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Integrating climate and food policies in higher education: a case study of the University of California

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ABSTRACT
Most climate change mitigation policies, including those of higher education institutions, do not include food system greenhouse gas emissions (GHGE). Yet the food system contributes ~30% of anthropogenic GHGE, mostly from animal source foods. Food system changes are necessary to meet GHGE mitigation targets and could do so relatively inexpensively and rapidly with major health, social and environmental co-benefits. To estimate the potential impact of integrating higher education institution climate and food policies, we used the case of the University of California (UC), comprising 10 campuses with 280,000 students. The UC is a leader in climate and food research, and has major policy initiatives for mitigating climate change and for promoting healthy, sustainable food systems. Like most higher education institutions, the UC climate change mitigation target for 2025 covers only Scope 1 and 2 GHGE (campus-generated and purchased energy), yet Scope 3 GHGE (indirect, including food system) are often institutions’ largest. We created scenarios using results of studies of US dietary changes, and existing, planned or potential UC food system changes. These scenarios could reduce UC Scope 3 food emissions by 42–55%, equivalent to 8–9% of UC’s targeted energy GHGE reduction, and 19–22% of offsets need to reach that target. These results have implications for broader climate policy in terms of food systems’ high GHGE, the health, environmental, economic and social benefits of food system changes, and ways these changes could be implemented. To our knowledge this is one of the first empirical studies of the potential for integrating climate and food policy in HEIs.

Key policy insights
- Most higher education institution climate policies, including those of the University of California (UC), do not include food system GHGE
- Research at higher education institutions makes major contributions to understanding the need to reduce food system GHGE to achieve Paris Agreement goals
- Higher education institutions, including UC, have made many food system changes, but their climate co-benefits are not optimized, documented or integrated with climate policies
- Our food system change scenarios show that UC’s food system could substantially reduce GHGE
- These changes can incentivize UC and other higher education institutions to integrate their climate and food policies.

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1. Introduction

Anthropogenic global climate change is an existential emergency threatening Earth’s ecosystems and human society (IPCC, 2018; Lenton et al., 2019; USGCRP, 2018), yet greenhouse gas emissions (GHGE) continue to increase at relatively rapid rates (WMO, 2019) in spite of the recent Paris Agreement by world nations to mitigate emissions (UNFCCC, 2015). The food system (Vermeulen et al., 2012), especially ruminant animal source foods and animal source foods in general (Eshel et al., 2014; Godfray et al., 2018), and food waste (Hiç et al., 2016), contributes one third or more of GHGE. Therefore, there is an urgent need to reduce food system GHGE to meet the goals of the Paris Agreement and avoid catastrophic climate change, while feeding a growing population (Harwatt, 2018). Recent work suggests that this is best done through a combination of healthier, more plant based diets in addition to technological improvements and reduction in food waste (Bajželj et al., 2014; Godfray et al., 2018; Hedenus et al., 2014; Springman et al., 2018; Willett et al., 2019).

Diets supported by the current food system are also a major cause of a pandemic of overweight, obesity and noncommunicable diseases (NCDs), including diabetes, heart disease and cancer (Afshin et al., 2019; Aleksandrowicz et al., 2016; Chen et al., 2018). In addition, NCDs are both associated with mental illness, and share the same risk factors (Stein et al., 2019). It is now well established that diets with the least climate impact can also have the most health benefit (Hallström et al., 2015; Macdiarmid, 2013; Springmann et al., 2016; Tilman & Clark, 2014). However, there are tradeoffs, for example for populations obtaining most of their energy from starchy carbohydrates, the addition of meat ‘or other major protein sources is likely to mitigate micronutrient deficiencies and have metabolic benefits by reducing high glycaemic load’ and improve overall health (Willett et al., 2019, p. 10).

The pandemic of NCDs contributes to rapidly rising health care costs which could reach $47 trillion annually by 2030 globally (Bloom et al., 2011), and a total of $95 trillion for 2015–2050 in the US, or $265,000 per person (Chen et al., 2018). NCDs exacerbate economic inequities within societies globally (Nugent et al., 2018), and in the US (NASEM, 2017). Health care costs of diet-related NCDs also generate GHGE (Eckelman & Sherman, 2016; Hallström et al., 2017).

While our understanding of the linkages between the climate and food systems is growing rapidly, most climate and food policies do not reflect this understanding. For example, many climate policies include only Scope 1 and Scope 2 emissions (from energy sources), and sometimes a portion of Scope 3 (commuting, work and business travel), even though Scope 3, including food, comprises the majority of most institutions’ emissions (GHGP, 2011). These include the policies of most higher education institutions (HEIs) that provide much of the research establishing these linkages (for example, AASHE, 2019), and are educating the scientists, activists and policy makers who will be critical in achieving policy integration.

HEIs see themselves as leaders in addressing climate change, e.g. since 2006 as part of Second Nature, which is a higher education non-profit organization promoting action on climate change. In this role they have created a number of commitments, including the Climate Leadership Network, to ‘lead on climate and sustainability’ now comprising ‘hundreds’ of HEIs in the US (SN CLN, 2020a). In 2018, HEIs from across North America formed the University Climate Change Coalition (UC3), affiliated with the Climate Leadership Network, to share knowledge and experience in mitigating climate change with each other and ‘surrounding communities, and public and private sector partners’ thus ‘serving as models for climate solutions’ (SN UC3, 2020).

