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45 actions to orient food systems towards environmental sustainability: co-benefits and trade-offs

Centre for Food Policy Research Brief

February 2023

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Introduction

Making explicit and highly specific recommendations to increase the environmental sustainability of food systems is challenging due to the number of variables at play and the complex ways in which they interact. In this Brief, we sought to address this challenge by presenting a menu of 45 actions which can be taken to re-orient food systems towards environmental sustainability. While policymakers are the main intended audience of our Brief, we recognise that all stakeholders in food systems could and should play an active role in implementing the actions, and thus we have aimed to provide an accessible short guide on the most up to date technical recommendations sourced from existing evidence-informed reports. The actions include those with potential to reduce the negative environmental impact of food systems, improve the positive impact, or both, across five environmental dimensions: GHG emissions, chemical pollution, freshwater resources, biodiversity, and soil health. For each action there is a clear and direct pathway to impact on one or more of these five environmental dimensions. Each action is accompanied by an assessment of trade-offs – defined as negative effects across any dimension – that could result from implementing the action, and of potential co-benefits for nutritional alongside environmental outcomes. We organised the actions into five groups, based on their domain: actions to reorient land use in agriculture (#1 to #7), actions to improve the environmental impact of agriculture & farming (#8 to #22), actions to improve the sustainability of wild fisheries and aquaculture (#23 to #28), actions to reduce food loss and waste (#29 to #36), actions to reorient diets and overall food demand (#37 to #45). There is no hierarchy to how groups or actions are presented, but closely related actions are displayed in proximity within groups.

Our decision to only include actions with a direct pathway to impact identified from existing evidence-informed reports led to some exclusions. For example, we did not include measures such as strengthening social safety nets for farmers in rural areas, a recommendation made by several sources, because while implementing this action could have large positive effects on the livelihoods and wellbeing of farmers, our sources did not make it clear what the direct links were with any specific environmental dimension. For the same reason we also did not include interventions on principles, governance, and political processes, such as establishing new multilateral alliances or platforms to steer governance processes at the international level.

Through the actions included in our list we show that (i) there is significant potential to transition to more environmentally sustainable food systems; (ii) positive environmental change could generate significant trade-offs in certain contexts; (iii) co-benefits between environmental outcomes and diets/nutrition are possible, but they will often require systematic and intentional efforts from the outset. The potential for action is large because food systems stretch across several domains of human activity – from land use to consumer diets – impacting the environment at each point along the way. Therefore, the actions are broad in scope and would operate across different scales. For example, actions to reorient land use in agriculture (#1 to #7) aim to drive macro-level changes in how land is used for food production across the globe, through a combination of public and private action. Some of the actions to reorient diets and overall food demand (#37 to #45) instead take a more micro-level approach, and aim to incentivise citizens to transition to more sustainable diets by combining regulatory interventions with improved access to information on the environmental impacts of certain foods. While illustrating the potential for substantial improvements in the sustainability of food systems, we also use the list as an opportunity to show that almost all actions, at least 42 out of 45, could potentially generate trade-offs across several dimensions.

We identified potential trade-offs by reviewing a broad range of sources in the available literature, both scientific and non peer-reviewed, and included them in the final list on pages 10-30 (see step 10 in the Methods section). Not to be taken as a deterministic assessment of what would *certainly* happen if a specific action is implemented, the trade-offs in our list provide a reminder to policymakers that successful efforts to make food systems more environmentally sustainable *could* negatively impact

Context

In 2020, the Centre for Food Policy at City, University of London, the Global Alliance for improved Nutrition (GAIN) and Johns Hopkins University compiled a list of 42 actions to orient food systems towards healthy diets[1]. Those actions have the potential to effect change through food supply chains, food environments and consumers.

In this Brief, we build on that work, shifting the focus towards the environment. We extracted a menu of 45 actions to re-orient food systems towards environmental sustainability using the same methodology. To emphasise the potential ramifications that implementing these actions on a large scale could imply, we also incorporated potential trade-offs and nutrition co-benefits within the list. Potential trade-offs have been identified through a review of existing literature, while potential co-benefits with the 42 policies and actions on healthy diets have been identified through a novel methodology designed for this project.

certain stakeholders. For example, several of the actions to improve the environmental impact of agriculture & farming (#8 to #22) *could* decrease yields and raise prices – at least temporarily and/or in specific contexts – potentially causing severe damage to more vulnerable populations. But policymakers will need to pay attention to more than just food security risks: actions to reorient land use in agriculture (#1 to #7) could, by setting firm limits on the exploitation of high-carbon landscapes, infringe on the ancestral rights of indigenous populations who live in or close to tropical forests, and actions to improve the sustainability of wild fisheries and aquaculture (#23 to #28) could, by establishing catch limits or fishing quotas, threaten the way of life of coastal communities that have relied for centuries on fishing for their sustenance. Across all five categories, actions to introduce new technologies may lead to the exclusion of stakeholders who are less familiar with or have less access to technological infrastructure and resources. The potential impact on women of many of these measures should also be explicitly acknowledged: actions that aim to reduce the use of chemical herbicides or promote zero-till techniques, for example, may require farmers to employ more manual labour to remove weeds. In many contexts women provide most of the manual labour in agriculture, and a larger share of labour-intensive tasks can be detrimental to their health and make it harder to achieve more independence and autonomy.

But many of the actions could also generate positive additional impacts: in the list, alongside trade-offs, we included potential co-benefits between environmental and dietary goals, to show how improving the sustainability of food systems could also lead to better diets. The co-benefits are based on a theoretical exercise we conducted after identifying the actions (see step 6 of the Methods section). While reviewing the literature for evidence on what could happen if the actions are implemented (as we did for the trade-offs), we asked how could a specific measure that aims to improve the sustainability of food systems also make it easier for people to eat better. To answer this question, we compared the pathways to impact of the 45 environmental actions with those developed for the 42 actions for nutrition presented by the Centre for Food Policy in 2020[1], assessing the potential for co-benefits to emerge between the two groups of actions (see step 6 in the Methods section). The results of this analysis are included in the list. We only included potential co-benefits for which we were able to develop a clear pathway to impact. The co-benefits show that synergies will likely not emerge spontaneously: policymakers and stakeholders will largely need to explicity aim to incorporate from the start both environmental and nutritional outcomes when designing a policy, or combine multiple policies. For example, actions that aim to reward farmers for adopting more sustainable practices – such as #8, on establishing direct payments for delivering environmental goods – could generate a co-benefit if policymakers also tie the rewards to growing more nutritious foods. Similarly, actions to reduce the amount of resources employed in raising livestock – such as action #18 on using alternative feeds or adopting rotational grazing – could generate a co-benefit *if* farmers are then incentivised to deploy the freed up resources to growing more nutritious foods for direct human consumption. The private sector could also facilitate achieving two objectives at once: financial institutions that extend credit to farmers who are more environmentally sustainable – see action #4 – could also incentivise them to growing crops that are more nutritious and/or contribute more to local diets, helping drive a shift towards healthy and sustainable diets.

By combining in one table the actions, co-benefits, and trade-offs, we make a strong case for applying broad thinking and a flexible approach to improving food systems, showing that the potential consequences of achieving change matter as much as the goals that are driving it. The systematic methodology we followed to identify and combine all elements of this research ensures consistency and transparency in how we presented our results in this brief. However, while all our sources approached food systems from a global perspective – and were authored by international groups of researchers – several of the actions are only applicable or relevant to higher income countries. This likely points to a bias in the explicit recommendations made by the documents we reviewed. This is one of the reasons why we included trade-offs - a step originally not included in our original methodology, to show how implementing some of the actions in the wrong context could generate negative consequences. In the section ‘Challenges and Limitations’ on page 7 we describe in more detail this potential bias along with other limitations of our project, and the measures we adopted to address them.

