Abstract

. In this study we estimated the environmental burden of eating away from home based on emission factors of food recipes consumed in different regions and countries within the United Kingdom. Food based emissions were expressed in kg CO_2 equivalent per capita per week and were calculated based on food consumption data between the years 2001 and 2018. Time series analysis was used to estimate emissions for the years 2019 and 2020 for all study areas. These results were used to estimate the endpoint impacts on human health as well as terrestrial and aquatic species during the study period. Finally, an estimate of the emissions for 2020 was also carried out based on available market data for the first 11 months of the year. This was subsequently compared with the forecasts calculated earlier to observe the impacts of Covid-19 led lockdowns on eating out and hence the emissions. By taking a subnational approach, we aimed to highlight the importance of appreciating similarities and differences among these regions and policy implications thereof. To the best knowledge of the authors this is the first and only study focusing on regional food-based emissions from eating out in the United Kingdom.

Key Words

Food; Eating out; Impact assessment; Emissions; Covid-19.

1. Introduction

The UK government is a signatory to the Paris Climate agreement and mandates regular carbon management under its Climate Change Act that aim to reduce Green House Gas (GHG) emissions to net zero by 2050 (Höhne et al., 2017; Walker et al., 2019). In order to achieve this there have been several initiatives by the government to reduce resource extraction and environmental pollution. Being a services-based economy, the UK can achieve some of its climatic targets by reducing the environmental footprint of non-essential services such as restaurants, pubs, bars, etc., (Hinnells et al., 2008). Evidence supporting this reasoning has also been provided by studies in other developed countries such as Japan where "higher carbon-footprint households" are distinguished from other households not by excessive meat consumption but elevated consumption in restaurants (Kanemoto et al., 2019). Thus, it is important to understand the existing level of GHG emissions from the eating out industry in the UK. Here we follow the definition by UK Family Food Survey according to which 'eating out' refers to all food and drinks that are never brought to the households (Office of National Statistics, 2014). The Covid-19 pandemic has influenced people's behavior of food consumption as many restaurants, bars and pubs have been closed to enforce social distancing. Covid-19 and food system sustainability are inter-related topics as it has been suggested that the origin of Covid can been traced back to food safety issues (Maxmen, 2021). Hence a sustainable and resilient food system is important to mitigate similar future disasters. Apart from food safety, a sustainable food system should also promote emission reduction and pollution prevention. This is important as food systems are responsible for a third of global anthropogenic GHG emissions (Crippa et al., 2021). Thus, GHG emission reduction from food systems is important to counter climate change and increase social resilience. Transforming the food system, to achieve Sustainable Development Goals (SDGs) is often challenging as the system consist of different complex components. For instance, some recent studies show negative environmental impacts from the food system as a consequence of the Covid-19 induced crisis. Issues include an increase in food and packaging waste (Pappalardo et al., 2020) as well as an increase in grocery buying which, in turn, should result in greater carbon emissions (Public Health England, 2021). However, there has also been a reduction in eating out behaviour which has the potential to offset such food-based emissions. Hence, any evaluation of changes in emissions from the whole food system perspective should look at both sides of the equation to measure net change (Muhammad et al., 2020a). As actual data for grocery buying in the UK regions for the years 2019 and 2020 wasn't available so this study focused on estimating changes in emissions from eating out only for which immediate market data was available from (CGA, 2020). The intended objectives include an evaluation of historical emissions for the period between the years 2001 and 2018 followed by forecasting for the years 2019 and 2020. This will allow a comparison between forecasted emissions for the year 2020 with those based on information from (CGA, 2020) for understanding the impact of the disruption caused by the Covid-19 pandemic. Here we aim to take a regional perspective to explore and highlight differences, if any, across the study areas. A regional perspective is eventually important for policymaking as a focus on local food systems can aid in emission reduction (Vicente-Vicente et al., 2021). It is important to note that this study will account for only food-based emissions while the actual reduction from eating out could also include contributions from changes in ancillary activities such as lighting, cooking, washing, transportation, etc. A future comprehensive study can look at the food-energy-waste nexus to holistically evaluate the combined effect of these changes (Subramanian et al., 2021).

Previous efforts to account for food-based emissions in the UK have included different Life Cycle Assessment (LCA) studies (Audsley et al., 2010). Many of these studies account for a particular food type such as meat or fish (Scarborough et al., 2014). Similarly, there have also been some studies to consider the impact of socio-economic factors while accounting for such emissions (Kehlbacher et al., 2016). However, few studies have taken a spatio-temporal perspective by accounting for food-based emissions from different regions and countries in the

UK over time. Recognition of local differences is important as consumers in the UK have varying levels of eating out. As such, not all regions or countries in the UK have similar food consumption behaviors with variations stemming from different levels of income, demographics and urbanization (Fitt et al., 2010). This in turn leads to changes in types and quantities of food consumed away from home. Hence it would be interesting to explore how the UK regions and countries stack up in comparison with each other in terms of emissions from eating out. To the best of our knowledge, this represents (a) the first regional study on emissions from eating out in the UK and (b) the first study to account for the impact of Covid-based lockdowns on food-based emissions. As such this is a timely and significant contribution to the existing literature that can be used for benchmarking and comparison purposes in future studies. The findings presented in this paper can also act as a baseline for comparison with projections based on alternative scenarios. Finally, policymakers can use this study to understand if different regions require customized solutions for mitigation of food-based emissions. This can be facilitated by detailed studies focusing on particular regions or countries within the United Kingdom.

