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Title:

Sustainable healthy diets from the lens of behavioural science

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27 **Summary**

28 Changes in the food system are key for attaining the Sustainable Development Goals. This viewpoint i)
29 contends that, alongside structural changes to the food production and distribution systems, the next
30 years are decisive to foster individual behaviour change for sustainable healthy diets , especially in high-
31 income countries, ii) provides a set of behaviour change techniques that can contribute to the design of
32 individual interventions aimed at that dietary change, iii) highlights the main weaknesses of previous
33 eating behaviour interventions and suggest how they may be overcome, notably by addressing potential
34 negative spillovers and trade-offs, and iv) provides an actionable definition of sustainable healthy diets
35 for designing behaviour change interventions. This viewpoint offers a relevant starting point for the
36 design of future interventions targeting individual behavioural change for sustainable healthy diets from
37 a multi-disciplinary perspective.

38

The way we produce and consume food carries high social and environmental costs. Despite producing more than enough calories to feed the global population, distribution is highly unequal.¹ More than two billion people are suffering some type of food insecurity, leading to undernutrition as well as overweight and obesity.² More than one third of the food produced is lost or wasted.³ Three billion people cannot afford a healthy diet, with unhealthy diets being the leading cause of morbidity and mortality worldwide.² Additionally, there are countless cases of forced labor conditions and unfair salaries across the food system.⁴ From a planetary health perspective, the food system is responsible of around one third of all greenhouse gas (GHG) emissions worldwide.^{5,6} Its contribution to global warming is so important that it has been postulated that even if the GHG emissions from all non-food-related sectors were immediately stopped and net zero from now on, emissions from the food system solely would still preclude reaching the Paris Agreement goal of limiting global warming to 1.5 degrees Celsius.⁷ Beyond climate change, the food system currently uses about 70% of freshwater withdrawals and is a major source of water eutrophication.^{8,9} Forty percent of the habitable land on Earth is used for growing our food or to feed farmed animals.¹⁰ About 73% of the world's deforestation is related to the food system,¹¹ being the leading cause of habitat degradation and biodiversity loss.¹² The consequences of this environmental degradation is already noticeable (e.g., extreme weather events are further compromising food security), affecting especially the most vulnerable areas.¹³ If the current food production and consumption patterns continue as usual, the global impact on the environment of the food system will increase among 50-90% by 2050 in comparison to 2010 values.¹⁴ Therefore, rapid, effective and combined structural, technological and individual changes are needed to achieve a more resilient, sustainable and fair food system within planetary boundaries.^{15,16} This viewpoint focus on the specific role of individual behaviour changes towards sustainable healthy diets (i.e., those healthy diets with low environmental impact, in which foods are obtained from fair and ethical sources)^{17,18}, from the consumers perspective, and under the lens of a multi-disciplinary collaboration between behavioural, socio-economic and climate scientists as well as nutritionists.

Promoting individual eating behaviour change: why, for whom, and how?

Why. The question of individual behaviour change versus systems change is a false dichotomy.^{16,19-21} Lifestyles choices are enabled and constrained by the physical environment, political contexts and infrastructures, but at the same time individual behaviours can spread into, and ultimately shape, social and cultural norms in a bottom-up fashion, thus leading to political and structural changes.^{15,22,23} Being generated in a top-down or bottom-up fashion, radical changes in current individuals' dietary patterns towards healthy diets with low environmental impact are essential for achieving a food system that fits in planetary boundaries, and contribute to end the global syndemic of malnutrition.^{16,24,25} Such healthy diets with low environmental impact, beyond differences in preferences and traditions of each specific culture, are characterized by being nutritionally-balanced patterns, mainly (if not totally) based on whole plant-sourced foods.^{2,25} Shifting current dietary patterns towards such diets has the potential of halving the pressure of the food system on climate change, and reducing by 6 to 22% other environmental impacts, such as water and land use, or the application of fertilizers.¹⁶ At the individual level, changing eating behaviour is one of the most effective climate change mitigation strategies that

someone can undertake, representing between 10 to 30% of an individual carbon footprint.²⁶⁻²⁹ Transitioning to healthy diets with low environmental impact would also have major impacts on human health, avoiding about 11 million deaths per year and reducing premature mortality by almost 20%.^{25,30} Additionally, if opting for foods from sustainable sources, not only considering environmental but also the socioeconomic dimension of food (e.g., working conditions, economic fairness, gender equality, etc.), consumers could significantly contribute to achieve a fairer food system, and the achievement of many of the Sustainable Development Goals (i.e., goals adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity).³¹