While our focus has been on assembling a list of technical actions taken from evidence-informed expert reports, we recognise that power dynamics are at the heart of who/what is prioritized and what isn’t when producing, distributing, and consuming food. Thus, the list should then be seen as a menu of potential options that must be implemented through participatory processes – empowering all stakeholders – to achieve full potential and limit negative side effects. These actions, and any other similar recommendations, should not be implemented with disregard for context and livelihoods. Our work should be seen as a starting point for further reflection on how positive change can be implemented, and not as a definitive account of what should be done by all actors in all contexts.

Overview of the methodology

The methodology to extract and consolidate actions built on the method developed to identify the *42 policies and actions to orient food systems towards healthier diets for all*, with the addition of an Advisory Board of international experts from Academia and the Third Sector, which provided feedback on the actions and on the methodology. Building on the Advisory Board's feedback, we then expanded the scope of the project, recruiting three more independent experts, conducting a co-benefit analysis, and searching the literature for evidence of potential trade-offs.

We identified the actions through a review of major international evidence-informed expert reports on food systems that include detailed recommendations on how to make food systems more environmentally sustainable. We created a first list of 49 actions, which we used as basis for a co-benefit analysis aimed at establishing potential synergies with the 42 actions for healthier diets, introduced by the Centre for Food Policy in a separate Research Brief in 2020[1]. For each action and potential co-benefit we identified pathways to impact, establishing how and through which mechanisms they could achieve their goals, drawing from our sources or relying on deliberation from the research team (see steps 5 and 6 in the Methods section). We excluded actions for which the original source did not identify a clear pathway to impact. After incorporating feedback on the list from the Advisory Board and producing a second iteration of the list, we searched the literature for evidence of potential trade-offs that could manifest – across any dimension – if actions are implemented as stated in the list (see step 10 in the Methods section). While searching for trade-offs, we recruited three independent experts who work on food systems change in Low- and Middle-Income Countries to provide a second round of feedback, focusing this time on how to improve the relevance of the list for LMIC.

Finally, we consolidated the updated list of actions, the co-benefits, and the trade-offs into a single table, which can be found on pages 10-30. This unique contribution brings together explicit, wide-ranging evidence-informed recommendations to improve the environmental sustainability of food systems and a focus on their potential impacts.

The Methods section on pages 4-6 provides a more detailed breakdown of the methodology described above.

Methods

Step 1.

Identify key environmental dimensions

To assess the potential impact of the recommendations on the environmental sustainability of food systems, we focused on five key dimensions: GHG emissions, biodiversity, freshwater resources, chemical pollution, soil health. This categorization is discussed in the 2019 report by the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems, is consistent with those used by our sources, and it was approved by our Advisory Board. Focusing on these dimensions allowed us to not limit our recommendations to a single environmental issue – for example climate change, and to identify actions that have clear pathways to impact.

Step 2.

Identify evidence-informed expert reports.

We first compiled a list of 76 documents that analysed or at least discussed interactions between food systems and the environment. The list included documents already known to the research team, documents suggested by the advisory board, and documents found through a literature search conducted on various online platforms. All were published between 2008 and 2021. We assessed each document against three criteria: (1) How food systems can be reoriented towards environmental sustainability is the main topic or is heavily discussed; (2) It contains detailed recommendations on actions, policies, or programs that focus specifically on how to reorient food systems towards environmental sustainability; (3) It contains an expert review on the topic of food systems and environmental sustainability, with references to leading scientific journals and/or possibly evidence of a peer-review process. A document had to meet all three criteria to be included.

Recommendations had to be action-oriented and specific – for example we would not include broad directives such as 'use natural resources more efficiently'. We did not include

reports and recommendations that only discuss adaptation measures to respond to environmental change, because the focus of this project is on actions to improve the impact of food systems on specific environment dimensions. Nine documents, published between 2018 and 2021, met all criteria and were used as sources for the following steps. [2-10]

Step 3.

Extract actions.

We reviewed each of the nine documents in detail, extracting approximately 200 actions or recommendations for which the source would draw an explicit link between the action and the positive effect that it could have on one of the key dimensions identified at Step 1. We then entered the recommendations into a spreadsheet using near-verbatim language to how it was presented in the report, noting where it appeared in the original source.

Step 4.

Combine and consolidate similar actions

As expected, we found overlap across several of the recommendations. This allowed us to condense some recommendations into more comprehensive actions and generate a shorter and more focused list. To ensure consistency at this stage, we adopted a structured approach to the phrasing of the actions. Every action was initially formed by: (i) an action verb or policy mechanism, (ii) a strategy, (iii) one or more tactics, (iv) one or more impacts targeting one or more specific environmental dimensions.

The verb or mechanism states how the action should be implemented or, where explicitly mentioned in a source, the policy mechanism that should be adopted. The strategy explains what the action is aiming to change. The tactics represent individual, specific methods implemented to achieve the strategy. Impacts describe the technical pathways through which the action will impact specific environmental dimension(s). For example, in action #11 *'Adopt agriculture practices that improve soil quality and structure such as zero-till arable farming, cover cropping and mulching, manure recycling, crop rotations, rotational livestock grazing and maintaining crop residues to increase carbon sequestration, nutrient fixation and cycling and to reduce soil erosion', 'Adopt' is the action's initial verb. 'Improve soil quality and structure'* represents the strategy this action pursues, while *'zero-till arable farming, cover cropping, (...) maintaining crop residues'* are potential tactics through which the action could be implemented, and the strategy achieved. The potential impacts on the environment are *'to increase carbon sequestration, nutrient fixation and cycling and (...) reduce soil erosion'*.

Step 5.

Develop pathways to impact

We developed a pathway to impact for each of the initial 49 actions, assessing what would need to happen for the action to reach its goals if implemented as stated on the list. To build the pathways, we relied on information contained in the sources and on deliberation from the research team. We assessed which actors would need to be involved and how, what policy mechanism (if explicitly stated in the report) would be implemented, how the action would produce a positive effect on the environment (technical analysis of impact), what potential additional positive/negative impacts it may generate, and under what circumstances the action could fail. We excluded or reworded actions for which a clear pathway to impact could not be identified. Actions were reworded while remaining as faithful as possible to the source.

Step 6.

Conduct co-benefit analysis

We assessed the potential for the original 49 environmental actions to generate co-benefits with the 42 actions for healthier diets. To do so, we compared the pathways to impact we generated for actions in both sets. The research team systematically assessed whether implementing an environmental action according to the stated pathway to impact could potentially strengthen or reinforce the pathway to impact of any of the 42 nutrition actions. We focused on the dimensions targeted by the nutrition actions: *increasing the availability, affordability, accessibility* and *appeal* of certain foods or food groups – while decreasing those of others. If the pathway to impact developed for an environmental action demonstrated the potential to also generate a positive effect on any of the above nutrition-related dimensions, we then recorded a potential co-benefit.

We distinguished between 'ancillary' and 'intentional' co-benefits. We labelled a co-benefit 'ancillary' if it would potentially manifest regardless of intentionality. That is, a co-benefit is 'ancillary' if implementing an action to improve the environmental sustainability of food systems generates a positive effect on diets and health, even if this was not a stated goal of the action itself. We labelled co-benefits 'intentional' if on the other hand they required explicit intentionality to manifest. That is, an 'intentional' co-benefit will happen only if policymakers explicitly incorporate improving nutrition/diets into the goals of an action originally implemented to improve the environmental sustainability of food systems. We also recorded the potential impact each co-benefit could have on the nutrition dimensions, which foods or food groups it could have an impact on, and what factors could reinforce or hamper the co-benefit. Most of the co-benefits we identified are 'intentional'.

After identifying and classifying each potential co-benefit, we developed a pathway to impact for the co-benefit itself, stating in narrative form how it would manifest and what impacts it could have. This served as the basis of the wording used to present the co-benefits in the list which can be found on pages 10-30 of this document. We updated the co-benefit analysis throughout the project to reflect any changes to the list or the language of the actions.

Step 7.