2. Methods

2.1 Goal and scope definition

In this paper we will employ environmental accounting of different food recipes in the UK that are consumed away from home by estimating GHG emissions. The system boundary includes the food supply chain from production to the retail distribution centre with density adjustments made for food imports and to account for differences in food production and consumption densities (Scarborough et al., 2014). GHG emissions factors were expressed in the units of kg CO_2-eq per 100 grams of food consumed (i.e., kg of GHG weighted by global warming potential over a 100 year time frame, with carbon dioxide weighted as 1, methane weighted as 25 and nitrous oxide weighted as 298). The emission factors were multiplied with the food consumption data reported in the units of 100 grams per person per week to report the final results in the units of kg CO_2-eq per person per week. As eating out involves different food recipes, calculation of emission factors for such food types is quite challenging. Fortunately, a set of emission factors had already been calculated for a range of recipes consumed in the UK and was made available on request (Scarborough et al., 2014). These parameters themselves were based on an earlier study that reported GHG emissions for 94 food commodities consumed in the UK (Audsley et al., 2010). Still, emission factors for some of the recipes (e.g., sandwiches) were unavailable and were calculated specifically for this study. Some ambiguous food categories (e.g., 'other'. 'unspecified', etc.,) were not considered in the analysis. Similarly, some other categories with zero consumption were also ignored. All calculations have been provided in the supplementary excel file. Results were also used to determine the endpoint impacts on human health as well as terrestrial and freshwater ecosystems using appropriate conversion factors following the ReCiPe method (Huijbregts et al., 2016). All calculations have been provided in the Supplementary data file.

2.2 Data sources

Inventory data for consumption statistics was obtained from secondary resources that reported food consumption and expenditure for different UK regions and countries over time. Most of this data was collected using latest available statistics from UK's Family Food datasets that report data for the years 2001 through to 2018 (DEFRA, 2018). The figures in Family Food are sourced from The Living Costs and Food Survey run by the Office for National Statistics (Office of National Statistics, 2014). As noted above, these datasets report food and drinks that are consumed outside households. This data is collected each year using voluntary sample survey of private households using a list of 22 major food categories which are then further disaggregated into their respective sub-food types. All data is available in the units of grams or milli litres per person per week which was converted for this study into the units of 100 grams per person per week after using density adjustments and unit conversions based on literature review. The data has been presented in the supplementary excel file.

2.3 Estimation of environmental impacts

For the first part of the analysis, emissions were calculated for each year between 2001 and 2018 for all regions and countries in the UK. Subsequently, time series modelling was used in SPSS v. 26 to forecast the emissions for the years 2019 and 2020 assuming a Business As Usual (BAU) scenario. Emissions for all UK regions were calculated separately. Time series forecasting involved estimation of Auto-correlation Functions (ACFs) and Partial Auto-correlation Functions (PACF) for all regions and countries in the UK to understand model parameters. The correlograms are provided in the supplementary file. For the sake of greater precision, expert modeler option was chosen in SPSS which automatically selects the best model for each time series. The results also indicated greater model fit (R^2) using the expert modeler in comparison with other options. Midpoint impacts were measured in kg CO_2 equivalent and were converted into endpoint impacts on human health as well as terrestrial and aquatic species using the ReCiPe method.

Secondly, eating out market footfall data was obtained from CGA as a proxy for eating out behavior in different regions and countries in the UK for the year 2020 (CGA, 2020). These statistics pertained to YoY change in market activity after the lockdown in UK in 2020 and included figures for bars, restaurants hotels, etc., This data reported UK regional and country-wise variations in reopening in the eating out industry between the months of August and July. In order to holistically forecast the change in eating out due to impacts of Covid-19, the year was divided into three parts namely pre-lockdown (January to March), lockdown (March to July) and post-lockdown (July to August) periods. BAU forecast discussed above was used for the pre-lockdown period, market activity and hence emissions were down 100% during the lockdown period as affirmed by data from (OpenTable, 2020). Regional re-openings post-lockdown period were used to estimate change in emissions for the post-lockdown period. Data for England wasn't reported by CGA and was calculated based on the average of regional variations. Similarly, data for Northern Ireland was missing and was calculated as an average of the figures for England, Scotland and Wales based on suggestions for imputing missing values (Curley et al., 2019). The final figures for all countries and regions within the UK were subsequently used to estimate their respective total GHG emissions till the beginning of August i.e., for the first seven months of the year.