Many HEIs are also making food system changes with goals of increasing healthfulness and decreasing negative environmental and social impacts (e.g. Middleton & Littler, 2019), but their climate co-benefits are seldom quantified and so not integrated with climate policy. As a result, food system changes are rarely part of climate policy-making, resulting in ‘distorted decision-making’ that overemphasizes costs, and in climate policies that fail to reach goals (Karlsson et al., 2020, p. 293). It is therefore critical to examine the potential for better integration between climate and food policies at HEIs.

We chose the University of California (UC) as a case study of the potential for integrating these policies because it is a key player in HEI climate policy; the above-mentioned UC3, for example, was envisioned by UC President Janet Napolitano (SN, 2020a). Like many other HEIs, UC is also a major contributor to climate and food systems research, and promotes major policy initiatives in both climate and food. These include the Carbon Neutrality Initiative (CNI) with the goal for UC of net zero Scope 1 and 2 GHGE by 2025, and the
Global Food Initiative, which targets improving health, food security and sustainability at UC, in California, the US and the world. UC is one of the world’s leading public research universities, with 280,000 students and 240,000 faculty and staff on 10 campuses. It is also the third largest employer in California, whose 40 million residents makes it the most populous state, while its economy ranks 5th among nations.

Our goals here are, first, to estimate the GHGE reductions of food system change scenarios for UC in order to evaluate the potential for these food system changes to contribute to UC and HEI climate policy. Our scenarios are based on studies of changes in the US food system, and on examples of food system changes at some UC campuses. Our second goal is to use results of our scenarios to stimulate discussion of the imperative for integrating food system changes within broader climate policy. This includes the food systems’ high GHGE, the economic, health, environmental, and social benefits of food system changes, and the ways in which these changes could be implemented. To our knowledge, this is one of the first empirical studies of the potential for integrating climate and food policy in HEIs.

2. Climate and food policy at the University of California

2.1. UC climate policy

UC’s main climate change mitigation policy, the CNI, was established in 2013 and is promoted as a leading example for global climate policy (Victor et al., 2018). The CNI goal is eliminating or offsetting all Scope 1 (on-campus energy sources) and Scope 2 (off-campus energy sources – purchased electricity and steam) GHGE by 2025 (amounting to 1,129,233 MtCO\textsubscript{2}e yr\textsuperscript{−1} as of October 2018), and by 2050 a portion (commuting to campus and business travel) of Scope 3 GHGE. These goals have since been adopted into UC’s Sustainable Practices Policy, which sets operational goals in sustainability for the entire UC system.

The three prongs of CNI’s mitigation effort (increased efficiency, alternative fuels, electrification) all have major technical, infrastructural and financial challenges that limit their scalability over the short and medium term (Victor et al., 2018), so that purchasing offsets of 477,117 MtCO\textsubscript{2}e (UC CNI, 2018) (42% of targeted emissions as of October 2018) will be necessary to meet the 2025 goal (CNFMTF, 2017, p. 12), and major investment will be required, with $\sim$429 million spent on UC carbon neutrality-related research during 2009–2014 (St. Clair & Chiang, 2016).

The CNI position on Scope 3 emissions (indirect emissions from purchased goods and services, including food), is that they ‘are subject to long-term goals but actionable plans will require more leadership’ (Victor et al., 2018). While some CNI policy background documents do mention food, e.g. the need to reduce animal food consumption and food waste (Forman et al., 2016, pp. 10–11), the policy proposes no food system changes (CNFMTF, 2017).

A CNI survey found the UC community skeptical of the CNI’s vision for meeting its goals, including the need for offsets and market-based solutions in general, and wanting a broader approach. In response it was suggested that the CNI ‘appeal beyond climate solutions’ by linking to other initiatives, for example ‘water, transportation, or other sustainability goals, new initiatives like the Healthy Campus Network program, or even social-justice initiatives’ (Bales et al., 2018, p. 66). These other initiatives involve changes in behaviour and underlying knowledge and values as key components, which are explicitly omitted from the CNI due to the ‘variability of human behavior and most campuses’ limited experience with inducing behavioral savings on a sustained basis’, although the CNI does acknowledge the potential of behaviour change (Meier et al., 2018, p. 33).

In sum, UC CNI policy is currently reducing Scope 1 and 2 GHGE to reach the 2025 target of zero emissions, which will be technically and infrastructurally difficult and expensive, and does not include food system or other Scope 3 GHGE, which likely constitute the majority of UC related emissions. The 2050 target includes some Scope 3 transportation emissions, but not food system emissions.

2.2. UC food policy

UC’s sustainable food policy was established in 2009. One of its major goals is that ‘each campus and health location foodservice operation shall strive to procure 20% sustainable food products by the year 2020, while
maintaining accessibility and affordability for all students and UC Health location’s foodservice patrons’ (UCOP, 2019, p. 15). ‘Sustainable food’ is defined as a food or beverage purchase that meets just one of 20 criteria (with the option for adding more) that include those focused on animal welfare, social justice, and environmental sustainability. It does not include climate change mitigation or nutritional quality in the policy, although campuses are ‘encouraged’ to promote ‘healthy’ and ‘sustainable’ food (UCOP, 2019, pp. 30–31). This policy is currently being revised to reflect changes in market standards and definitions of sustainability, and some measures to reduce GHGE of campus food systems by serving plant-based foods are being considered.