Encouragingly, early signs of this transition are already noticeable and should now be encouraged. For instance, a report from the grey literature shows that almost 40% of people in the United States point that environmental sustainability has an impact on their decision to buy certain foods and beverages, and a similar percentage say that knowing that the workers who produce, distribute, or serve the food are treated in a fair and equitable way is important.³² In Europe, another report from the grey literature, conducted across 7 countries (i.e., Germany, Denmark, Switzerland, Austria, Portugal, France and Belgium), shows that the number of Europeans deliberately consuming meat less frequently is growing rapidly at 23%, with the primary motivator reported being health followed by sustainability.³³ This highlights that relatively new interests towards sustainable healthy diets is ongoing in consumers. This transition should now be strongly encouraged to help people changing their behaviours and ultimately progressively create new food-related social norms.³⁴

For whom. To be fair and effective, most behaviour changes initiatives promoting sustainable healthy diets should be first directed to the higher emitter groups, usually the individuals with the higher incomes, between- and within-countries.^{15,35,36} Between countries, mathematical modelling studies suggests that the general adoption of sustainable healthy diets in developed countries could be an effective strategy in reducing GHG emissions by 70-90% and the use of resources by 5-50%, while improving people's health.^{35,37} The general adoption of healthy diets in low-income countries, however, would require an increased use of natural resources due to the need to address existing combinations of often inefficient farming systems and widespread dietary insufficiency in terms of both quantity and quality.³⁵ Further, eating behaviours in high-income countries can have social, economic and environmental consequences in low-income countries, that can exacerbate food insecurity and environmental degradation in those areas (e.g., the boom of quinoa demand from the Global North countries has led to biodiversity loss in the producer countries, conflicts over land among peasants, and a reduced accessibility to this staple food by low-income families).³⁸

Within high-income countries, individuals' dietary environmental impact is higher among men,^{39,40} and among those with higher socioeconomic status and incomes.^{36,41} Food insecurity and hunger are even experienced among people with the lowest incomes in high-income countries.⁴² Thus, individuals from upper socioeconomic level in high income countries, frequently men, should be targeted first if we are to achieve significant reductions in diet-related environmental impact and a fair food system as soon as possible. Similar groups in rapidly industrialising countries, such as China, are also key targets for behavioural scientists if we want to prevent emerging economies to follow the unsustainable pathways of high-income countries.⁴³

How: Two main approaches have been applied so far for promoting eating behaviour change: *i*) interventions inspired by behavioural economics using large- (e.g., taxing and subsidizing foods) and micro-environmental (the so-called “nudges”) modifications to alter peoples’ behaviours with little cognitive engagement (e.g.,^{44,45}), and, central to this viewpoint, *ii*) individual behavioural change interventions targeting peoples’ knowledge, capability, attitudes and motivations in order to help individuals reevaluate their behaviours and adopt relevant modifications (e.g.,^{46,47}). The combination of both approaches is required to achieve scaled and long lasting change in eating behaviors.²⁰ Indeed, although reshaping food environments can be effective to change eating behaviours,^{15,44,48} this set of approaches is likely to be more powerful if combined with individual measures aimed at educating, raising awareness and motivating individuals directly.²⁰ Individuals behaviour change interventions can also contribute to the acceptability of political, structural and environmental modifications and to limit potential forms of psychological reactance.⁴⁹

Behaviour change interventions targeting individuals are also effective in changing eating behaviours on their own (increasing the consumption of certain food groups, such as fruits and vegetables,⁵⁰⁻⁵³ and reducing the intake of others, such as meat^{47,54-56}). Those behavioural interventions are composed of several “active ingredients”, usually reported and labelled in the literature under the term “behaviour change techniques (BCT)”.^{57,58} These techniques describe the content of behavioural change interventions by naming each specific individual component forming the intervention, such as “providing information about the health consequences”, “goal setting”, or “self-monitoring”. One of the challenges in designing individual behaviour change interventions is to use a good “cocktail” of BCTs. In theory, BCTs can be selected with the aim to target specific modifiable factors, also called mechanisms of actions, that can cause the targeted behaviour.⁵⁹ For example, if one assumed that eco-anxiety is positively associated with the consumption of fruits and vegetables,⁶⁰ specific BCTs can be selected to explicitly manipulate eco-anxiety and ultimately the consumption of fruits and vegetables. A second option that can help identifying relevant BCTs is to empirically review the literature to identify which techniques are associated with interventions’ efficacy. Following this second option, and as part of this perspective, we performed a scoping review of systematic reviews and meta-analyses of eating behaviour change interventions to identify key BCTs that can effectively contribute to the promotion of successful eating behaviour changes. Key results from this scoping review are presented in the following section (please, see additional methodological details and findings of this review at:

<https://osf.io/q8jmk/>).