3. Results

3.1 Regional and country-wise estimations of GHG emissions

Figure 1 given below displays the results for GHG emissions of eating out activities from different English regions from the years 2001 to 2018. The figure displays the results in the form of a hierarchy where for each year the highest emissions are presented at the top. On average the greatest emissions were generated from the North East, York & Humber and North West regions, in descending order, during the study period. The least amount of emissions came from the South East, West Midlands and East regions, in ascending order. The greatest change in emissions during the studied period occurred in the North East region where the emissions reduced by 4.73 kg CO_2-eq per person per week between the years 2001 and 2017. The minimum change occurred in the South West region where the emissions reduced from a peak of 7.36 kg CO_2-eq per person per week in 2004 to 4.94 kg CO_2-eq per person per week in 2015.

It can be seen from Figure 1 that the emissions from all regions decreased till the year 2013 followed by a gradual uptick in some of the regions. This is because of a decreasing trend of eating out across most of the regions for the aforementioned period. These results point towards underlying differences between these regions related to eating out behavior. It can be seen that no single region maintains its position within the hierarchy across the study period. For instance, North East had the highest per capita food emissions per week for 8 years in the studied period. Most of the emissions from eating out came from products based on meat and alcoholic drinks which is consistent with findings in other studies in countries such as the Netherlands (Van de Kamp et al., 2018). For the years 2016 and 2017 the North East region had the lowest consumption of these food categories among its peers which was also reflected in emissions per capita as shown in Figure 1. Interestingly, the most consistent fall in emissions was exhibited by London and the South East regions where the emissions continued to decrease till they reached minimum values in the year 2018. Similarly, for the West Midlands region, the emissions in 2018 were at the same level as they were between the years 2012 and 2013. For all other regions the emissions from eating out in 2018 were more than they were a decade ago.

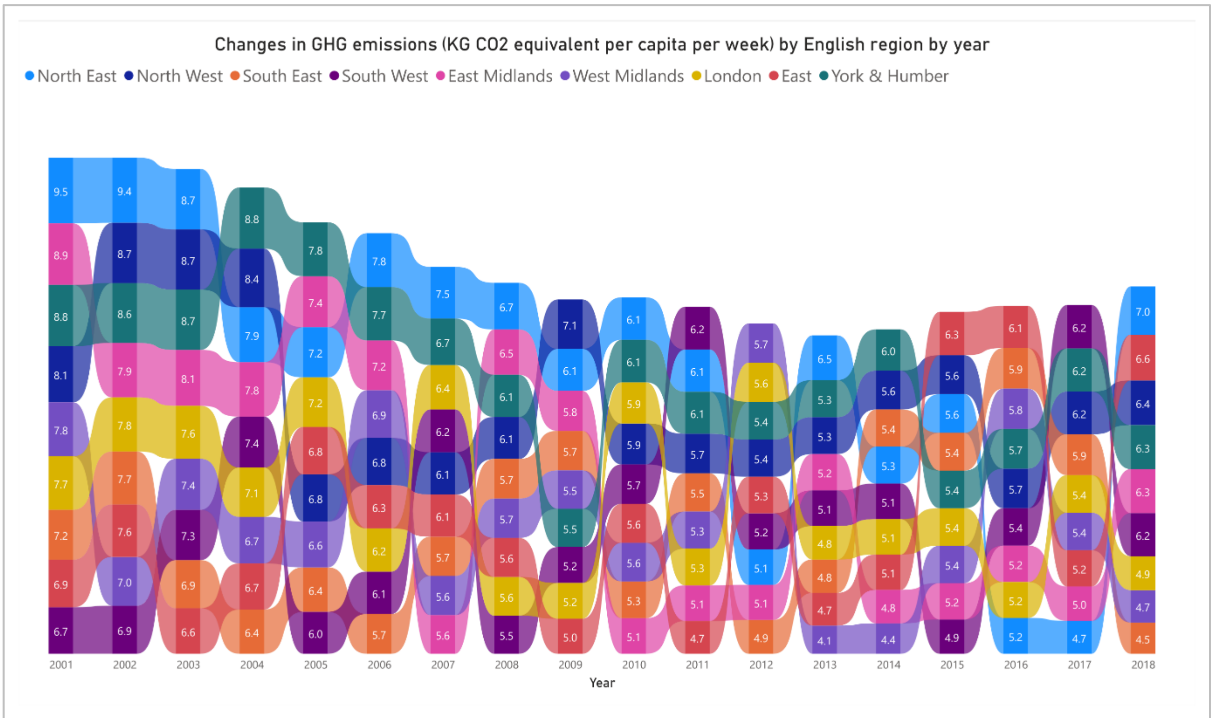

Figure 1: GHG emissions by English region by year.