In addition, a systemwide Global Food Initiative was established in 2014 to: ‘help individuals and communities access safe, affordable and nutritious food while sustaining our natural resources’, to ‘shape, impact and drive policy discussions’, and to draw on ‘UC’s leadership in the fields of agriculture, medicine, nutrition, climate science, public policy, social science, biological science, humanities, arts and law, among others’ (UCOP, n.d.). The Initiative’s purview is ‘both external, such as how UC translates research into policy and helps communities eat more sustainably, and internal, such as how UC leverages its collective buying power and dining practices to create desirable policies and outcomes’ (UCOP, n.d.). While reducing GHGE to mitigate climate change could easily be included under these broad goals, to date it has not been.

Since 2016, the main focus of the Global Food Initiative is the Healthy Campus Network. It grew out of the Healthy Campus Initiative (HCI) at UC Los Angeles (UCLA), created in 2013 (Slusser et al., 2018). The main goal of the Network is to build on the experience of the HCI, UC San Francisco (UCSF)’s ban on the sale of sugar-sweetened beverages, and UC’s smoke and tobacco free policy, to ‘advance a culture of health and well-being’ (UC GFI, 2017). The Network does not include reducing food GHGE, although this is currently being discussed.

In sum, UC food policy has made much progress toward healthier, more sustainable campus food systems, much of which also reduces GHGE, though emission reduction has not been an explicit goal, the effect on emissions has not been well documented, and food policy is not linked to climate policy.

3. Methods

Our methods comprised four main steps summarized in this section; more details are in the Supplementary Information, including tables for each scenario.

3.1. Step 1, constructing scenarios

To estimate the potential for food system change to reduce UC GHGE, we created two sets of scenarios and estimated their GHGE reductions compared with a baseline (column 1, Tables S3-S7). First, we created nine scenarios using five peer reviewed life cycle assessment studies of the effect of change in the US diet on GHGE, assuming these changes were adopted by the UC population (Tables S3-S7). Some scenarios also included a reduction in food waste. Scenarios US1-US3 are US Department of Agriculture recommended diets compared with the current, or standard American diet (SAD) for food eaten and wasted (Heller & Keoleian, 2015) (Tables S3). US4-US6 are alternative diets based on changing about 50% of the calories in SAD in ways that reduce GHGE in the food system as well as the risk of NCDs, which reduces their health care costs (GHGE of health care costs are also reduced, but not included in our scenarios) (Hallström et al., 2017) (Tables S4). The main changes were increasing fruits, vegetables and whole grains, and decreasing refined grains and red and processed meat. US7 is a diet which replaces all beef in the SAD with plant foods (Eshel et al., 2016) (Tables S5). US8 is the diet of the US population quintile with mean GHGE compared with the diet of the quintile with the highest GHGE (Heller et al., 2018) (Tables S6). US9 is a diet shifting 48% of meat and dairy calories in the SAD to a non-dairy vegetarian diet (Weber & Matthews, 2008) (Tables S7).

We created a second set of eight scenarios based on existing, planned or potential food system changes on some UC campuses, assuming these changes were fully implemented across all campuses (Tables S9-S14). We included UC campus practices and policies in two of the three main categories affecting the food system at the retail and consumer levels (Garnett et al., 2015): informational and educational food environments (scenario UC1), and physical food environments (scenarios UC2-UC8, Table S8). We found no examples of the third area, food prices.
Scenario UC1 is the effect of a course on food and the environment at UCLA on students’ self-reported food intakes from before to after the course, compared with analogous data for students in a control course (Table S9); UC2 is the substitution of 30% plant blended burgers for 100% beef burgers in UCLA dining halls (Table S10); UC3 is based on UC2, but assumes replacement with 100% plant burgers (Table S10); UC4 is the elimination of beef from 4 UCLA dining halls one day a week, and assumes it is replaced with beans with the equivalent amount of protein (Table S11); UC5 is based on UC4, but assumes beef is replaced with chicken (Table S11); UC6 is the removal of trays from dining halls at UC Santa Barbara (UCSB) to reduce food waste (Table S12); UC7 is the elimination of sugar sweetened beverage sales at UCSF to improve health, and assumes they are replaced by tap water (Table S13); UC8 is the anaerobic composting of food waste based on a pilot project at UC San Diego, and assumes food waste would otherwise be sent to landfills (Table S14).

3.2. Step 2, estimating GHGE reductions for scenarios

We estimated the maximum effect of each scenario on reduction in GHGE as CO$_2$e cap$^{-1}$ yr$^{-1}$ (column 2, Tables S2, S8). For the scenarios based on US food system changes (Tables S3-S7) we used the amount of CO$_2$e cap$^{-1}$ yr$^{-1}$ reduction from the pre-change baseline in the study cited, or calculated it using national data in the study divided by the US population size for the appropriate year.