Effective behaviour changes techniques for achieving individual eating behaviour change

In the last years, several systematic reviews or meta-analyses explicitly testing BCT effectiveness for changing eating behaviours,^{50-53,61,62} or identifying eating interventional features associated with changes in eating behaviours have been published (see a description of these individual studies at <https://osf.io/q8jmk/>).^{47,54-56,63} Table 1 presents the behaviour change techniques identified according to different food groups and defined according to the BCT taxonomy (v1).⁵⁷ Overall, we identified 16 techniques that were associated with eating behaviour change across the different reviews and meta-analyses. Some BCTs, such as “goal setting” or “self-monitoring of the behaviour”, were positively associated with interventions efficacy considering different food groups, such as increases in fruit and

vegetable intake,^{51,52} decreases in meat consumption,^{47,55} and change in overall diet, including fat and energy intake.⁶³ On the other hand, other BCTs were associated with intervention efficacy for changing some specific behaviours but not others. For instance, “information about emotional consequences” (e.g., emphasising animal suffering) was positively associated with reductions in meat consumption,^{54,55} but negatively with the promotion of fruits and vegetables in one systematic review and meta-analysis.⁵¹ Finally, some BCTs were only associated with one food group, such as “information about others’ approval” that can positively contribute to reduced meat consumption.⁵⁴

This meta-synthesis of the literature offers a list of BCTs that can positively contribute to successful eating behaviour changes and, thus, can serve as a basis to design individual behaviour changes interventions based on available empirical evidence. Although this question should be explored further, it appears that depending if we want to promote or hinder the consumption of certain food groups, different BCTs should be implemented. In other words, some BCTs could be more effective for targeting a reduction in the consumption (e.g., reduce meat consumption) than for targeting an increment (e.g., promote fruits and vegetables intake).²⁵ It is also worth mentioning that different eating behaviours probably don’t have the same behavioural plasticity or, in other words, are not equally easy to change and sustain.⁶⁴ It is likely that some deeply established behaviours, such as meat consumption, are more difficult to change and require greater emphasis when designing an intervention than other behaviours, such as increased fruit and vegetable consumption.⁴⁶ Beyond the type of the BCTs to be applied, it seems that using several BCTs in the same intervention would lead to more effective results,⁵³ up to a certain threshold where the manipulation of too many interventional components can have detrimental effect.⁶⁵ The most effective combination of BCTs and the order in which they have to be implemented is something that requires further research.⁶⁶ Importantly also, the effectiveness of eating behaviour interventions may depends on the characteristics and motivations of targeted individuals. The assessment of intervention features that are most likely to successfully tackle eating behaviours in those with less sustainable diets is definitely needed.

Limitations of previous individual behaviour change interventions and perspectives

Past eating behaviour interventions mainly focused on specific food groups, such as fruits and vegetables intake, the reduction of meat consumption or reduced fat and energy intake, instead of taking a global dietary approach. Focusing on single food groups comes with a particular limitation: the lack of consideration of potential behavioural spillovers (also called rebound effects when expressed in terms of energy). Spillovers occur when a change in one specific behaviour leads to secondary order changes in other related behaviours.⁶⁷ In some cases these spillovers can be positive, when one favourable change to one’s diet leads to another favourable behavioural change; but they can also be negative, when one positive change comes with a secondary order, likely unplanned, change in another behaviour, compromising the overall effect of the intervention. These negative spillovers may occur *among food groups*, for instance when an increment in vegetable consumption “licenses” a subsequent increase in added sugars, offsetting the health benefits of increased vegetable intake,⁶⁸ or when meat reduction, such as pork or poultry, is compensated by an increase in cheese (one of the food products with the higher environmental impact, not only by weight, but also by protein and energy content), incrementing the dietary environmental impact.⁶⁹ Spillovers can also arise in behaviours unrelated to

food choices: within the *whole food domain* (e.g., the environmental benefits of adopting a low environmental impact diet would be offset if followed by more food wasted);⁷⁰ between *high-environmental impact behaviours* (e.g., when the money saved from reducing meat consumption is re-directed to goods or services with high environmental impact, for instance, traveling by plane)⁷¹ or *between health-related behaviours* (e.g., when the adoption of a healthier diet could license the lack of practice of a regular physical activity).⁷²

Additionally, it is quite rare to find literature on eating behaviour change that simultaneously aims at promoting diets that are both healthier and more sustainable. While the healthiness and environmental impact of foods/diets usually go hand in hand, this is not always the case. For example, fish is a healthy food, but -in some instances- its environmental impact is notorious.⁷³ Similarly, the promotion of healthy diets may lead to health benefits, but at the expenses of a higher dietary environmental impact depending on the foods added and removed.^{74,75} Even healthy foods with low environmental impact, if obtained from unfair sources, could compromise the wellbeing and even food security of producers and other stakeholders all along the food system.⁷⁶ All these dimensions should be considered together to achieve the maximum co-benefits, avoiding unintended spillovers and trade-offs among domains.