Figure 2 shows the emissions for different countries that make up the United Kingdom including, England, Scotland, Wales and Northern Ireland. Figure 2 displays the emissions from different countries in the form of a hierarchy where for each year the country with the greatest GHG emissions is at the top. As such, it can be seen that in 2001 the highest GHG emissions originated in Wales and the least came from Northern Ireland. At the turn of the decade, in 2010, Northern Ireland had the greatest emissions and Scotland the lowest. According to the latest available figures, i.e., for the year 2018, England had the highest emissions and Wales the lowest. Thus within 2 decades, Wales has reduced its emissions to the greatest degree relative to the other three countries in the UK. On the other hand, Northern Ireland has moved in an opposite direction so that, in relative terms, it had the greatest GHG emissions for the longest duration between the years 2010 and 2018.

For the studied period, on average, the greatest emissions were generated from Wales followed by Northern Ireland, England and Scotland in that order. As discussed above, the greatest change in emissions during the studied period occurred in Wales where the emissions reduced by 4.56 kg CO_2-eq per person per week between the years 2002 and 2013. The minimum change occurred in the Northern Ireland where the emissions reduced from a peak of 7.17 kg CO_2-eq per person per week in 2001 to 5.11 kg CO_2-eq in 2013 per person per week. It can be seen from Figure 1 that the emissions from all countries decreased till the year 2013 followed by a gradual increase in all of them. For all countries the emissions from eating out in 2018 were more than what had been at-least 5 years ago. As explained above, the variations in emissions were driven by changes in consumption behaviour. The change in consumption itself could be based on demographic changes, food costs or other variables which can be investigated in full-length study as a corollary.

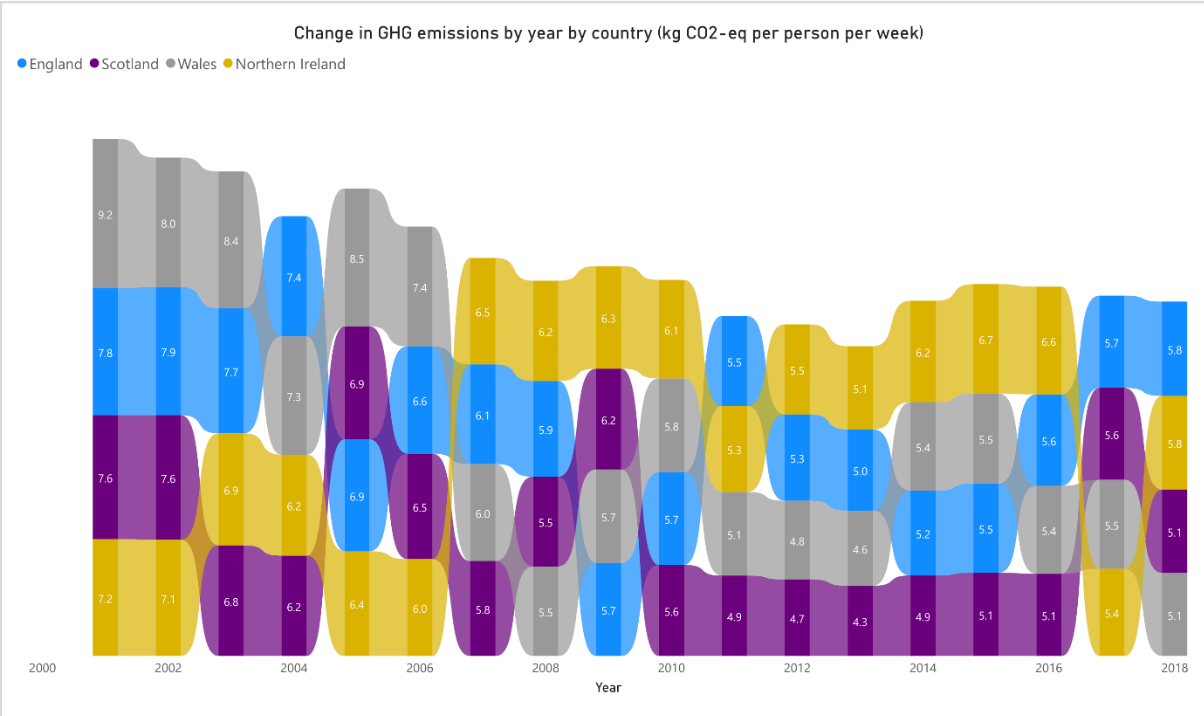

Figure 2: GHG emissions hierarchy by country by year in the United Kingdom.