Collect technical feedback from Advisory Board

We submitted the original first list of 49 actions to the members of our Advisory Board, along with a detailed description of our methodology. Members were asked to review the list, provide feedback on the individual actions, and comment on the methodology we developed to identify co-benefits. We collected both written and verbal comments. The suggestions made by the Advisory Board were then used to exclude, rephrase, recombine, or clarify actions. As mentioned in the Introduction, some Members of the Board

expressed concern about potential biases in the list. They noted that it included several actions which would be only or mostly relevant to high income countries. To address these comments, we expanded the scope of our project by implementing the measures described at steps 8-11.

Step 8.

Review more documents for potential inclusion as sources

To assess whether new actions could be added to the list and mitigate its potential biases, we reviewed over 25 documents published by organizations based in LMIC, including advocacy groups. The documents were identified through online search or suggested to the research team by external experts. Only two documents met all three inclusion criteria described at Step 2, but as they did not include any recommendation not already covered by the actions in the list, we did not select them as new sources.

Step 9.

Collect second round of feedback, from external experts

We held a second round of feedback with a small group of external experts who are from or work in LMIC. We asked them to evaluate the list's relevance for a global audience and to suggest improvements. All experts offered valuable comments, which led us to conduct a final round of changes to the structure of the list and to the language of the actions, yielding the version available in this document on pages 10-30. Their comments, along with those of the Advisory Board, also informed the writing of this brief and the overall framing of our project.

Step 10.

Review literature for potential trade-offs

We assessed the potential for the 45 environmental actions to generate trade-offs. To do so, we surveyed our sources and the wider literature for evidence of negative consequences attributable to implementing any of the actions or tactics presented in the list.

To ensure diversity and consistency, we adopted a systematic multi-step process:

i. We examined if the original source paragraphs from which we extracted the actions included any explicit mention of potential trade-offs.

ii. We examined if our nine source documents contained chapters or sections that specifically focused on trade-offs.

iii. We examined if suitable documents that were assessed but not used as sources contained chapters or sections that specifically focused on trade-offs.

iv. We searched the technical scientific literature for trade-offs, focusing on actions for which none were identified when implementing steps i-iii.

v. We examined documents (such as position papers, case studies, etc.) published by NGOs or advocacy groups from LMIC and which focused on potential trade-offs in Developing/Emerging contexts.

At each step, we extracted any trade-off that related specifically to the actions or tactics presented in the list. That is, we would extract a trade-off presented as *'[negative consequence x] would manifest if farmers move to no-till techniques in an attempt to increase soil quality'*. Instead, we would not extract a trade-off that said *'[negative consequence x] would happen if we make agriculture more sustainable'*, because the phrasing is too generic.

While recording each potential impact, we labelled them as either Economic, Political, Environmental, Health-related, or Social. This allowed us to monitor which dimensions of potential trade-offs were underrepresented in the analysis, and explicitly attempt to extract more within those categories. Overall, Economic and Environmental trade-offs appeared with the highest frequency, while Political trade-offs were the less common in our analysis.

This process yielded around 100 individual trade-offs. We were unable to identify trade-offs for only three actions.

Step 11:

Finalize and consolidate into one document

We reviewed the language of each action, co-benefit, and trade-off, making changes to increase overall consistency and clarity. Actions for which we could not identify a satisfactory pathway to impact were excluded, yielding the final list of 45 that can be found in this document.

To make it easier to navigate the list, we divided actions into five groups, based on their domain: Land Use, Agriculture & Farming, Fisheries & Aquaculture, Food Loss & Waste, Diets & Food Demand. There is no hierarchy to how groups or actions are presented, but closely related actions are displayed in proximity within groups.

In its final form, which can be found on pages 10-30, the list includes 45 actions, separated in the five groups. Next to each action, we displayed i) which environmental dimension(s) it would positively impact; ii) what potential trade-offs it could generate; iii) how the action could generate a potential co-benefit with diets and nutrition.

Challenges and limitations

While we did our best to maintain a systematic and rigorous approach, we recognise that our project presents five main limitations:

1. Several recommendations lacked detailed information on implementation.

When making recommendations, sources often did not indicate which policy mechanism should be implemented, or who would need to act. Documents sometimes listed recommendations in one chapter or section, and potential policy mechanisms in others, without explicitly linking them. In the list, we included a specific policy mechanism (such as taxes, subsidies, regulations, etc.) only when the source explicitly stated it as part of the recommendation. In all other cases we used generic verbs such as 'adopt'. While this lack of explicit policy mechanisms may detract from the strength of some actions, we felt it was important to highlight how often calls for change remain vague and abstract even in long, technical documents.

2. We were only able to use English-language sources.

In drawing these actions exclusively from documents written in English, we may have under-represented views and results contained in research published in other languages. To address this limitation, further research should dedicate funding to ensure that the language of publication does not represent a barrier to the inclusion of relevant knowledge.

3. Some actions exhibited a bias towards high income countries.

As noted by Members of the Advisory Board, while all or most of the documents that met our criteria have been prepared by international groups of authors, several of the recommendations which met our criteria were mostly applicable or relevant to high income countries. This increases the risk that the recommended actions embody only some forms of knowledge, understandings of environmental sustainability, and perspectives on what to do.

4. The applicability and effectiveness of most actions will be highly dependent on context.

Many of the actions in the list will not be suitable in all contexts. One example is the consumption of animal-source foods, or ASF. All our sources agreed that excessive production and consumption of ASF (primarily red meat and dairy) have a negative effect on the environmental sustainability of food systems. However, many people across the world consume little to no ASF, and they could gain nutritional benefits from increasing consumption. Actions to reduce ASF consumption are thus less applicable in contexts where ASF consumption is very low. Another example is the issue of food loss and waste, or FLW. All reports agree that we should reduce both and suggest, for example, several strategies for reducing food waste at the consumer level. However, many consumers, especially in LMIC countries, generate little to no food waste. Hence actions that focus on reducing food waste would apply best to contexts where this is high, and actions to reduce food loss would be better suited to those countries where this is the main issue. These examples show that our actions should not be implemented without a careful evaluation of their suitability to a specific context.

5. Most if not all the actions could potentially generate negative outcomes.

In complex systems, policy changes can have unintended effects. They may generate high social costs, often unequally distributed. Some of the actions for example could require drastically altering supply chains and potentially eliminating millions of jobs. Others may lead to dispossessing indigenous peoples of lands or resources. To incorporate some of this complexity, we included potential trade-offs in the list, drawing from the literature. While the trade-offs we identified are not exhaustive and represent just examples of what could happen, we drew from as wide a range of sources as possible. Their role within our analysis is to stress that policymakers, citizens, and stakeholders will need to work together to ensure that these actions can be used to make food systems more environmentally sustainable while respecting livelihoods.

To address the above limitations, we adopted the following measures (described in more detail at steps 8-11 of the Methods section):

I. Collected a second round of feedback on the actions, this time from three independent experts with direct knowledge of food systems change in LMIC, to determine if and how the list could be made more applicable and relevant to those contexts.

II. Assessed several more documents as potential sources, drawing from research/advocacy work published by NGOs and research teams from LMIC, to examine whether we could include new actions that are more relevant to those contexts.

III. Searched the literature for potential trade-offs for each of the 45 environmental actions, to clearly illustrate how well-meaning interventions can generate large negative impacts, and how these impacts will often be felt the most by those who have less power and fewer resources.

IV. Combined the actions, the co-benefits, and the trade-offs in a single table, as opposed to producing separate documents as originally intended, to shift the focus on the potential impacts that the actions could have.

Notwithstanding these important challenges and limitations, we hope that the list will spark constructive discussion among policymakers, researchers, citizens, and help all those who work to make our food systems more environmentally sustainable.

Future avenues for research

We identified several opportunities for researchers to expand on our work and potentially address some of the limitations we faced. Below are five promising avenues of research:

1. Apply the list to a specific country or region.

Researchers could choose a country or region as a case study, and assess which actions from the list would be applicable to that context and would have the higher potential for positive change, but also what trade-offs would be more likely to manifest, and what would be the easiest way to generate co-benefits across environmental and nutritional goals. By examining a specific country, researchers could also investigate whether actions not included in our list could be beneficial to that context, and potentially use this knowledge to add new actions to the list or refine existing ones. In the longer term our list, which we present as a menu of options, could change and expand by reflecting the experience of researchers and stakeholders working at country or regional level.