We argue here that addressing spillovers and trade-offs is crucial when designing interventions to promote sustainable healthy diets to ensure an overall positive impact of the intervention in terms of human health, planetary health and social equity. Based on this, and considering the major dietary changes required in high-income countries for the general adoption of sustainable healthy diets,²⁵ we propose an actionable definition based on previous guiding principles,¹⁸ but explicitly tailored to researchers, practitioners and policy-makers aimed at the promotion of sustainable healthy diets:

When promoting sustainable healthy diets, the consumption of animal-sourced proteins, such as meats, especially red and processed meat, and dairies should be reduced, and substituted by plant-based proteins, i.e. legumes and nuts. At the same time, the consumption of whole grains should be emphasized over the refined versions, unsaturated and unrefined oils (e.g., virgin olive oil, canola oil) should be promoted over other dietary fats (e.g. butter, coconut oil), and the consumption of water should be targeted as a main dietary beverage, over sweetened beverages and alcoholic drinks. The consumption of fruits and vegetables should be incentivised, while the intake of highly processed foods rich in sugars, salt and/or fats be decreased.²⁵ All these behavioural changes should be monitored accounting for potential negative spillovers across food groups, making sure that all required nutrients and energy are intake, neither in deficiency nor in excess. Special attention should be paid also on spillovers across high-environmental impact and health-related behaviours, and so potential trade-offs within the dimensions of dietary sustainability: human healthiness, environmental impact and socio-economic wellbeing.

Additionally, and as pointed out elsewhere,⁶⁴ future eating behaviour change interventions will also have to overcome specific limitations of the previous interventions related to pro-environmental and/or health behaviour change. This includes i) the adoption of study designs allowing for strong causal inferences such as randomized control trials but also N-of-1 trials, offering higher possibilities of tailoring

and continuous optimization, at lower financial costs;⁷⁷ *ii*) longer period of monitoring, such as several months, to capture accurate patterns of change in eating behaviours over time, and at the right resolution (i.e., changes happening from week to week);⁷⁸ and *iii*) the inclusion of citizen and directly targeted users in the development process of such interventions to increase the chances for its acceptability and feasibility, and gathering relevant information on peoples' needs.⁷⁹

Further, the development of reliable measurement tools and scoring procedures to both briefly screen as well as continuously monitor individuals changes in sustainable diets, together with the aforementioned spillovers, is definitely necessary. Traditional dietary indices have only focused on the dietary healthiness and nutrient adequacy, leaving aside the environmental, socio-cultural and economic dimensions of food; the scoring criteria of those few that considered all those dimensions at once was not easily applicable by consumers, nutritional practitioners or behavioural researchers.^{80,81} Some efforts have been done in the last years for the development of more practical scores for the assessment of sustainable healthy diets, but they still lack consideration of the socio-cultural and economic dimensions, and so other behaviours beyond diet.^{82,83} Their consideration is key to evaluating the overall effect of the intervention on the sustainability as a whole. The utilisation of more objective data collection, in parallel with self-reported behavioural outcomes, such as food photos, could also help improving the evaluation of these interventions.⁸⁴

Conclusions

A social transformation toward a lifestyle in general, and diet in particular, that fits with the planetary boundaries is urgent. Beyond structural changes, individual behavioural change is deeply needed in order to accelerate such a transition, notably among high-income groups within- and between-countries. The present viewpoint offers a starting point for the design of future individual interventions for sustainable healthy diets based on available evidence in terms of effective behaviour change techniques for promoting different eating behaviours. We also draw important new perspectives related to the consideration of various spillovers and trade-offs when changing one's behaviour. Ultimately, this viewpoint is also a call for more multidisciplinary collaborations between environmental, socio-economic, nutrition and behavioural researchers to develop future relevant interventions promoting sustainable healthy diet as a whole and in its full complexity.

Author contribution: UF and GC conceptualized the study, searched the literature, collected data, and wrote the original draft; PB searched the literature and reviewed and edited the draft; VAS conceptualized the study and reviewed and edited the draft; SJL reviewed and edited the draft; FEH reviewed the draft. All authors have read the whole document and accept responsibility to submit for publication.

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References:

1. Nations U. Can we feed the world and ensure no one goes hungry? 2019. Available online: <https://news.un.org/en/story/2019/10/1048452>. Accessed on 3 March 2022
2. FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO. 2020. Available online: <https://doi.org/10.4060/ca9692en> Accessed on 8 January 2022
3. UNEP. Food Waste Index Report 2021, Nairobi 2021. Available online: <https://wedocs.unep.org/handle/20.500.11822/35280;jsessionid=8E3298E8C0650C5AD1571644FA93BB84> Accessed on 8 January 2022
4. Blackstone NT, Norris CB, Robbins T, Jackson B, Decker Sparks JL. Risk of forced labour embedded in the US fruit and vegetable supply. *Nature Food* 2021; **2**(9): 692-9.
5. FAO. The share of food systems in total greenhouse gas emissions. Global, regional and country trends, 1990–2019. FAOSTAT Analytical Brief Series No. 31. Rome., 2021. Available online: <https://www.fao.org/documents/card/es/c/cb7514en/> Accessed on 12 January 2022
6. Crippa M, Solazzo E, Guizzardi D, Monforti-Ferrario F, Tubiello FN, Leip A. Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food* 2021; **2**(3): 198-209.
7. Clark MA, Domingo NGG, Colgan K, et al. Global food system emissions could preclude achieving the 1.5 degrees and 2 degrees C climate change targets. *Science* 2020; **370**(6517): 705-8.
8. FAO. Livestock's long shadow. Environmental issues and options. Rome 2006. Available online: <http://www.fao.org/3/a0701e/a0701e.pdf> Accessed on 15 March 2022
9. Diaz RJ, Rosenberg R. Spreading Dead Zones and Consequences for Marine Ecosystems. 2008; **321**(5891): 926-9.
10. WWF. Bending the Curve: The Restorative Power of Planet-Based Diets. 2020. Loken, B. et al. WWF, Gland, Switzerland
11. FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. 2020 Rome. Available from: <https://doi.org/10.4060/ca8642en>
12. Benton TG, Bieg C, Harwatt H, Pudasaini R and Wellesley L. Food system impacts on biodiversity loss. Three levers for food system transformation in support of nature. Chatham House 2021 Available from: https://www.chathamhouse.org/sites/default/files/2021-02/2021-02-03-food-system-biodiversity-loss-benton-et-al_0.pdf Accessed on 3 February 2022
13. IPCC AR6 WG2. Climate Change 2022. Impacts, Adaptation and Vulnerability, 2022. Available online: <https://www.ipcc.ch/report/ar6/wg2/> Accessed on 18 March 2022
14. Springmann M, Clark M, Mason-D'Croz D, et al. Options for keeping the food system within environmental limits. *Nature* 2018; **562**(7728): 519-25.
15. Newell P, Twena M, Daley F. Scaling behaviour change for a 1.5-degree world: challenges and opportunities. *Global Sustainability* 2021; **4**: e22.
16. Springmann M, Clark M, Mason-D'Croz D, et al. Options for keeping the food system within environmental limits. *Nature* 2018; **562**(7728): 519-25.
17. Burlingame B, Dernini S. Sustainable diets and biodiversity. 2012. Food and Agriculture Organization of the United Nations. Available online: <https://cgspace.cgiar.org/handle/10568/104606>
18. FAO and WHO. Sustainable healthy diets – Guiding principles. 2019. Rome. Available online: <https://www.who.int/publications/i/item/9789241516648>
19. Chevance G, Fresán U, Hekler E, et al. Thinking Health-related Behaviors in a Climate Change Context: A Narrative Review. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine* 2022. doi: 10.1093/abm/kaac039