For CO$_2$e cap$^{-1}$ yr$^{-1}$ in the scenarios based on UC examples we used GHGE intensities in the literature for the food system changes in each scenario to estimate the difference between baseline emissions before the change and emissions after the change, and divided this by the appropriate population (Tables S9-S14). For example, for the UCLA blended burger scenario (Table S10), we used GHGE intensities for beef in the US to calculate CO$_2$e yr$^{-1}$ for the beef used for 100% meat burgers before introduction of blended burgers and subtracted from this the sum of 70% of beef emissions plus the emissions from the plant foods comprising 30% of the blended burgers. We then divided this by the estimated number of students eating in the dining halls per year.

3.3. Step 3, estimating the scenarios’ GHGE impact for the UC population

We used each scenario estimate of reduced CO$_2$e cap$^{-1}$ yr$^{-1}$ to calculate the reduction in MtCO$_2$e yr$^{-1}$ for the on-campus meals eaten by the UC population (students, staff and faculty) (column 3 Tables S2, S8). We assumed that all first year students ate three meals per day during the academic year, all other students ate one meal per day (lunch) during the academic year, and faculty and staff ate one meal per day (lunch) five days per week throughout the year (not including holidays) (Table S1). For scenarios US1-US9, UC1, UC6, UC7 and UC8 we used all meals eaten on campus, but for the other UC scenarios we removed the breakfasts of first year students. We did this because we assumed that students would not eat burgers or beef for breakfast. We defined the academic year as the days during which residential dining halls were open (based on UCLA’s schedule), not including summer sessions. Because we did not count meals of summer session students, conference attendees, special programme (e.g. summer sport) participants or campus visitors, our estimates are conservative.

3.4. Step 4, estimating the scenarios’ contribution to food system GHGE and to CNI goals

We calculated the reduction in GHGE of each scenario as a percentage of UC baseline Scope 3 food system emissions (column 4, Tables S2, S8). The baseline for most of the US scenarios was based on data in the study used for each scenario. Where this was not possible, and also for all of the UC scenarios, we used the mean food system GHGE for the US population based on (Heller et al., 2018).

To calculate the contribution to the UC CNI defined target of net zero Scope 1 and 2 GHGE by 2025 we divided the scenarios’ reduction in MtCO$_2$e yr$^{-1}$ by the amount to be eliminated or offset (129,233 MtCO$_2$e yr$^{-1}$) as of 2018 (UC CNI, 2018) (column 5, Tables S2, S8). To calculate the contribution to the amount of offsets needed to achieve net zero Scope 1 and 2 GHGE in 2025, we divided the scenarios’ reduction in MtCO$_2$e yr$^{-1}$ by the amount needing to be offset (477,117 MtCO$_2$e yr$^{-1}$) as of 2018 (UC CNI, 2018) (column 6, Tables S2, S8).
4. Results

4.1. The potential of scenarios based on US food system changes to reduce UC GHGE

We found an average potential reduction for the scenarios of 623 kg CO$_2$e capita$^{-1}$ yr$^{-1}$, and of 61,606 MtCO$_2$e yr$^{-1}$ for UC on-campus meals (Figure 1, cols. 2–3 Table S2). This is equal to an average 29% of total 2018 UC Scope 3 food system emissions, 6% of 2018 UC Scope 1 and 2 emissions, and 13% of the offsets needed in 2025 (cols. 4–6 Table S2).

4.2. The potential of scenarios based on UC campus food system changes to reduce UC GHGEs

The UC scenarios produced a wide range of reductions in kg CO$_2$e cap$^{-1}$ yr$^{-1}$, from 7 for scenario UC2 (blended burgers) to 309 for scenarios UC1 (academic course) and UC4 (tray-less dining) (col. 2 Table S8). If adopted across the UC population, they would reduce UC GHGE from between 1,500 and 46,800 MtCO$_2$e yr$^{-1}$ (col. 3 Table S8), equal to 1–21% of total 2018 UC Scope 3 food system emissions, 6% of 2018 UC Scope 1 and 2 emissions, and 13% of the offsets needed in 2025 (cols. 4–6 Table S8).

The combined potential of multiple food system changes was much greater. To estimate this, we created scenario UC9, by combining the effects of the physical food environment scenarios (UC3, UC4, UC6-8) whose modes of action do not overlap. UC9 shows a potential reduction of 468 kg CO$_2$e cap$^{-1}$ yr$^{-1}$, or 73,376 MtCO$_2$e yr$^{-1}$ for on-campus meals for the UC population, equal to 34% of total 2018 UC Scope 3 food emissions, 7% of 2018 UC Scope 1 and 2 emissions, and 15% of offsets needed by 2025 (Figure 2a, scenario UC9 Table S8).

For scenario UC10 we replaced the reduced beef scenarios (UC3 and UC4) in scenario UC9 with the UCLA course (scenario UC1), because the reduced GHGE of UC1 was almost entirely due to students’ decrease in...
reported beef consumption. UC10 has a potential reduction of 714 kg CO$_2$e capita$^{-1}$ yr$^{-1}$, or 90,697 MtCO$_2$e yr$^{-1}$ for on-campus meals for the campus population, which translates into 42% of total 2018 UC Scope 3 food emissions, 8% of 2018 UC Scope 1 and 2 emissions, and 19% of offsets needed by 2025 (Figure 2b, scenario 10 Table S8).