2. Link the actions in the list with standardized, widely-used technical indicators of environmental quality.

Researchers could use recent advances in establishing global datasets of environmental indicators to tie each action to more standardized metrics. We maintained a consistent approach and established the potential of each action for generating a positive impact on five environmental dimensions (GHG emissions, biodiversity, chemical pollution, freshwater resources, soil health), but not all our sources adopted the same metrics across dimensions – for example they may have used different metrics to measure biodiversity, or the quality of freshwater resources. Researchers could identify metrics that allow to compare the sustainability of food systems along a specific environmental dimension at a global scale – while still allowing for the peculiarity of local contexts – and then link these measurements with each of the 45 actions.

3. Assess and quantify the potential impact of the actions on the environment.

Once researchers have identified enough suitable standardized indicators of environmental quality and linked them to the 45 actions, as discussed in the previous point, they could use this knowledge to quantify the potential impact on the environment of implementing each action. Researchers could model the impact that an action could have if implemented in a specific context by using local data as input, and globally comparable standardized metrics as the unit of measurement. This would allow researchers to show which actions would have the highest potential to increase the environmental sustainability of food systems in each context for which data is available, helping policymakers prioritise among actions.

4. Conduct more systematic work on the implementation of the actions.

Researchers could use available evidence or develop new case studies to provide more details on how these and similar actions could be implemented. When making recommendations, our sources often did not explicitly state who would need to act, or provide examples of potential policy mechanisms. By focusing on small groups of actions at a time, researchers could explore which policy mechanisms would be more suited to different contexts, and generate clearer guidance for policymakers or offer examples of best practices. This would also allow researchers to expand on our work on co-benefits and trade-offs, as it is highly likely that different implementation pathways would lead to different co-benefits and trade-offs. While this project has tried to answer the question 'what could be done?', pursuing this avenue of research would allow researchers to also answer the question of '*who should act, and how?*'

5. Identify new actions that target intermediate steps along the production-consumption axis.

Most of the actions in our list, and especially the ones with the largest potential for positive impact, aim to act on either the production of food – farming, agriculture, fishing – or the consumption of food – diets and consumer demand. Few actions target what sits between these two extremes of a simplified linear model of food systems. This reflects the little attention dedicated by our sources to all the steps that sit between the production and consumption of food. Researchers could analyse new sources or draw on other types of knowledge – e.g. interviews with industry experts, activists, etc. – to identify actions with large potential for positive change that could be implemented in how food is transformed, transported, stored, and sold, making the list more accurate and exhaustive.

The list

This list should be read as a menu of wide-ranging evidence-informed options to improve the environmental sustainability of food systems, with a focus on their potential impacts and unforeseen ramifications. The 45 actions provide examples of what the current consensus explicitly recommends, while the trade-offs and the co-benefits illustrate how implementing the actions could generate both unwanted and desirable additional effects.

The actions are placed in five groups based on the domain they aim to affect:

- Actions to reorient land use in agriculture (#1 to #7).
- Actions to improve the environmental impact of agriculture & farming (#8 to #22).
- Actions to improve the sustainability of wild fisheries and aquaculture (#23 to #28).
- Actions to reduce food loss and waste (#29 to #36).
- Actions to reorient diets and overall food demand (#37 to #45).

There is no hierarchy to how the actions are presented, and their order does not suggest that some are more important than others or should be implemented first. Many of the actions would indeed need to be to be implemented in conjunction with others to produce the highest possible benefit. Some actions will be relevant for certain contexts but not for others.

Each action is listed next to the environmental dimension (GHG emissions, biodiversity, freshwater resources, chemical pollution, soil health) that the sources stated it would impact. Many actions are multi-functional and will deliver multiple benefits, for example reducing GHG emissions and chemical pollution at the same time. Where this is the case, the action or category of actions explicitly say which separate dimensions will be impacted. We have only included the environmental dimensions that the original source explicitly mentioned when making its recommendation, though we acknowledge that in several cases the potential impacts could extend further. For example, a source may recommend planting trees and hedgerows on field borders with the explicit goal of capturing excess nutrients before they leak into the environment. This practice could potentially also improve biodiversity by providing more natural habitats to wild species. However, we would not include this additional impact on the list if the original source did not explicitly mention it.

While most actions list examples of how they could be implemented or include a policy mechanism, not all do. This discrepancy reflects how recommendations were made in our sources: we only included examples and policy mechanisms where these had been explicitly linked to the action while making the recommendation in the original text. If no policy mechanism or concrete examples were provided, we used generic wording when drafting the actions.

All actions were originally drafted with an explicit reference to the environmental dimension they would impact (see Step 4 in the Methods section). However, within some of the five groups all actions target the same environmental dimension(s). Where this was the case, to avoid excessive repetition we removed the explicit reference to the dimension(s) they would impact from the phrasing of individual actions and attributed it to the category as a whole. For example, actions in the Food Loss & Waste category derive from recommendations made by our sources that all shared a common target: reducing GHG emissions by increasing overall efficiency and by lowering the share of resources consumed by food systems. Instead of stating in each action that their intended impact was to reduce GHG emissions, we made this explicit in the text that introduces the category of FLW.

Actions to reorient land-use in agriculture

The main aim and impact of these actions is to reduce overall net GHG emissions, mostly through land sparing or increased carbon sequestration.

Each action lists examples of potential tactics that could be used to achieve this. Other environmental dimensions, such as biodiversity, may also be positively impacted. The importance, relevance and effectiveness of each action will be highly dependent on the context it is applied to.

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
1 **Provide subsidies to farmers and landholders for restoring degraded or unproductive croplands and grazing lands to natural habitats and ecosystems, such as through set-asides, by rewilding forests and grasslands, or by re-wetting peatlands**	GHG emissions	• Increased food prices, as land is removed from food production for restoration efforts (Searchinger et al., 2019) • Reduced access to resources - such as timber, wild honey, etc. - and lands for local and indigenous populations (Bossio et al., 2021) • Increased inequality, if subsidies mostly reward land-owning elites while inadequately compensating other members of the local communities (Chomba et al., 2016)	n/d
2 **Designate and enforce the boundaries of forests, peatlands and grasslands through strong monitoring and policing, establishing penalties for transgressors and using independent judicial bodies and watchdog organizations**	GHG emissions	• Reduced income of the rural poors, especially those who depend on clearing new lands for their livelihood (Davis, Lipper, & Winters, 2021) • Reduced income and/or increased workload for women in contexts where they are primarily responsible for foraging in forests, procuring foods and other resources that can be consumed domestically or sold to generate additional income (Pross, Han, Kim, & Vigil, 2021)	n/d

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
3 **Phase out meat and milk production subsidies to remove incentives for farmers to increase production, to reduce the amount of land used for meat/dairy production**	GHG emissions	• Increased prices, which In populations that do not have access to a balanced diet could potentially lead, for example, to increased levels of stunting in children (Adesogan, Havelaar, McKune, Eilittä, & Dahl, 2020) • Reduction in herds, which can lead to lower income and employment opportunity for farmers (Chandel, Lal, & Kumari, 2019) • Negative impact on employment in meat and dairy sectors (Balié, J. 2020)	In countries with populations that display high levels of meat/dairy consumption, phasing out existing subsidies could increase the prices of meat and milk, making them less affordable. This could potentially lead to lower consumption of meat and dairy products
4 **Develop investment, funding and accounting policies or tools (such as True Cost Accounting) within financial institutions that encourage conservation and rewilding by financing businesses that incorporate environmental outcomes into agriculture while withholding financing from companies driving land conversion**	GHG emissions	• Increased food prices, as land is removed from food production (Searchinger et al., 2019) • Increased negative environmental impacts, if land conversion shifts through market leakage to other countries that do not adopt these policies/tools, and damages even more fragile ecosystems (Searchinger et al., 2019)	Financial institutions explicitly link financing and credit to both environmental and dietary considerations, which could potentially increase the availability and affordability of micronutrients and healthier foods
5 **Institute taxes that support the production and purchase of deforestation-free products such as higher taxes on food products made with deforestation-linked commodities or removing taxes on forest-positive products**	GHG emissions	• Increased food prices, which could have a higher impact on people on lower incomes, who spend a larger share of their earnings on purchasing food (Balié, 2020) • Increased risk to the livelihoods of rural poor people, especially those who depend on clearing new lands for their income (Davis, Lipper, & Winters, 2021)	Governments/authorities introduce taxes that target companies that drive deforestation, directly or indirectly, and that sell less healthy foods to consumers - especially if produced on newly converted lands. This could incentivise the targeted companies to raise prices, change their offering, change production practices, or reformulate products to make them less unhealthy, potentially making certain less healthy foods less available and affordable

	Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
6	**Develop accountability, traceability, and transparency mechanisms to monitor and publicly report on businesses across major commodity supply chains (such as palm oil, beef, soy, cocoa, coffee, etc) that may be driving landscape conversion of intact lands and wilderness areas for agricultural production.**	GHG emissions	• Increased risk to user privacy and data ownership, if newly available technologies for supply chain transparency are scaled too quickly (Köhler & Pizzol, 2020) • Increased costs and complexity for producers, which can potentially lead to the exclusion of smallholders from formal markets (Adams & Tanos, 2021)	Stakeholders develop mechanisms to collect and disseminate information on the impact a food business has on land conversion but also on its contribution to improving people's diets. In response to the newly available information, consumers could shift their demand and buy products that have a lower environmental footprint and that are less harmful to diets, potentially making more nutritious foods more available, affordable and appealing, while doing the reverse for less nutritious foods
7	**Develop industry-wide standards, company policies, disclosure requirements and verification methods among agribusinesses and buyers along the supply chain to prevent future agricultural land conversion of remaining intact lands and wilderness areas**	GHG emissions	• Increased risk to the livelihoods of rural poor people, especially those who depend on clearing new lands for their income (Davis, Lipper, & Winters, 2021)	n/d

Actions to improve the environmental impact of agriculture and farming

These actions aim to drive the adoption of more environmentally sustainable agricultural practices.

Each action lists which environmental dimensions it aims to impact, and examples of potential tactics that could be used to achieve this. The importance, relevance and effectiveness of each action will be highly dependent on the context it is applied to.

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
8 **Pay farmers for delivering public environmental goods such as increasing soil carbon sequestration or using watershed protection strategies to reduce pollution from fertilizers and manure**	Chemical pollution Soil health GHG emissions	• Increased competition for water and other resources with crops, if farmers introduce non-native trees as monocultures with the aim of providing ecosystem services (Bossio et al., 2021)	Governments/authorities redirect agriculture subsidies and use them to pay farmers to provide ecosystem services and grow more nutritious foods. If the overall nutritional yield increases, this could make more nutritious foods more available and affordable
9 **Integrate low-carbon and renewable energy sources into all new government-led agriculture investment programmes, promoting technologies such as zero-energy cooling chambers, manure digesters, and solar- and wind-powered irrigation systems or water pumps, to reduce direct on-farm GHG emissions**	GHG emissions	• Increased risk of job losses in fossil fuel and related industries (International Council for Science, (ICSU), 2017)	n/d

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
10 **Tax GHG emissions from agricultural inputs, technologies, and production methods (e.g., fertilizer production, machinery) to incentivize the adoption of innovations and practices that reduce emissions (e.g., renewable energy sources) and to drive a shift in production towards less GHG-intensive foods**	GHG emissions	• Decreased yield and increased prices, which could lead to higher food insecurity (von Braun, Afsana, Fresco, & Hassan, 2021) • Increased pollution in areas in which taxes on GHG emissions are not implemented, if production relocates there through market leakage (von Braun, Afsana, Fresco, & Hassan, 2021)	Governments/authorities introduce taxes that target food products associated with high GHG emissions and poor nutritional content. The new taxes make it more expensive for agricultural businesses to maintain their GHG emission levels and to produce less healthy foods, which could incentivise them to increase prices, produce/grow healthier foods, or reformulate foods so that they are healthier, potentially making less healthy foods such as HFSS less affordable and less available
11 **Adopt agriculture practices that improve soil quality and structure such as zero-till arable farming, cover cropping and mulching, manure recycling, crop rotations, rotational livestock grazing, and maintaining crop residues, to increase carbon sequestration, nutrient fixation and cycling, and to reduce soil erosion**	Soil health GHG emissions	• Decreased productivity in the livestock sector if using mulch to protect soils from erosion results in less crop residues made available as fodder (Affholder, Bessou, Lairez, & Feschet, 2019; AFSA, 2016) • Increased risk to the health of farmers and field workers if zero-till arable farming practices are accompanied by an increase either in herbicide use or manual labour to remove weeds through means other than tillage (Wekesah, Mutua, & Izugbara, 2019) • Increased labour burden for women if zero-till arable farming practices result in a strong shift of labour from tasks associated with male labour (tillage) to tasks associated with female labour (hand weeding) (Giller, Witter, Corbeels, & Tittonell, 2009)	Farmers implement practices to improve soil quality and structure, some of which involve choosing which crops/foods to grow. Farmers prioritise crops that maximise both nutrient density/quality and positive contribution to soil quality/structure, which could potentially make micronutrients more available

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
12 **Incorporate a diversity of trees and hedges within farms to provide habitats for biodiversity, support the delivery of ecosystems services, and to reduce overall GHG emissions through increased carbon capture**	Biodiversity GHG emissions	• Increased food prices, if land is removed from food production (Searchinger et al., 2019; Shukla et al., 2019) • Increased water scarcity and erosion, if trees are incorporated in grassland or pastures (Bossio et al., 2021) • Increased competition for resources (water, light, nutrients) between trees/hedges and crops, and increased pest pressure (Bossio et al., 2021)	Farmers introduce a diversity of trees and hedges along the margins of their fields, to increase the provision of natural habitats for wild species. Farmers manage to do this without decreasing overall yield, either through productivity increases or by choosing unused or degraded land to host these new trees/ hedges. Farmers prioritize planting edible species that are indigenous/locally adapted and provide more diverse and nutritious foods, which could make more nutritious and healthy foods more available and affordable
13 **Adopt practices to increase water use efficiency in irrigated production systems, such as drip-fed precision irrigation, rainwater harvesting and storage, water capture and recycling, lowering evapotranspiration (for example through mulching), and selecting less water-intensive or more locally adapted crops, to reduce freshwater consumption**	Freshwater resources	• Increased incidence of waterborne diseases, including malaria, if irrigation is brought to areas that do not have access to it yet by storing and reusing rainwater without adopting preventative measures (International Council for Science, (ICSU), 2017)	n/d
14 **Tax non-point source agricultural pollution of waterways either through ambient taxes to be paid by all potential polluters in a region, or taxes on polluting material such as fertilisers, to reduce water pollution from Nitrogen and Phosphorous leakage**	Freshwater resources Chemical pollution	• Increased costs of inputs and goods, which could potentially lead to a reduction of economic activity in the area (Kyei & Hassan, 2019) • Increased inequality, as unless redistributive policies are implemented, taxes on polluting products/activities could weigh disproportionally on poor households if these consume a larger share of high-pollution products (Kyei, Clement Kweku & Hassan, 2021)	n/d