20. Sniehotta FF, Araújo-Soares V, Brown J, Kelly MP, Michie S, West R. Complex systems and individual-level approaches to population health: a false dichotomy? *The Lancet Public Health* 2017; **2**(9): e396-e7.
21. Akenji L, Bengtsson M, Toivio V, Lettenmeier M, Fawcett T, Parag Y, Saheb Y, Coote A, Spangenberg JH, Capstick S, Gore T, Coscieme L, Wackernagel M, Kenner D. 2021. 1.5-Degree Lifestyles: Towards A Fair Consumption Space for All. Hot or Cool Institute, Berlin Available online: https://hotorcool.org/wp-content/uploads/2021/10/Hot_or_Cool_1_5_lifestyles_FULL_REPORT_AND_ANNEX_B.pdf
22. Schill C, Anderies JM, Lindahl T, et al. A more dynamic understanding of human behaviour for the Anthropocene. *Nature sustainability* 2019; **2**(12): 1075-82.
23. Kaaronen RO, Strelkovskii N. Cultural Evolution of Sustainable Behaviors: Pro-environmental Tipping Points in an Agent-Based Model. *One Earth* 2020; **2**(1): 85-97.
24. Swinburn BA, Kraak VI, Allender S, et al. The Global Syndemic of Obesity, Undernutrition, and Climate Change: *The Lancet* Commission report. *The Lancet* 2019; **393**(10173): 791-846.
25. Willett W, Rockström J, Loken B, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* 2019; **393**.
26. Wynes S, Nicholas KA. The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environmental Research Letters* 2017; **12**(7): 074024.
27. Jones CM, Kammen DM. Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. *Environmental science & technology* 2011; **45**(9): 4088-95.
28. Lacroix K. Comparing the relative mitigation potential of individual pro-environmental behaviors. *Journal of Cleaner Production* 2018; **195**: 1398-407.
29. Ivanova D, Barrett J, Wiedenhofer D, Macura B, Callaghan M, Creutzig F. Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters* 2020; **15**(9): 093001.
30. Springmann M, Spajic L, Clark MA, et al. The healthiness and sustainability of national and global food based dietary guidelines: modelling study. *BMJ* 2020; **370**: m2322.
31. United Nations. Food systems submit x SDGs. Available online: www.un.org/en/food-systems-summit/sdgs Accessed on 22 March 2022.
32. International Food Information Council. 2022 Food and Health Survey. 2022. Available online: <https://foodinsight.org/wp-content/uploads/2022/06/IFIC-2022-Food-and-Health-Survey-Report-May-2022.pdf> Accessed on 1 August 2022
33. Veganz. Veganz nutrition study. 2020. Available online: <https://vegan.com/blog/vegan-nutrition-study-2020/> Accessed on 1 August 2020
34. Bennett G, Williams, F. Mainstream Green: Moving sustainability from niche to normal, 2011. Ogilvy & Mather. Available from: <https://climateaccess.org/resource/mainstream-green-moving-sustainability-niche-normal> Accessed on 19 April 2022
35. Springmann M, Wiebe K, Mason-D'Croz D, Sulser TB, Rayner M, Scarborough P. Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *The Lancet Planetary Health* 2018; **2**(10): e451-e61.
36. Song K, Qu S, Taiebat M, Liang S, Xu M. Scale, distribution and variations of global greenhouse gas emissions driven by U.S. households. *Environment International* 2019; **133**: 105137.
37. Springmann M, Godfray HCJ, Rayner M, Scarborough P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc Natl Acad Sci U S A* 2016; **113**(15): 4146-51.
38. Angeli V, Miguel Silva P, Crispim Massuela D, et al. Quinoa (*Chenopodium quinoa* Willd.): An Overview of the Potentials of the "Golden Grain" and Socio-Economic and Environmental Aspects of Its Cultivation and Marketization. *Foods (Basel, Switzerland)* 2020; **9**(2).

39. Hallström E, Bajzelj B, Håkansson N, et al. Dietary climate impact: Contribution of foods and dietary patterns by gender and age in a Swedish population. *Journal of Cleaner Production* 2021; **306**: 127189.
40. Walker C, Gibney ER, Hellweg S. Comparison of Environmental Impact and Nutritional Quality among a European Sample Population – findings from the Food4Me study. *Scientific reports* 2018; **8**(1): 2330.
41. Eini-Zinab H, Shoaibinobarian N, Ranjbar G, Norouzian Ostad A, Sobhani SR. Association between the socio-economic status of households and a more sustainable diet. *Public health nutrition* 2021; **24**(18): 6566-74.
42. Pollard CM, Booth S. Food Insecurity and Hunger in Rich Countries-It Is Time for Action against Inequality. *International journal of environmental research and public health* 2019; **16**(10): 1804.
43. Schroeder P, Anantharaman M. "Lifestyle Leapfrogging" in Emerging Economies: Enabling Systemic Shifts to Sustainable Consumption. *Journal of Consumer Policy* 2017; **40**(1): 3-23.
44. Hollands GJ, Bignardi G, Johnston M, et al. The TIPME intervention typology for changing environments to change behaviour. *Nature Human Behaviour* 2017; **1**(8): 0140.
45. An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: a review of field experiments. *Public health nutrition* 2013; **16**(7): 1215-28.
46. Gifford R. Environmental Psychology Matters. *Annual Review of Psychology* 2014; **65**(1): 541-79.
47. Bianchi F, Dorsel C, Garnett E, Aveyard P, Jebb SA. Interventions targeting conscious determinants of human behaviour to reduce the demand for meat: a systematic review with qualitative comparative analysis. *International Journal of Behavioral Nutrition and Physical Activity* 2018; **15**(1): 102.
48. Food Climate Research Network. Policies and actions to shift eating patterns: What works? A review of the evidence of the effectiveness of interventions aimed at shifting diets in more sustainable and healthy directions. 2015. Available online: https://tabledebates.org/sites/default/files/2020-10/fcrn_chatham_house_0.pdf Accessed on 7 December 2021
49. Maestre-Andrés S, Drews S, van den Bergh J. Perceived fairness and public acceptability of carbon pricing: a review of the literature. *Climate Policy* 2019; **19**(9): 1186-204.
50. Ashton LM, Sharkey T, Whatnall MC, et al. Effectiveness of Interventions and Behaviour Change Techniques for Improving Dietary Intake in Young Adults: A Systematic Review and Meta-Analysis of RCTs. *Nutrients* 2019; **11**(4): 825.
51. Bull ER, McCleary N, Li X, Dombrowski SU, Dusseldorp E, Johnston M. Interventions to Promote Healthy Eating, Physical Activity and Smoking in Low-Income Groups: a Systematic Review with Meta-Analysis of Behavior Change Techniques and Delivery/Context. *International journal of behavioral medicine* 2018; **25**(6): 605-16.
52. Lara J, Evans EH, O'Brien N, et al. Association of behaviour change techniques with effectiveness of dietary interventions among adults of retirement age: a systematic review and meta-analysis of randomised controlled trials. *BMC medicine* 2014; **12**: 177.
53. Rodriguez Rocha NP, Kim H. eHealth Interventions for Fruit and Vegetable Intake: A Meta-Analysis of Effectiveness. *Health education & behavior : the official publication of the Society for Public Health Education* 2019; **46**(6): 947-59.
54. Graça J, Godinho CA, Truninger M. Reducing meat consumption and following plant-based diets: Current evidence and future directions to inform integrated transitions. *Trends in Food Science & Technology* 2019; **91**: 380-90.
55. Kwasny T, Dobernig K, Riefler P. Towards reduced meat consumption: A systematic literature review of intervention effectiveness, 2001–2019. *Appetite* 2022; **168**: 105739.