5. Discussion

5.1. The necessity of including food and other Scope 3 emissions in HEI climate policy

Results of our US and UC scenarios show that if food systems were included in UC climate policy, changes like those in our scenarios could reduce UC food systems emissions by up to 42–55%, equivalent to 8–9% of CNI
defined Scope 1 & 2 GHGE in 2018. If this policy change is not made before 2025, then UC food system changes could contribute up to 19–22% to the offsets needed to reach CNI goals for 2025. The effect of food system changes in terms of UC Scope 1 and 2 (energy) GHGE is smaller than would be expected based on average cap$^{-1}$ fossil fuel combustion CO$_2$e emissions for the US. This is likely largely because UC Scope 1 and 2 emissions cap$^{-1}$ of the UC population, weighted for the amount of time spent on campus, is several times higher than the US average cap$^{-1}$ fossil fuel emissions (section SI 4, Table S15).

Including food system changes would of course reduce total UC GHGE, so that there would be fewer emissions to mitigate when Scope 3 is eventually included in climate policy, which is the long term plan. This is a major advantage over the current practice of purchasing offsets from off campus, because they will not contribute to reduced Scope 3 GHGE at the time when they are eventually included.

According to the Greenhouse Gas Protocol organization, whose guidelines for GHGE accounting are widely used by HEIs, including the CNI, Scope 3 GHGE, which include food system emissions, can be the ‘largest source of emissions’ and the most significant opportunity to reduce them (GHGP, 2011, p. 5). For example, Cambridge University (UK) estimated that of its total 2012–13 emissions, Scope 3 emissions were 70%, of which business and commuter travel comprised only 14% (AECOM Limited, 2014), and Barnard College (US) estimated of its total emissions Scope 3 emissions were 68%, of which 14% was from food production and distribution (but not including food waste disposal) (GIES, 2016).

Food systems GHGE in the US account for 13.6% of fossil fuel CO$_2$ emissions (Canning et al., 2017), but they also emit a large proportion of both methane and nitrous oxide, which have relatively short atmospheric lifetimes but global warming potentials (GWPs) much greater than that of CO$_2$ (Myhre et al., 2013, p. 714). Therefore, if their emissions can be stabilized, their additional warming effect will go to zero, while the warming effect of CO$_2$ will continue even if emission rates are stabilized. In the US in 2016, agriculture accounted for 80% of nitrous oxide emissions, mostly from soil, and 32% of methane emissions, 94% of that from enteric fermentation of ruminants, and manure management (calculated using data in EPA, 2018). Because of methane’s short lifetime and high 20-year GWP (86 times that of CO$_2$), reducing its rate of emissions is especially important for achieving climate change mitigation over the shorter term, and reduced animal source food consumption will be key (Balcombe et al., 2018; Godfray et al., 2018). Beef is by far the most emissions intensive food, and just substituting beans for beef in the 2012 US diet on either an energy or protein mass basis would reduce annual emissions by 334 MMtCO$_2$e yr$^{-1}$ (Harwatt et al., 2017), about 6% of US 2012 net GHGE (EPA, 2015).

Our US scenarios, and several of our UC scenarios, illustrate the strong contribution to reducing GHGE of reducing animal food, especially beef. For example, per gram of protein, ruminant meat produces over 250 times as much CO$_2$e as legumes (Tilman & Clark, 2014). A US Department of Agriculture recommended vegan diet would reduce GHGE by more than 1,080 kg CO$_2$e cap$^{-1}$ yr$^{-1}$ compared with the SAD (scenario US3). Just replacing the beef in the SAD with plant food with equivalent nutrients would reduce GHGE by more than 860 kg CO$_2$e cap$^{-1}$ yr$^{-1}$ (scenario US7).

HEI’s are adding more plant-based foods on campus, in part to reduce GHGE (Middleton & Littler, 2019). The World Resource Institute has developed a Cool Food Pledge that a number of HEIs have signed, including UC’s five medical centres (not included in this study). The Pledge commits HEIs to reducing food GHGE by 25% by 2030 relative to 2015, focused on replacing animal source food protein with plant protein (CFP, 2019). In the most recent survey of the US Association for the Advancement of Sustainability in Higher Education members, 83% of the 397 reporting indicated having a ‘vegan dining program that makes diverse, complete-protein vegan options available to every member of the campus’ (based on data in AASHE, 2020). Universities are even beginning to remove ruminant meat from campus as part of climate policy, e.g. the University of Cambridge and Goldsmiths, University of London, in the UK, and the University of Coimbra, in Portugal.

Yet Scope 3 emissions are still omitted from most higher education policies in part due to the difficulty of documenting and measuring them. Most Association for the Advancement of Sustainability in Higher Education members do not estimate Scope 3 GHGE, or only the employee commuting and air travel portion (AASHE, 2019; Sinha et al., 2010). The Climate Leadership Network member HEIs are only required to report Scope 3 emissions from ‘commuting and from air travel paid for by or through the institution’ (SN CLN, 2020b). Among the many panels and sessions in the agenda for the 2020 Higher Education Climate Leadership Summit (co-sponsored by Second Nature) the only one including food was by a venture capital fund director (SN, 2020b).
5.2. Other benefits of including food system change in climate policy

Our food system change scenarios not only reduce GHGE, but could provide many health, environmental and social benefits that can contribute to reducing the net costs of comprehensive climate change mitigation, and to motivating institutional policy change and individual behaviour change.