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
15 **Adopt manure management practices in livestock production that reduce water contamination such as keeping manure away from areas with high groundwater, investing in riparian planting and fencing off waterways from cattle to reduce water contamination from manure**	Freshwater resources Chemical pollution	• Lower yields, if riparian planting is introduced in cultivated areas - such as in mixed crops-livestock systems - by removing land from food production (Witing et al., 2022)	n/d
16 **Adopt agriculture practices that reduce environmental damage from synthetic fertilisers such as crop rotation, cover cropping, using bio-fertilisers, using organic manure and compost, nutrient recycling, using fertilisers and plant species that secrete nitrification inhibitors, and precision fertiliser application technology, to increase soil fertility while reducing Nitrous Oxide emissions and water pollution**	Chemical pollution GHG emissions	• Lower yields, if less fertilizer is used without efficiently replacing it with nutrients from alternative sources - especially in contexts where fertilizers are already under-utilized (Davis, Lipper, & Winters, 2021) • Increased GHG emissions, if reducing the need for synthetic fertilizer lowers food prices and generates additional demand for further land conversion (Herrero et al., 2021)	n/d
17 **Adopt agriculture practices that reduce environmental damage from synthetic pesticides such as reducing their prophylactic use, using integrated pest management and natural predators, introducing bio-protectants, and precision pesticide application technology, to support the delivery of ecosystem services from biodiversity and to enhance soil biodiversity**	Biodiversity Soil Health	• Lower yields, if less pesticide is applied without implementing appropriate alternative pest-control strategies (Cheze et al., 2020)	n/d

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
18 **Adopt livestock management practices or technologies that reduce environmental damage from meat/dairy production such as alternative feeds that reduce land used for feed production, feed additives that can reduce Methane and Nitrous Oxide emissions, rotational grazing that reduces soil erosion, or silvopasture that provides natural habitats for biodiversity**	GHG emissions Soil health Biodiversity	• Increased risk to animal welfare, which could result from implementing some of the tactics available to reduce methane production in livestock systems (Shukla et al., 2019; Llonch, Haskell, Dewhurst, & Turner, 2017) • Increased costs and uncertainty as most of the alternative feeds that could be used to substitute crop-based feeds can be more expensive, not economically feasible, nor easily upscalable in most systems (Shukla et al., 2019)	Newly developed feeds are widely adopted in livestock production. These feeds are less land-intensive than soy, and free up land. If this happens in combination with a transition of subsidies away from staple crops and towards more nutritious alternatives, farmers could be incentivised to grow more nutritious foods destined for human consumption, potentially making micronutrients and more nutritious foods more affordable and available
19 **Adopt livestock management practices that increase productivity such as providing more nutrient-dense feed, better veterinary care, and raising improved or locally adapted animal breeds, to reduce the amount of land used for meat/dairy production and decrease Methane and Nitrous Oxide emissions**	GHG emissions	• Increased GHG emissions and freshwater use, if following productivity increases farmers are encouraged to expand their operations and farm more animals (Antle & Valdivia, 2021; von Braun, Afsana, Fresco, & Hassan, 2021) • Negative impact on farmers who rely on the multi-functionality of livestock and benefit from owning larger herds, if productivity increases are obtained by rearing fewer animals of improved breeds. In many contexts, owning livestock serves important social and cultural roles, which are often strongly linked with herd size (Paul et al., 2020) • Increased risk for the long-term income of farmers, if they transition to non-native improved breeds which could display lower fertility, higher mortality, higher sensitivity to climate conditions, and require higher costs for disease prevention and care compared to native breeds (Paul et al., 2020)	Livestock producers, especially those who rear animals for their own substenance, and/or who serve populations with very low levels of consumption of animal-source foods, increase their productivity. This could lower price and potentially make animal-source foods more affordable and available to populations with very low levels of animal-source foods consumption

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
20 **Adopt rice production practices that reduce methane emissions such as breeding new varieties that emit less methane, reducing or interrupting periods of flooding, expanding dry seeding, using a single midseason water drawdown or adding irrigation water only when needed, alternating wetting and drying practices, integrating rice farming in polycultures (such as in rice-duck-fish systems), to reduce GHG emissions**	GHG emissions	• Increased Nitrous Oxide emissions, which could negate or even reverse the positive overall effect of reducing Methane emissions (Searchinger et al., 2019) • Reduced profitability for farmers who have access to free water resources (for example where water use is subsidised), if they implement water-saving practices for which they would sustain the cost but obtain no economic benefit (Searchinger et al., 2019) • Lower yields generated by applying water-saving techniques to rice farms - particularly in the US (Searchinger et al., 2019)	Scientists and farmers breed new rice varieties that directly or indirectly lead to less methane emissions while also maximising nutritional content, which could potentially increase the availability of micronutrients
21 **Incentivize farmers to share knowledge, tools, and equipment to support the transition towards desirable agricultural practices by adopting practices such as facilitating knowledge exchange, instituting public seed banks for crop rotations and cover cropping, or sharing zero-till machinery or mechanical weeders, to improve soil health and reduce GHG emissions and chemical pollution**	GHG emissions Chemical pollution Soil health	• Increased risk of spreading diseases across herds by sharing tools and equipment among livestock farmers (Tälle et al., 2019) • Reduced employment opportunities for farmworkers, especially women, if farmers share tools or machinery which could replace practices such as manual weeding (Beuchelt & Badstue, 2013)	n/d

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
22 **Invest in R&D and innovation in areas that would increase agricultural productivity while delivering on specific environmental targets such as regenerative agronomic practices and bio-fertilizers that could enhance soil health, or Internet of Things (IoT) technologies and water/nutrient recycling infrastructure that could increase precision and efficiency of input use, to reduce freshwater use and chemical pollution**	Freshwater resources Chemical pollution	• Increased prices, driven by initial investments needed to adopt new technologies (El Bilali & Allahyari, 2018) • Increased cybersecurity risks (IoT solutions or data platforms are vulnerable to breakdown, abuse and misuse) and increased risk of disruption caused by power outages in highly technology-driven farms (Misra et al., 2022) • Increased power concentration, if data is accumulated by small groups of large companies which already dominate the agribusiness sector, especially in contexts of unequal data ownership in which farmers don't own the data generated by their operations (El Bilali & Allahyari, 2018) • Increased risk of excluding smaller producers who lack access to the resources needed to make the initial investments, and/or those stakeholders who are computer illiterate or less familiar with new technologies (El Bilali & Allahyari, 2018)	Governments and private businesses invest in R&D to increase agricultural productivity, funding innovation that links nutritional benefits with positive environmental outcomes, such as crops that have a higher nutritional content and require less water. This could increase the availability of micronutrients

Actions to improve the sustainability of wild fisheries and aquaculture

The aim of these actions is to protect and enhance biodiversity by ensuring the long-term sustainability of wild fisheries as a source of food, and to reduce the net environmental impact of aquaculture.

Each action lists which environmental dimensions it aims to impact, and examples of potential tactics that could be used to achieve this. The importance, relevance and effectiveness of each action will be highly dependent on the context it is applied to.

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
23 **Adopt strategies to ensure that fish stocks reach and maintain sustainable levels, such as closing off breeding areas, avoiding harvest during important breeding seasons, or placing key habitats under direct governmental control, to reduce overfishing and protect biodiversity**	Biodiversity	• Reduced yields, at least initially, which could lead to financial losses to fishers in the near to medium term (Searchinger et al., 2019) • Increased risk to the livelihoods of poor coastal communities that rely on fishing for sustenance, and for whom fishing plays a large cultural role (Searchinger et al., 2019) • Increased market concentration, if setting total allowable catches or granting catch shares leads to industry consolidation - which could drive the marginalization of small-scale fishers (Searchinger et al., 2019)	Improved fisheries management ensure that fishing can stabilize at maximum sustainable levels. Overall yield and productivity in the long term increase because fish stocks do not collapse as a consequence of overfishing, which could make fish more widely available and affordable