56. Taufik D, Verain MCD, Bouwman EP, Reinders MJ. Determinants of real-life behavioural interventions to stimulate more plant-based and less animal-based diets: A systematic review. *Trends in Food Science & Technology* 2019; **93**: 281-303.
57. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine* 2013; **46**(1): 81-95.
58. Knittle K, Heino M, Marques MM, et al. The compendium of self-enactable techniques to change and self-manage motivation and behaviour v.1.0. *Nat Hum Behav* 2020; **4**(2): 215-23.
59. Sheeran P, Klein WMP, Rothman AJ. Health Behavior Change: Moving from Observation to Intervention. *Annual Review of Psychology* 2017; **68**(1): 573-600.
60. Zheng L, Luszczynska A, Miao M, Chen Y, Gan Y. Effects of Environmental Worry on Fruit and Vegetable Intake. *International journal of behavioral medicine* 2022; **29**(2): 141-51.
61. Vargas-Garcia EJ, Evans CEL, Prestwich A, Sykes-Muskett BJ, Hooson J, Cade JE. Interventions to reduce consumption of sugar-sweetened beverages or increase water intake: evidence from a systematic review and meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2017; **18**(11): 1350-63.
62. Whatnall MC, Patterson AJ, Ashton LM, Hutchesson MJ. Effectiveness of brief nutrition interventions on dietary behaviours in adults: A systematic review. *Appetite* 2018; **120**: 335-47.
63. Deliens T, Van Crombruggen R, Verbruggen S, De Bourdeaudhuij I, Deforche B, Clarys P. Dietary interventions among university students: A systematic review. *Appetite* 2016; **105**: 14-26.
64. Nisa CF, Bélanger JJ, Schumpe BM, Faller DG. Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change. *Nature Communications* 2019; **10**(1): 4545.
65. Wilson K, Senay I, Durantini M, et al. When it comes to lifestyle recommendations, more is sometimes less: A meta-analysis of theoretical assumptions underlying the effectiveness of interventions promoting multiple behavior domain change. *Psychological Bulletin* 2015; **141**(2): 474-509.
66. Dusseldorp E, van Genugten L, van Buuren S, Verheijden MW, van Empelen P. Combinations of techniques that effectively change health behavior: evidence from Meta-CART analysis. *Health psychology : official journal of the Division of Health Psychology, American Psychological Association* 2014; **33**(12): 1530-40.
67. Galizzi MM, Whitmarsh L. How to Measure Behavioral Spillovers: A Methodological Review and Checklist. *Frontiers in psychology* 2019; **10**.
68. Chevance G, Golaszewski NM, Baretta D, et al. Modelling multiple health behavior change with network analyses: results from a one-year study conducted among overweight and obese adults. *Journal of Behavioral Medicine* 2020; **43**(2): 254-61.
69. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science* 2018; **360**(6392): 987-92.
70. Conrad Z, Niles MT, Neher DA, Roy ED, Tichenor NE, Jahns L. Relationship between food waste, diet quality, and environmental sustainability. *PLOS ONE* 2018; **13**(4): e0195405.
71. Sorrell S, Gatersleben B, Druckman A. The limits of energy sufficiency: A review of the evidence for rebound effects and negative spillovers from behavioural change. *Energy Research & Social Science* 2020; **64**: 101439.
72. King AC, Castro CM, Buman MP, Hekler EB, Urizar GG, Jr., Ahn DK. Behavioral impacts of sequentially versus simultaneously delivered dietary plus physical activity interventions: the CALM trial. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine* 2013; **46**(2): 157-68.
73. Clark MA, Springmann M, Hill J, Tilman D. Multiple health and environmental impacts of foods. *Proc Natl Acad Sci U S A* 2019; **116**(46): 23357-62.