Compared with the current CNI strategies for reducing Scopes 1 and 2 GHGE, reducing food system GHGE would not require new technology or infrastructure, and would be much less expensive per unit CO$_2$e reduced (next section). In turn, UC food policies’ emphasis on increasing health, sustainability and social equity would be served by explicitly addressing climate change. In addition, slowing climate change would reduce air pollution, flooding, wild fires, and extreme temperatures, and their negative effects on food production in California (Bedsworth et al., 2018) and worldwide (IPCC, 2018).

Many lower GHGE intensive foods such as fruits, vegetables, and whole grains and legumes, are healthier than foods with higher GHGE, especially red and processed meat and dairy (Tilman & Clark, 2014), which account for the majority of US food system GHGE. Thus, increasing healthy foods and decreasing unhealthy foods could contribute to reducing NCDs (Springmann et al., 2016), with additional climate co-benefits via reducing GHGE in the health care system (Eckelman & Sherman, 2016; Hallström et al., 2017).

However, these climate and health goals need to be explicitly linked in policy, because actual diets may not achieve this (Rosi et al., 2017). Diets recommended as being equally nutritious can have very different climate impacts, e.g. the Mediterranean, vegetarian and vegan diets in the Dietary Guidelines for Americans (Blackstone et al., 2018). Sugar has low GHGE, but makes a large contribution to disease risk (Payne et al., 2016). In scenario UC7 (replacing sugar sweetened beverages with tap water) (Table S13), direct GHGE emission reductions are relatively small, but the health benefits (Epel et al., 2019) would reduce health care costs (Huang et al., 2019) and their GHGE (Eckelman & Sherman, 2016).

Another co-benefit of healthier diets is increasing social equity, because minority populations in the US are disproportionately affected by obesity (Hales et al., 2017) and NCDs, e.g. diabetes (Cheng et al., 2019). Low income and low food security are also strongly related to risk of diet-related and other NCDs (Gregory & Coleman-Jensen, 2017). These higher risk populations have made up an increasing proportion of US HEI students over the last 20 years (Espinosa et al., 2019), including the UC (SI 1).

5.3. Financial costs and benefits of food system change as part of climate policy

Many food system changes that would reduce GHGE could also reduce UC costs because many lower GHGE intensity and healthier foods are also less expensive. If all UC students replaced 1 serving wk$^{-1}$ of beef with beans (scenario UC4, Table S8), net savings would be >$9 million yr$^{-1}$. Our US scenarios 2–7, 9, and UC scenarios 1–5 reduced beef consumption. Over time, healthier diets will reduce the prevalence of NCDs and therefore the cost of health care. Conservative estimates of US health care cost savings due to healthier alternative diets (Table S2, scenarios US4-6) resulted in savings of $77–93 billion (75% from diabetes), equal to 35–42% of the total costs for treating the diseases affected (Hallström et al., 2017). If the UC population adopted the HAD-3 diet (including no red or processed meat) (Hallström et al., 2017) savings could be $10 million yr$^{-1}$ from on-campus meals once these diets had been established for some time.

Healthier diets would also decrease UC costs for health insurance and lost employee productivity, a potential recognized by the UC Office of the President’s recent sponsorship of a system-wide Healthy Beverage Initiative to increase tap water consumption and decrease sugar sweetened beverage consumption, and a Diabetes Prevention Program. In addition, because food systems emissions comprise a disproportionately higher amount of methane and nitrous oxide, the social cost savings would be disproportionately greater than reduction in energy GHGE, which are mostly CO$_2$ (IAWG, 2016; Shindell et al., 2017).

Recognition of the financial co-benefits of food system changes can help to counter a major institutional obstacle to campus food system changes that are healthier and more climate-friendly – the conflict of these changes with the revenue generating role of campus food (e.g. BFI, 2016, p. 5). The for-profit food industry controls US and global food environments including those of UC and most other US HEIs, resulting in food environments dominated by ultra-processed and relatively unhealthy foods. The current socioeconomic system...
incentivizes businesses to sell food that is profitable, but bad for the climate, health and society, and allows them to block changes to the status quo (Swinburn et al., 2019, p. 32).

Most campuses support fast food franchises and have multi-year soda pouring rights contracts which promote foods that fuel poor health and food insecurity (Horacek et al., 2013; Poulos & Pasch, 2015). Many of these foods, especially ruminant meat and dairy, are also GHGE intensive (Tilman & Clark, 2014). However, the conflict between these campus food environments and the mission of HEIs to promote the well-being of their students, staff and faculty are rarely discussed or even publicly acknowledged. Yet our experience is that many UC students, faculty, and food system staff are eager to implement changes to increase campus food health and sustainability, including to reduce GHGE.