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
24 **Adopt strategies to limit the overexploitation of wild fisheries such as establishing access rights, setting total allowable catches, introducing gear restrictions and seasonal limits, to protect biodiversity**	Biodiversity	• Reduced yields, at least initially, which could lead to financial losses to fishers in the near to medium term (Searchinger et al., 2019) • Increased risk to the livelihoods of poor coastal communities that rely on fishing for sustenance, and for whom fishing plays a large cultural role (Searchinger et al., 2019) • Increased market concentration, if setting total allowable catches or granting catch shares leads to industry consolidation - which could drive the marginalization of small-scale fishers (Searchinger et al., 2019)	n/d
25 **Redirect capacity-enhancing subsidies that incentivize overfishing (such as fuel subsidies) towards technologies that maintain sustainable yield levels such as fleet control infrastructure, port improvements and new sensing, tracking, mapping, simulation, and ledger systems, to protect biodiversity**	Biodiversity	• Reduced profitability of entire fleets or fishing areas, especially in the context of high-seas fishing, which could lead to the loss of economic activity (Sala, Enric, et al., 2018) • Increased barriers to growth for developing countries, who without being able to deploy subsidies could have limited options available to develop fisheries sectors (International Council for Science, (ICSU), 2017)	Improved fisheries management ensure that fishing can stabilize at maximum sustainable levels. Overall yield and productivity in the long term increase because fish stocks do not collapse as a consequence of overfishing, which could make fish more widely available and affordable
26 **Adopt aquaculture management practices that reduce environmental damage from fish farming such as using settling ponds, adopting alternative feeds to substitute crop-based feeds and fishmeal, converting aquaculture ponds to integrated aquaculture-agriculture operations, and improving fish health, to reduce GHG emissions and increase carbon sequestration**	GHG emissions	• Increased health risk for consumers, if integrating multiple species within a single aquaculture operation intensifies pathogen exposure (Ahmed, Bunting, Glaser, Flaherty, & Diana, 2017)	n/d

	Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
27	**Adopt aquaculture practices to increase productivity such as better health diagnostics, improved breeding techniques, better sanitation, improving feed conversion rates and using dietary supplements and vaccines to reduce overfishing for fishmeal and land use for crop-based feed production**	Biodiversity GHG emissions	• Increased water acidification, water eutrophication, and water pollution (Henriksson, Belton, Jahan, & Rico, 2018)	Aquaculture operators adopt practices to increase productivity, which could lead to higher production and lower prices, potentially making fish more available and affordable
28	**Adopt aquaculture practices to restore degraded aquatic environments such as expanding the cultivation of bivalves or seaweed to increase water filtration and uptake of excess nutrients, or adding seaweed to aquaculture operations, to reduce ocean acidification and preserve biodiversity**	Biodiversity	• Increased risk of genetic contamination between farmed and wild species of seaweed, and increased prevalence of pathogens and diseases carried by non-indigenous microorganisms which can proliferate in seaweed farms (Buschmann et al., 2017)	n/d

Actions to reduce food loss and waste (FLW)

The main aim and impact of these actions is to reduce GHG emissions and the overall use of resources in food production by reducing loss/waste and increasing efficiency.

For some countries, food loss is the main issue; for others, food waste is. The applicability and relevance of these actions will be highly dependent, among other things, on the prominence of food loss vs food waste in the context they are implemented.

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
29 **Reduce food losses across the supply chain by improving harvesting techniques and on-farm and warehouse storage, developing cold chain infrastructure and packaging, or processing foods into products with a long shelf-life using traditional methods (such as canning, pickling, drying, etc.)**	GHG emissions	• Increased costs for farmers, generated by implementing new technical solutions, for example improved harvesting techniques or new on-farm storage facilities (Shukla et al., 2019) • Increased food loss/waste across the downstream supply chain, through cascading effects that start with production output increasing - due to reduced food loss at the farm level. This could make more food available at each subsequent step along the chain, increasing the total amount wasted, at least initially (Sethi et al., 2020)	Producers and processors adopt practices and technologies to reduce food loss from the farm up to the retail point, potentially increasing the availability and affordability of more nutritious perishable foods

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
30 **Invest in waste management infrastructure and recycling strategies that can separate and redistribute organic food waste for alternative uses such as composting for use by local farmers or converting to animal feeds or energy sources**	GHG emissions	• Increased GHG emissions, if recycling organic food waste as animal feed lowers the price of feed, which could lead to increased livestock production/ consumption (Herrero et al., 2021) • Lower yields, if using compost as fertilizer is less effective compared to mineral fertilizers; this could lead to reduced income for farmers (Svensson, Odlare, & Pell, 2004) • Lower profitability for farmers, if incentivising waste recovery and building waste infrastructure increases the economic value of waste, leading to increased competition among its various uses. This could potentially make organic food waste to be used as manure more expensive and scarce (Herrero et al., 2021)	n/d
31 **Adopt practices to better match food supply and demand, such as developing early forecasting systems, optimizing inventory management and procurement, or establishing new farm-to-fork virtual marketplaces, to reduce food loss and waste**	GHG emissions	• Increased risk of excluding stakeholders who are less familiar with or do not have access to modern technology (Patel, Dora, Hahladakis, & Iacovidou, 2021)	Food businesses develop practices, infrastructure, markets and technologies to better match demand with supply. Less food is lost or wasted along the supply chain, and because it's easier for producers to match their supply with demand, they could have a greater incentive to grow and sell more nutritious perishable items - if these are more profitable - rather than staple crops or other commodities. This could make perishable more nutritious foods more available and affordable

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
32 **Deliver education and awareness programs to farmers (such as ag extension services, demonstration sites, training courses) on improved storage tactics and technologies, to reduce food losses**	GHG emissions	• Increased food loss/waste across the downstream supply chain, through cascading effects that start with production increasing - due to reduced food loss at the farm level. This could make more food available at each subsequent step along the chain, increasing the total amount wasted - at least initially (Sethi et al., 2020)	Producers and processors adopt practices and technologies to reduce food loss from the farm up to the retail point, potentially increasing the availability and affordability of more nutritious perishable foods
33 **Launch public awareness and communication campaigns about food waste to promote improved planning of purchases, understanding of 'best before' and 'use by' labels, storage practices, food preparation techniques, and knowledge of how to use leftovers, to reduce food waste**	GHG emissions	• n/d	Governments/authorities design and launch mass public communication campaigns aimed at reducing food waste at the consumer level. The campaigns teach people how to reduce their food waste and how to incorporate more nutritious perishable items into their diets, potentially making them more accessible
34 **Incentivize food businesses to redistribute food surplus to food banks and those affected by food poverty by offering tax breaks for redistribution and clarifying liabilities in case the end consumers are harmed by the donated food**	GHG emissions	• Increased health risk, if the food being redistributed is of poor nutritional quality - for example if generated by fast-food operations - and it is consumed by the same people with high frequency (Patel, Dora, Hahladakis, & Iacovidou, 2021) • Negative impact on the dignity of those who receive the donated food, which could also facilitate the loss of cultural preferences and personal tastes (Patel, Dora, Hahladakis, & Iacovidou, 2021)	Governments/authorities introduce incentives to make it more convenient for businesses to redistribute unused food to food banks and to those affected by food poverty. This could incentivise food businesses to improve their capacity to collect and redistribute perishable foods used across their operations that cannot be sold/reused but that are safe to consume, potentially making more nutritious perishable foods more available, accessible and affordable

	Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
35	**Incentivize companies to measure food loss and waste and implement food loss and waste policies through demonstrating possible cost savings, strengthening company reporting and disclosure to investors, or reinforcing third-party monitoring**	GHG emissions	• Increased costs for businesses which could translate in higher prices for consumers (Balié, J. 2020)	Businesses, including but not limited to food businesses that directly serve consumers, improve their ability to track and reduce their food waste. They learn from success cases in their industry, and report their results to external parties who can monitor their efforts. As a result, food waste could decrease, potentially making more nutritious perishable foods more available
36	**Reduce portion sizes in food outlets to simultaneously reduce market demand for excess food and reduce food waste at point-of-service by adopting practices such as offering smaller portion sizes at lower prices, or eliminating cafeteria-style trays**	GHG emissions	• n/d	Food outlets reduce incentives for consumers to purchase more food than they need, to reduce food waste, while also providing them with clear and comprehensive nutritional information/training. This can potentially make healthier foods more accessible and available

Actions to reorient diets and overall demand

The main aim of these actions is to reduce overall net GHG emissions by shifting demand away from more land/carbon-intensive foods and towards more environmentally sustainable options.

The explicit goal of several of the actions is to reduce demand for red meat among populations that display high levels of consumption. The emphasis on red meat reflects the conviction in our sources that, of all the possible dietary changes to pursue, reducing its consumption holds by far the largest potential for positive change in the sustainability of food systems.