3.2 GHG emission forecasts for the years 2019 and 2020

As explained above, GHG emissions for the years 2019 and 2020 were forecasted using the expert modelling function in SPSS. These emissions are based on a business as usual scenario. As such they represent the emissions from eating out in UK regions and countries based on the assumption that there had been no business disruption. As mentioned earlier, time series forecasting methods were used to estimate emissions after the year 2018. Time series for almost all regions and countries exhibited "stationarity", as indicated by the Augmented Dickey-Fuller test (Im et al., 2003). Hence, forecasting methodologies such as Auto Regressive Integrated Moving Average (ARIMA) and Holt were used in those cases. A detailed discussion of these methodologies and the theory behind them can be found here (Adhikari and Agrawal, 2013). Similar studies have used such methods in the past for forecasting, for instance, particulate matter in Chinese cities and CO2 emissions in the EU-28 countries (Waheed Bhutto et al., 2017; Zhang et al., 2017). The Engle-Grenger test highlighted co-integration among the time series of emissions in different countries as well as that for different regions. In the present case, annual emission data consisted of only 18 points for each location corresponding to the time period between 2001 and 2018. As such, co-integration tests such as the Johansen test or advanced forecasting methods forecasting methods such as the Vector Error Correction Model (VECM) were difficult to use. The low number of data points was because of the complexity involved in calculating the emissions for each location for the study period in the first place. Previous studies on similar topics have been published with an even lower number of data points. For instance, a study forecasting China's coal consumption by employing the ARIMA method used annual data for the period between the years 2000 and 2015 (Jiang et al., 2018). Similarly, another study forecasting (by ARIMA method) the consumption of gasoline in the transportation sector in Pakistan adopted data for 23 years between 1991 and 2014 (Waheed Bhutto et al., 2017).

Table I: Forecasts for GHG emissions from UK regions for the years 2019 and 2020. All units in kg CO2-eq per person per week.

Region/Country	**Model**	**GHG emissions (**kg CO2-eq per capita per week)					
		2019 forecast	**Lower confidence limit**	**Upper confidence limit**	**2020 forecast**	**Lower confidence limit**	**Upper confidence limit**
North East	Holt	5.65	4.16	7.14	5.87	4.28	7.46
North West	Simple	6.42	5.10	7.74	6.42	4.60	8.24
York & Humber	ARIMA (0,1,0)	6.20	5.10	7.30	6.06	4.50	7.61
East Midlands	Holt	6.02	4.84	7.21	6.41	5.03	7.79
West Midlands	ARIMA (0,1,0)	4.49	3.10	5.88	4.30	2.34	6.27
East	Simple	6.15	4.81	7.50	6.15	4.60	7.71
London	ARIMA (1,1,0)	4.92	4.01	5.84	4.66	3.64	5.67
South East	ARIMA (0,1,0)	4.34	3.27	5.42	4.18	2.67	5.70
South West	Simple	6.22	5.10	7.34	6.22	4.63	7.80
England	ARIMA (1,1,0)	5.88	5.48	6.27	5.94	5.17	6.71

Scotland	ARIMA (0,1,0)	4.97	3.84	6.11	4.83	3.22	6.44
Wales	ARIMA (0,1,0)	4.86	3.33	6.39	4.62	2.46	6.78
Northern Ireland	Simple	5.74	4.57	4.31	5.74	6.91	7.16

3.3 Endpoint impacts on human health and species

As mentioned above, the health impacts of GHG emissions can be calculated using DALYs. DALY represents the years of life lost and the number of years lived as a disabled person due to the impact of emissions, and it is based on an approach developed by the World Health Organization (WHO) (Reza et al., 2014). Similarly, the impacts on terrestrial and freshwater ecosystems can be measured based on species extinctions as measured in the units of species-years. These end-point impacts for all UK regions and countries for the years between 2001 and 2020 have been presented in Figures 3, 4 and 5 below. These are based on actual data for the years between 2001 and 2018 and forecasts for the years 2019 and 2020 as presented above. All results have been shown below using the 'hierarchist' perspective which is the default in most of the LCA studies (Weidema, 2015). In Figures 3 through 5, it can be seen that the trend lines for all regions are similar to those shown in Figure 1 as they are based on fixed conversion factors.