Thus, in order to integrate HEI climate and food policies, we need to discuss the often conflicting roles of food for profit and food for climate change mitigation, human health, and equity. Students are leading the way, e.g. advocating not renewing UC Berkeley’s pouring rights contract with PepsiCo (Solis & Melgoza, 2019). It is likely that public HEIs in the US will have to relinquish the private sector business model that has increasingly dominated them (Newfield, 2016) in order to prioritize the broader public good and move toward climate and environment friendly, healthy diets that support social equity. This has happened in limited ways, as shown by the move to local food sourcing at UCSB (Cleveland et al., 2014), and the sugar sweetened beverage sales ban at UCSF (scenario UC7, SI 3.5). The integration of climate and food policy offers HEIs an opportunity to engage with the national and global environmental sustainability, public health and social justice communities in addressing the need for profound changes in values and structure needed to truly prioritize public good over private profit. This would also help public HEIs, e.g. in the US, to restore flagging public approval and support (Newfield, 2016).

### 5.4. Options for implementing HEI food system changes with climate co-benefits

Individual food choices are influenced by a wide range of interacting variables including biological predisposition, social and physiological conditioning, personal and interpersonal factors, and food environments (Contenko, 2016; Leng et al., 2017). HEIs have the potential to alter physical, social, economic and informational food environments to support food choices that contribute to both climate and food policies, while they also have the purchasing power to affect the upstream food system to respond to those choices (Thottathil, 2019).

HEIs are also in a unique position to influence the motivations for food choice among their staff, faculty and especially students, given their educational mission of increasing knowledge and critical thinking skills, for example via classroom and interpersonal education and point of purchase signage. This is recognized in the ultimate goal of UC’s Healthy Campus Network ‘to influence social norms so that culture, environment and living well become integral to academic success’ (UC GFI, 2017).

The UCLA course scenario (UC1) was the only one based on informational and educational food environments (Table S8). The food course presented information about the environmental impacts of foods, including GHGE intensity, and had a large effect on reducing GHGE of students’ self-reported food intakes from before to after the course, compared with analogous data for students in a control course (Jay et al., 2019). Students reported much lower beef intake after the food course, which accounted for almost all of their emissions reductions. This effect was greater than that of the scenarios that explicitly reduced beef consumption (UC2-UC5) because the UCLA course affected all campus meals, not just the limited number of meals in the beef reduction scenarios.

These results may be due to the effect of the course on students’ perceptions that the benefits of food choice change outweigh the costs, and on their confidence that their actions will make a difference (Orji et al., 2012). In contrast, food labels with health or climate impact information that do not have a larger supporting educational environment may not be as effective as ‘indulgent’ labels appealing to taste, as found in a US HEI study (Turnwald et al., 2017).

Seven of the food system changes we used in our UC scenarios (section 4.2) were physical food environment change and do not directly require conscious behaviour change. However, adding supportive information can enhance the effect of physical food environment changes (Steg, 2018), while lack of lack of information can undermine physical food environment changes. For example, when dining halls at several UC campuses...
increased the proportion of plant-based foods without adequate information, this resulted in lower student traffic.

Many of the physical food environment changes in our UC scenarios have been accompanied by changes in information and education. For example, UCLA’s beeless Thursdays (UC3, UC5) have been promoted online and by large informational displays in the dining halls. Education following the sugar sweetened beverage sales ban at UCSF amplified the effect of the ban. Among employees previously drinking the most sugar sweetened beverages, those randomly assigned to a treatment group received a brief motivational intervention including a graphic description of amount of sugar ingested daily, help with setting goals, and educational materials (Epel et al., 2019). The treatment group reduced their sugar sweetened beverage intake three times more than the randomly assigned control group.

While data on long-term effects of educational interventions at HEIs are scarce (Deliens et al., 2016), a ten-lesson online curriculum focusing on healthful eating and physical activity, stressing nondieting principles such as size acceptance and eating competence was effective in increasing university students’ fruit and vegetable intake and physical activity, after the intervention and at a 15-month follow up (Greene et al., 2012). A study in Finland found that the barriers to making climate friendly food choices that students perceived as most important, differed from those most associated with their self-reported food choices (Mäkiniemi & Vainio, 2014), suggesting that helping students see the connection between their values and their food choices can support behaviour change.

The promotion of behavioural spillovers and educational outreach to surrounding communities and beyond is consistent with the mission of the UC CNI and Global Food Initiative (and of most HEIs) of sharing knowledge and experience with each other and ‘surrounding communities, and public and private sector partners’ thus ‘serving as models for climate solutions’ (SN UC3, 2020). Changes in information, education and social food environments will be needed in addition to changes in physical environments to increase the probability of food system changes on campus moving off campus. For example, a Danish study found that when people reported successfully increasing intake of healthy and decreasing intake of unhealthy foods, this had a spillover effect on the intention to make these food choices in the future (Bech-Larsen & Kazbare, 2014). A study of university students in the UK found their food choices were influenced by their perception of the eating habits of their social media peers (Hawkins et al., 2020).