Given the diversity of local diets and consumption patterns, what constitutes an 'alternative protein' may differ among contexts. The same applies to the relevance, applicability, and efficacy of each action, especially as a large portion of the global population eats little to no meat at all.

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
37 **Adopt public food procurement guidelines that create a market for sustainably produced foods such as purchasing from producers who implement practices that regenerate soils and reduce fertilizer/pesticide use, to increase soil health and reduce chemical pollution, and purchasing from local urban and peri-urban producers to shorten supply chains and reduce transport-related GHG emissions**	GHG emissions Soil health Chemical pollution	• Lower yields, if reducing the use of synthetic fertilizer is not compensated with input of nutrients from alternative sources, especially in contexts where fertilizers are already under-utilized (Davis, Lipper, & Winters, 2021)	Authorities introduce new guidelines for public food procurement that, among other goals, incentivise purchasing from local urban and peri-urban producers. This increases the demand for locally produced foods, potentially including more nutritious and perishable items such as fruit and vegetables. This additional demand could stimulate the growth of new producers and markets able to supply urban and peri-urban populations with more nutritious perishable foods, potentially making these more available and affordable

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
38 **Institute a border tax on food imports that have a high environmental cost, particularly carbon emissions, to discourage their consumption and reduce overall GHG emissions**	GHG emissions	• Increased malnutrition for certain population groups, if a tax on GHG emissions levied at the consumer level reduces food consumption (Henderson, B., Verma, M., Tabeau, A., & van Meijl, H. 2019) • Reduced income of producers and farmers, especially smaller ones located in developing countries who could not have the resources needed to reduce their production-related emissions (Henderson, Verma, Tabeau, & van Meijl, 2019) • Increased overall GHG emissions, if consumption shifts through market leakage to countries that do not apply the tax and overall consumption increases (Henderson, Verma, Tabeau, & van Meijl, 2019)	Governments/authorities introduce border taxes on food imports that have a high environmental costs and that are more unhealthy or less nutritious, driving up their prices and potentially making them less affordable and available
39 **Launch public awareness and communication campaigns to reduce the demand for animal-source foods - particularly red meat - in populations that already display high levels of consumption**	GHG emissions	• Increased inequalities in access to information among citizens with differing levels of education; this could reinforce the advantages of more educated citizens, who are better equipped to access the information made available through the communication campaigns (Weiss & Tschirhart, 1994) • Excessive focus on individual behavioural change as the main driver of positive change - as opposed to structural interventions (Weiss & Tschirhart, 1994)	In countries with populations that display high levels of animal-source foods consumption, large public communication campaigns inform consumers about the adverse environmental impacts of producing animal-source foods at the current scale, reducing their appeal. This could potentially lead to lower consumption of meat and dairy products
40 **Establish labelling and certification of meat and other protein sources based on their GHG emissions and other environmental factors, to reduce the demand for animal sourced foods**	GHG emissions	• Income loss for small-scale producers, if they lack the resources needed to comply with the labelling requirements; this could mean losing access to markets where the labelling system is enforced (Hadjimichael & Hegland, 2016) • Increased market concentration, if the introduction of eco-labelling systems advantages only larger players with sufficient resources who can achieve and maintain the requirements needed for certification; this could lead to the formation of oligopolies and monopolies (Hadjimichael & Hegland, 2016)	In countries with populations that display high levels of animal-source foods consumption, introducing clearly designed labels which inform consumers about the environmental and dietary impact of meat and other protein sources could potentially lead to lower consumption of meat and dairy products and higher consumption of alternatives such as pulses

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
41 **Among populations that currently consume more than recommended daily amounts of animal-source foods, introduce retail taxes – prioritizing red meat and dairy – and remove taxes on or subsidize alternatives (such as legumes) to encourage smaller animal-source foods portion sizes and reduce animal-source foods overconsumption, while encouraging a switch to protein sources with lower environmental impacts**	GHG emissions	• Increased inequality, if introducing taxes on foods at the retail level has an overall regressive effect and weighs disproportionally on the poorer segments of the population, who must dedicate a larger share of their incomes to purchasing food (Seiders & Petty, 2004) • Increased risk to food security in at-risk population groups, if consumption taxes reduce food consumption (Sethi et al., 2020) • Increasing prices of certain foods through targeted taxation can reduce the revenue obtained by producer countries who export those items, as consumption in importing countries falls (Sethi et al., 2020)	In countries with populations that display high levels of animal-source food consumption, governments/ authorities introduce retail taxes on animal-source food and remove taxes on or subsidize alternative protein sources that have a lower environmental footprint and are highly nutritious, potentially leading to lower consumption of meat and other animal-source food, and higher consumption of alternatives such as pulses
42 **Adopt public food procurement guidelines to reduce purchases of animal-source foods - particularly red meat - in favour of other sources of proteins, to drive down the costs of alternative proteins and reduce the consumption of animal-source foods**	GHG emissions	• Increased risk to health and wellbeing for population groups who do not have access to balanced diets and need to consume more animal-source foods, not less (Davis, Lipper, & Winters, 2021)	In countries with populations that display high levels of animal-source food consumption, new public food procurement guidelines call for purchasing less red meat and more alternative protein sources that are highly nutritious and have a lower environmental footprint, potentially leading to lower consumption of meat and other animal-source foods and higher consumption of alternatives such as pulses
43 **Among populations that currently consume more than recommended daily amounts of animal-source foods, limit the amount spent on advertising and marketing that promote overconsumption and redirect budgets towards increasing the desirability of plant-based foods and educating consumers on appropriate portion sizes**	GHG emissions	• n/d	In countries with populations that display high levels of animal-source food consumption, Governments/ authorities deploy regulations and incentives to ensure the private sector redirects funding for marketing away from animal-source food and towards alternative protein sources. This could increase the appeal of highly nutritious and more environmentally sustainable protein sources, for example pulses, and potentially lead to lower consumption of meat and other animal-source foods

Action	Environmental dimension(s)	What potential trade-offs could this action generate?	How could this action generate potential co-benefits with diets and nutrition?
44 **Invest in research and development on alternative protein sources such as plant-based proteins, insects, microbial or cultured proteins, to increase the pace of development and decrease costs to consumers**	GHG emissions	• Increased negative environmental impact, if the scaling up of cultured meat generates a higher environmental footprint than conventionally produced meat (Onwezen, Bouwman, Reinders, & Dagevos, 2021) • Increased deforestation, if incentivising alternative proteins reduces demand for and production of soybean (as feed for cattle); as soybean is also used to produce oil, reducing its production could potentially increase demand for alternatives such as palm oil, which can be a driver of deforestation (Herrero et al., 2021)	Governments/authorities invest in the development and scaling of non-animal based protein sources which are highly nutritious and have a lower environmental footprint, potentially making nutritious alternative non-animal based protein sources more available and affordable
45 **Reformulate products that use animal ingredients with plant-based alternatives (such as incorporating vegetable fat into butter)**	GHG emissions	• Higher costs for producers, which could translate in higher prices for consumers (Buttriss, 2013)	In countries with populations that display high levels of animal source food consumption, governments/ authorities mandate that companies reformulate certain processed foods so that they contain less animal-based ingredients and are more healthy or more nutritious, potentially leading to lower consumption of meat and other animal-source foods and increased availability of micronutrients

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Please cite this Brief as:

Caleffi, S., Hawkes, C., Walton, S., (2023) 45 actions to orient food systems towards environmental sustainability: co-benefits and trade-offs. London: Centre for Food Policy, City, University of London.

About us

The Centre for Food Policy at City, University of London, is an interdisciplinary unit working to shape food systems that improve the health of people, society, the environment and the economy. We engage with people across the food system to uncover how it really works in practice. We use these insights to educate, influence, and to inform effective, joined-up food policy.

Acknowledgements

We are very grateful for the funding received for this project from the Swiss Agency for Development and Cooperation.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Agencia Suiza para el Desarrollo
y la Cooperación COSUDE

We would also like to thank the following individuals for the important contributions they made to the project:

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