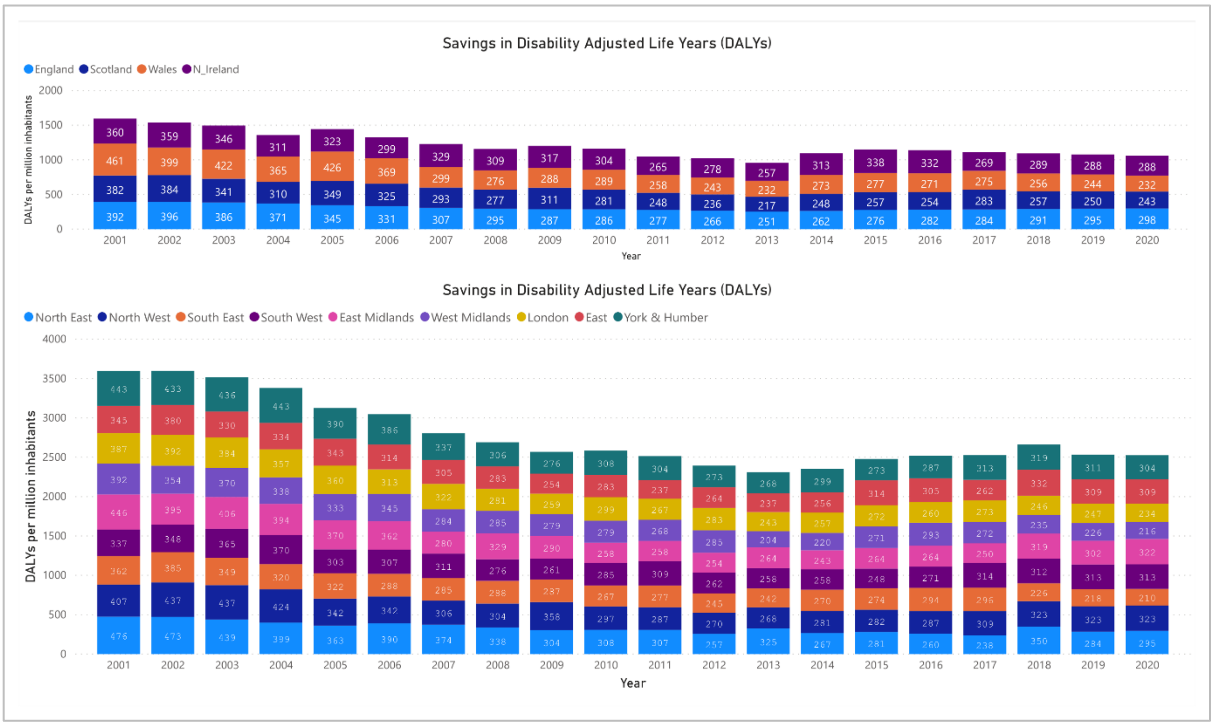

Figure 3: Health impacts of GHG emissions in DALYs per million people.

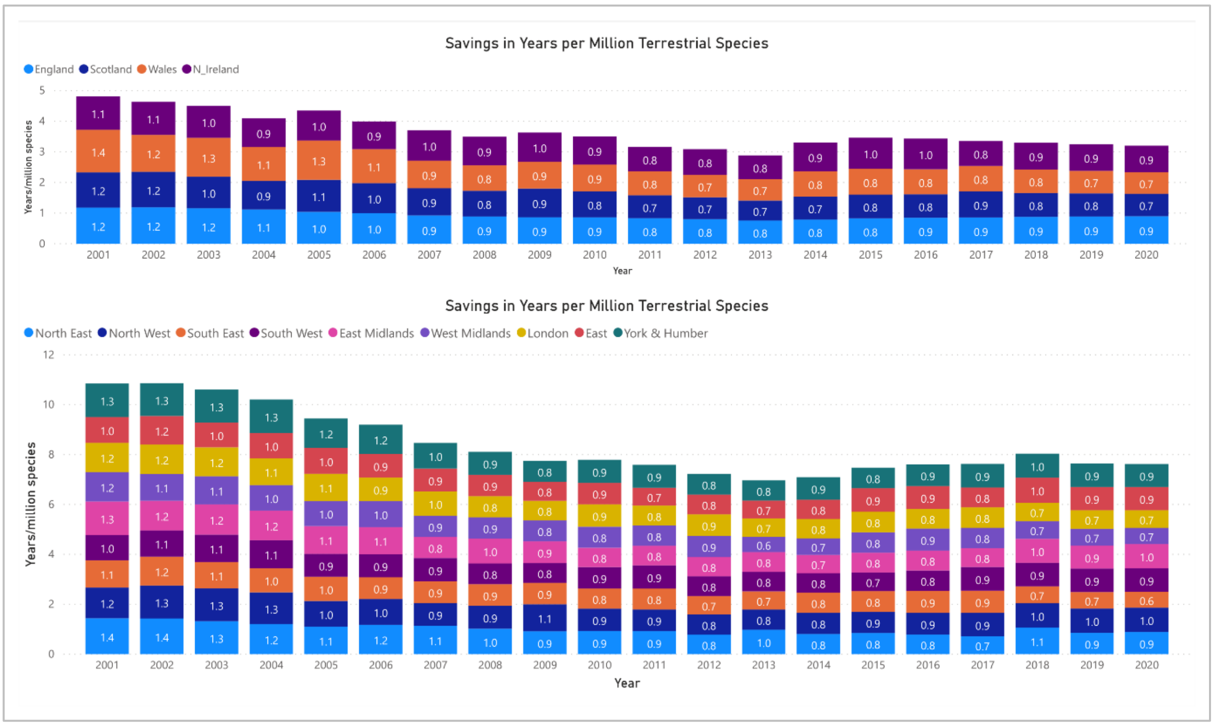

Figure 4: Impacts of GHG emissions in life-years per million terrestrial species.