74. Grasso AC, Olthof MR, van Dooren C, et al. Effect of food-related behavioral activation therapy on food intake and the environmental impact of the diet: results from the MoodFOOD prevention trial. *European journal of nutrition* 2020; **59**(6): 2579-91.
75. Vieux F, Soler L-G, Touazi D, Darmon N. High nutritional quality is not associated with low greenhouse gas emissions in self-selected diets of French adults. *The American journal of clinical nutrition* 2013; **97**(3): 569-83.
76. Dendena B, Corsi S. Cashew, from seed to market: a review. *Agronomy for Sustainable Development* 2014; **34**(4): 753-72.
77. Potter T, Vieira R, de Roos B. Perspective: Application of N-of-1 Methods in Personalized Nutrition Research. *Advances in Nutrition* 2021; **12**(3): 579-89.
78. Chevance G, Perski O, Hekler EB. Innovative methods for observing and changing complex health behaviors: four propositions. *Translational behavioral medicine* 2020; **11**(2): 676-85.
79. Araújo-Soares V, Hankonen N, Presseau J, Rodrigues A, Sniehotta FF. Developing behavior change interventions for self-management in chronic illness: An integrative overview. *European Psychologist* 2019; **24**(1): 7-25.
80. Fresán U, Martínez-González MA, Segovia-Siapco G, Sabaté J, Bes-Rastrollo M. A three-dimensional dietary index (nutritional quality, environment and price) and reduced mortality: The "Seguimiento Universidad de Navarra" cohort. *Preventive medicine* 2020; **137**: 106124.
81. Seconda L, Baudry J, Pointereau P, et al. Development and validation of an individual sustainable diet index in the NutriNet-Santé study cohort. *The British journal of nutrition* 2019; **121**(10): 1166-77.
82. Stubbendorff A, Sonestedt E, Ramne S, Drake I, Hallström E, Ericson U. Development of an EAT-Lancet index and its relation to mortality in a Swedish population. *The American journal of clinical nutrition* 2021; **115**(3): 705-16.
83. Nicholls J, Drewnowski A. Toward Sociocultural Indicators of Sustainable Healthy Diets. *Sustainability* 2021; **13**(13): 7226.
84. König LM, Van Emmenis M, Nurmi J, Kassavou A, Sutton S. Characteristics of smartphone-based dietary assessment tools: a systematic review. *Health Psychology Review* 2021: 1-25.

Table 1. Associations between behaviour change techniques (BCT) and eating behaviours outcomes

BCT		Definition	Eating behaviour change			
			Improve overall diet	Increase fruit and vegetable intake	Reduce meat consumption	Decrease SSB and increase water
1.1	Goal setting	Set or agree on a goal defined in terms of the behaviour to be achieved	+	+	+	
1.2	Problem solving	Analyse, or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators	+	+		
1.4	Action planning	Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity)	+		+	
2.2	Feedback on behavior	Monitor and provide informative or evaluative feedback on performance of the behaviour		mixed		
2.3	Self-monitoring of behavior	Establish a method for the person to monitor and record the outcome(s) of their behaviour as part of a behaviour change strategy	+	+	+	
3.1	Social support (unspecified)	Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues, 'buddies' or staff) or non-contingent praise or reward for performance of the behaviour		+		
4.1	Instruction on how to perform a behavior	Advise or agree on how to perform the behaviour			+	+

4.2	Information about antecedents	Provide information about antecedents (e.g. social and environmental situations and events, emotions, cognitions) that reliably predict performance of the behaviour	+			
5.1	Information about health consequences	Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour	+	–	+	
5.3	Information about social and environmental consequences	Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behaviour			+	
5.6	Information about emotional consequences	Provide information (e.g. written, verbal, visual) about emotional consequences of performing the behaviour		–	+	
6.1	Demonstration of the behavior	Provide an observable sample of the performance of the behaviour, directly in person or indirectly e.g. via film, pictures, for the person to aspire to or imitate			+	+
6.2	Social comparison	Draw attention to others' performance to allow comparison with the person's own performance	+			
6.3	Information about others' approval	Provide information about what other people think about the behaviour. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do			+	
7.1	Prompt/cues	Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behaviour	+	mixed		
15.3	Focus on past success	Advise to think about or list previous successes in performing the behaviour	+			

Improvement in overall diet includes outcomes such as fruits and vegetables together with reduced fat intake and caloric intake. "+" indicates that interventions using the specific BCT are more effective at changing the behavioural outcomes compared to interventions that do not integrate the specific BCT; "mixed" indicates mixed findings about the effectiveness of that behaviour change technique on those outcomes (including positive and negative

effects); "-" indicates that interventions using the specific BCT are less effective at changing the behavioural outcomes compared to interventions that do not integrate the specific BCT.