.7	0.2	23.4	-	1.0	0.4	171.1 (37.7)
<b>Total by action</b>	<b>753.1</b>	<b>181.2</b>	<b>116.2</b>	<b>5.6</b>	<b>2.4</b>	<b>35.0</b>	<b>12.6</b>	<b>177.0</b>	<b>19.7</b>	<b>20.0</b>	<b>15.3</b>	<b>1338.1</b> (584.9)
<b>Total by action area</b>	<b>1050.4</b>			<b>8.0</b>		<b>47.6</b>		<b>231.9</b>				<b>1338.1</b>

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## ANNEX: METHODS USED TO ESTIMATE COSTS

### REROUTE farming and rural livelihoods to new trajectories

**Action 1.1. Ensure zero agricultural land expansion on high-carbon landscapes: avoid expansion on 250 million ha of tropical forests and 400 million ha of peatlands.**

Costs per ha were estimated in the places where most (80 percent) of the global forest loss by 2030 is expected to take place, along eleven deforestation fronts, many but not all of which are in the tropics (Steiner et al. 2020). These were then rescaled to the targets above.

**Action 1.2. Enable markets and public sector actions to incentivize climate-resilient and low emission practices: bring 200 million farmers into appropriate markets by 2030 through increased profitability and market development.**

This action mixes several types of investment to reduce carbon emissions, increase productivity through climate-smart agriculture, improve resilience, and develop markets. A broad spectrum of activities is possible, and here we estimated costs related to a subset of possible climate-smart agriculture (CSA) practices: improved seeds for heat and drought tolerance, fertilizers and soil amendments, and micro-irrigation. Costs were estimated for 185 million farms — conventional small-scale farmers who are less likely to be digitally connected (Pathway 2 in Table 1 of Steiner et al., 2020) and more extensive farmers in riskier environments (Pathway 4). Average farm sizes were from Lowder et al. (2016).

**Action 1.3. Support prosperity through mobility and rural reinvigoration: build attractive rural livelihoods, including exits from agriculture, and create 20 million rural jobs by 2030 by investing in infrastructure and youth.**

To estimate the cost of this action, we used estimates from recent infrastructure investment analyses to develop a unit cost per person per year. An analysis of the impact of migrant capital on the structure of rural labour markets was used to estimate the cost per person of establishing safety net policies to facilitate migration out of failing farming systems. These unit costs were then upscaled to 400 million rural dwellers in low- and

lower-middle-income countries.

### DE-RISK livelihoods, farms and value chains

**Action 2.1. Secure resilient livelihoods and value chains through early warning systems and adaptive safety nets: end dependence on humanitarian assistance for 40 million rural dwellers by 2030, realigning USD 5 billion per year for adaptive safety nets.**

A unit cost per person per year was estimated from two reviews of safety net programs, and the average cost was applied to the farmers in Pathway 4 (Steiner et al. 2020) in the climate risk hotspots identified by Jarvis et al. (2021) in the Middle East-North Africa, sub-Saharan Africa, Latin America and Caribbean, East Asia, Southeast Asia and South Asia, scaled to 40 million farmers in total.

**Action 2.2. Help farmers make better choices: take climate services to scale by connecting 200 million farmers and agribusinesses to ICT-enabled bundled advisory services by 2030.**

The unit costs per farmer per year were averaged from three recent sources and applied to 200 million farmers in low- and lower-middle-income countries. The total includes upfront and recurring costs per year.

### REDUCE emissions through diets and value chains

**Action 3.1. Shift to healthy and sustainable climate-friendly diets: incentivize dramatic reductions in beef and dairy consumption in 15 high-income countries and all C40<sup>1</sup> cities by 2030.**

The unit cost per person per year was calculated as the difference in cost of a recommended diet compared with the current diet, averaged across three sources, for the population of the 15 highest-income countries and all the C40 cities (overlaps excluded). Ten percent of the resultant total cost was assumed to be needed for spending on public health promotions, supporting labelling and certification, promoting awareness campaigns and social movements, and exploring possibilities for consumption taxes and subsidies.

<sup>1</sup> C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change.

**Action 3.2. Reduce food loss and waste (FLW): by 2030, target 50 percent reductions in FLW in five major supply chains where both greenhouse gases and loss or waste are high.**

Costs were estimated from two sources on reducing post-harvest losses via improving electricity, paved roads and rail and road capacity, and on improving cold and dry storage, rural and wholesale market facilities, and processing facilities. The average costs were then allocated across six (rather than five) major food supply chains and then across countries based on their share of the food supply (kg per person per year).

**REALIGN policies, finance, support to social movements, and innovation**

**Action 4.1. Implement policy and institutional changes that enable transformation: by 2025, realign USD 300 billion of agricultural subsidies to a climate change agenda in 16 countries, improve “ease of doing business” in 24 Sub-Saharan African countries, and significantly improve the readiness score of the ND-GAIN Country Index<sup>2</sup> in 49 countries.**

For simplicity, to estimate the cost of this action we used an “overhead” cost of 16% (ADB 2018) as the additional cost of climate proofing investments and applied this to the total cost of Actions 1.1 through 3.2.

**Action 4.2. Unlock billions in sustainable finance: release USD 320 billion in public and private capital per year to realize business opportunities in the implementation of the Sustainable Development Goals (SDGs).**

For public-sector investment, we used a forecast of incremental climate risk debt to 2030. For the private sector, we estimated the decrease in project costs needed to increase the benefit-cost ratio of a portfolio of regional adaptation projects to at least 3.5. This level of BCR is fairly realistic for adaptation projects (Harris and Orr 2014; Azumah et al., 2020). The regional totals of public plus private de-risking

<sup>2</sup> This index summarizes a country’s vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help governments, businesses, and communities better prioritize investments for a more efficient response to the immediate global challenges ahead.

were then allocated across the 154 million farmers in Pathway 5, lower-endowment small-scale farmers (Steiner et al. 2020).

**Action 4.3. Drive social change for more sustainable decisions: reach 10 million young people by 2025 through science-based social movements to catalyze climate action in food systems.**

We estimated the cost of this action using education costs of young people in OECD countries as a proxy, multiplied by the proportion that is aimed at being climate related.

**Action 4.4. Transform innovation systems to deliver impacts at scale: by 2025, significantly change the approach of public agricultural research for development, with at least 50 percent of public investment in this research providing end-to-end solutions that support meeting food-related SDGs.**

For this action, we averaged costs from several sources on estimated expenditures needed to enhance agricultural research for development efficiency.

To these we added costs aimed at reducing the gender gap with respect to female literacy and education and access to productive resources. These costs were then allocated to countries proportionally to the number of farmers in all the five pathways in Steiner et al. (2020).