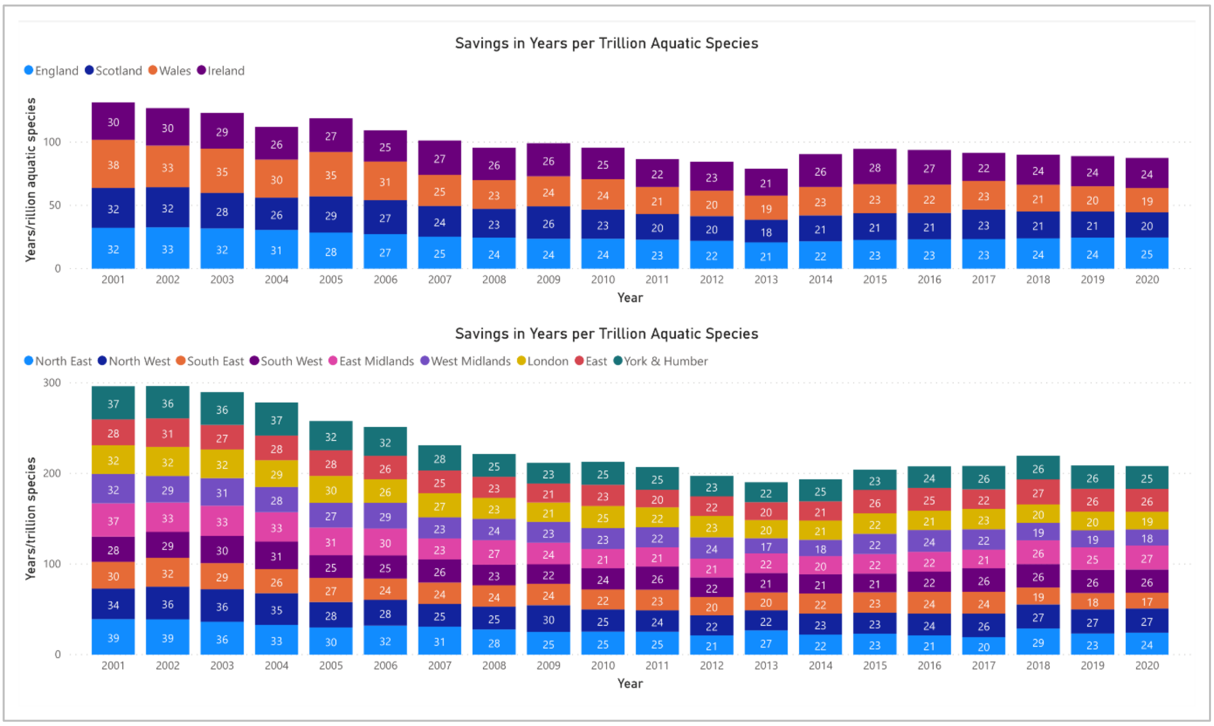

Figure 5: Impacts of GHG emissions in life-years per trillion aquatic species.

Figures 3, 4 and 5 given above have relevance for communicating the results to policymakers as well as scientific audience interested in health or ecological research. For instance, data analysed for this research also shows greater consumption of processed foods rich in sugar such as confectionery and desserts as compared to fruit & vegetable intake. This has a direct bearing on human health leading to issues such as obesity which affects roughly 64.3% of the UK population (Stevens et al., 2020). Evidence regarding health impacts of food choices is necessary to legislate and implement policymaking instruments such as subsidies, taxes, labels and display options at the retail level (Okrent and Alston, 2012). Similarly, a future "public money for public goods" scheme in UK can benefit from evidence regarding food system impacts on ecosystems such as terrestrial and aquatic species (Gosal et al., 2020).

3.4 Estimates of GHG emissions for the year 2020 based on market recovery data

To account for the impact of Covid-19 on easting out emissions during the year 2020, we approximated the change in eating out using a 3 pronged strategy where estimates of emissions from eating out (a) before March 2020 were considered to be the same as that forecasted in

Table I given above (b) during the lockdowns were considered to be zero and (c) during recovery phase after March 2020 were based on market recovery information regarding restaurants, pubs, bars and other eating out venues from CGA. This included data for all regions and countries in the UK except Northern Ireland. The data from CGA showed that, in UK overall, there were 115,108 venues open in March and monthly reports present change in the number of open venues after March 2020 for the different regions. It must be mentioned here that during 2020 there were two lockdowns in England i.e., between 23rd of March and 4th of July and from 5th of November to 2nd of December. Scotland and Wales followed the first lockdown during roughly the same dates as England. A 'firebreak' lockdown was also enforced in Wales from mid-October to mid-November. Due to lack of availability of relevant data, analysis for Northern Ireland was not carried out. Based on the available figures GHG emissions for 2020 for UK regions and countries are given below in comparison with the BAU scenario in Figure 6.