5.5. Limitations of our study

Our results are conservative because the life cycle assessment studies we used in scenarios based on US food system changes do not capture all food system GHGE, for example, for land use change, especially important for animal products (Eshel et al., 2014). When land clearing is included, the food system GHGE are much higher and the proportional effect of reducing animal source foods is much greater, especially for beef. For example, when soybean (mostly for animal feed) is produced in the warm tropics by clearing rainforest, average annual emissions of CO₂e kg⁻¹ of soybean over the 20 years for soil carbon pools to reach equilibrium are more than 30 times greater than when there is no conversion of land (Castanheira & Freire, 2013). Including CO₂e released by conversion of forests and woody savannahs to cropland and especially to grazing land, amortized over 20 years into the future, would result in the average U.S. diet producing almost 17 MtCO₂e capita⁻¹ yr⁻¹, half from beef, which is about the same as total energy CO₂e capita⁻¹ yr⁻¹ (Searchinger et al., 2018, p. 15). More comprehensive life cycle assessment accounting would increase the impact attributable to the food system and to the mitigating effects of the food system changes we analyzed.

Our scenarios also underestimate potential GHGE reductions as a result of food system change because some of the life cycle assessments included in our estimates used GWPs for methane that are outdated and lower than the current GWP, and methane is an important food system GHG, especially for ruminant meat and dairy, and food waste in landfills.

Variables for which we did not have data and that we did not consider in the scenarios, that could potentially take back some of the GHGE saved include: (1) leakage between on – and off-campus food choices, i.e. lower GHGE food choices on campus offset by an increase in higher GHGE food choices off campus, (2) leakage between on-campus food locations/times, e.g. lower GHGE food choices in one dining hall one day a week
offset by an increase in higher GHGE food choices in other dining halls on the same day, or in the same dining hall on other days, and (3) indirect rebound, i.e. using monetary savings from substitution of less expensive lower GHGE foods to purchase other goods or services that increase GHGE, e.g. spending savings from substituting less expensive plant foods for more expensive animal source foods on air travel (Moran et al., 2018).

6. Conclusion

Our case study of the UC is one of the first quantitative studies of the potential for integrating HEI climate and food policies. As our scenario results illustrate, food system GHGE are an important component of UC emissions, and the kinds of food system changes in our scenarios can effectively mitigate them. Scope 3 emissions likely comprise the majority of HEI emissions, and GHGE reductions via diet change and food waste reduction can make important contributions to meeting the critical need for GHGE reductions in the near term (IPCC, 2018). This should be done as soon as possible to address the climate emergency (Lenton et al., 2019).

Food system changes on UC campuses could achieve relatively rapid GHGE reductions because, compared to the three-pronged approach of the CNI to reduce Scope 1 and 2 emissions, food system changes have limited technology and infrastructure needs, and lower costs. Research suggests that combining changes in the physical food environment with supportive information and curriculum content can be very effective in promoting food system change. Many small-scale successful interventions already exist on UC campuses that could be thoroughly documented, improved, and scaled up across the system. UC students, staff and faculty are working on and have already implemented many food system changes with potential climate co-benefits which we did not include in our scenarios because data were not available (section SI 5).

There is an urgent need to support changes like these at HEIs, as well as new food-climate initiatives, with rigorous analysis of their effects on GHGE, the environment, health, and equity, in order to provide feedback for adjusting their implementation to optimize benefits, incentivize their expansion, and provide high quality data on their potential for contributing to climate change mitigation goals.

Including food system GHGE in HEI climate change mitigation policies and highlighting the many health, environmental and social co-benefits of reducing them could help to secure broad support for climate change mitigation policies, which is currently lacking in the UC community (CNFMTF, 2017, p. iii). The justifications for the CNI in terms of UC’s core mission apply equally to diet change as part of an integrated climate-food-equity policy (Forman et al., 2016).

Based on our results and analysis, developing an integrated HEI climate-food policy should be a participatory process beginning with a substantive institutional commitment to prioritizing the campus and public good over financial profit. This commitment would comprise explicit recognition of the potential for food system change to mitigate GHGE, and improve human health, environmental sustainability and social equity. Operationalizing the policy would include: establishing (1) a baseline for each campus’s food GHGE; (2) protocols for data collection; (3) a dynamic database of food climate impact factors for evaluating the climate effects of diet and food system change, including median or mean CO₂e kg⁻¹ of food with options for different scenarios, e.g. for transport mode and distance, production system, and processing; (4) appropriate GWP standards, e.g. the 100-year GWP of 28 for methane currently used by CNI underestimates methane’s short term impact on climate change, and therefore would underestimate the food system mitigation potential, since the food system, especially ruminant animal source foods, emits a disproportionate amount of methane (Balcombe et al., 2018; Godfray et al., 2018).

In 2019 UC President Janet Napolitano and all 10 UC campus chancellors (McMillan, 2019) signed a Climate Emergency Letter (EAUC, 2019) that recognizes ‘the need for a drastic societal shift to combat the growing threat of climate change’, and commits signatories to deliver relevant ‘education across curriculum, campus and community outreach programmes’. Hundreds of other HEIs from around the world are also ‘represented’ by the letter. Current research shows that food system change is an essential part of that dramatic societal shift, and can provide many important health and equity co-benefits. Our results show that UC and other HEIs could make rapid progression on (and off) campus by including bold food system changes in their climate policies.
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