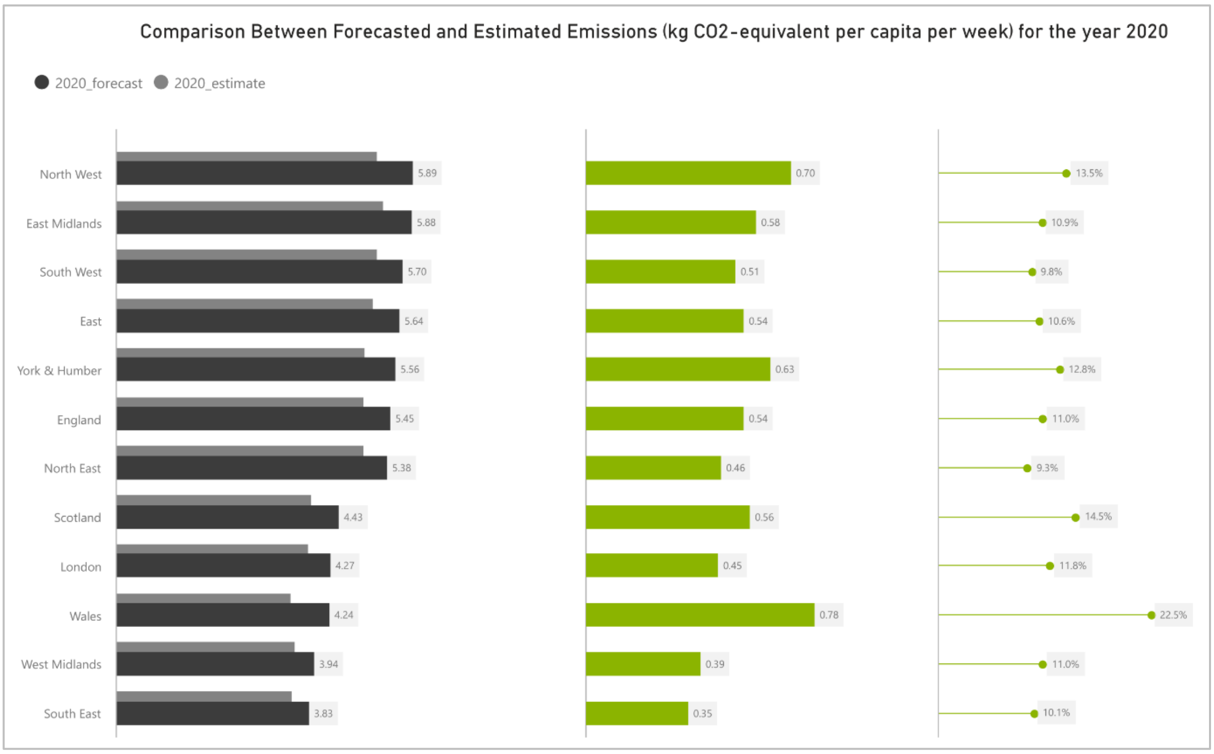

Figure 6: Comparison of GHG emissions for UK regions in the year 2020 according to Business As Usual (BAU) and actual scenarios as represented by 2020_forecast and 2020_estimate respectively.

Figure 6 also presents the results for GHG emissions for the countries of England, Scotland, and Wales. Figure legends highlight bars representing findings for the BAU scenario as well as those for the Covid-19 scenario.

4. Discussion

Balancing the trade-offs between food system resilience and sustainability are important concerns across national and regional boundaries around the world. In the UK some of the most important challenges to food security and sustainability for agri-food supply chains include Brexit, climate change and Covid-19. There are clear incentives for improving the resilience of the food system by sourcing a greater proportion of food locally. However, this may have negative repercussions for the sustainability of the ecosystem services and Natural Capital in the country. As such policymakers should ideally design an optimal food system that balances the social, environmental and economic concerns with each other. This is especially true for the restaurant and eating out industry in the UK because of its significant environmental footprint and critical role in the food value chain. Many agri-food businesses rely on the restaurant industry for their growth and survival. Yet restaurants and bars contribute to environmental emissions through factors such as fuel consumption for traveling to restaurants, restaurant lighting and kitchen activity.

Most of the current debates on policies involving eating out in UK involve either economic aspects e.g., ‘eat-out to help-out’ scheme (González-Pampillón et al., 2021) or health aspects e.g., obesity (Fraser et al., 2010). There have been few studies to account for the environmental impact of eating out in the UK. This study aims to fill this gap by presenting empirical evidence of the differences in impacts from eating out across both time and scale. Some studies show that while diners are willing to pay more for sustainable foods while eating out, there is a lack of clarity regarding what constitutes such foods (Curry et al., 2015). Other studies show opposing results indicating that sustainability and climate change do not influence consumer buying behaviour (O'Keefe et al., 2016). Hence future policies should aim to highlight why food system sustainability matters to an individual consumer in a certain region. This should be accompanied with communication regarding diets that are sustainable as well as healthy and affordable. Another take away from this study is the need to customise policy design with respect to the individual needs of the consumers in different regions. This is least due to the fact that adoption of environmentally friendly eating is positively influenced by personal norms, social norms, and attitudes (Kim et al., 2020).

Specific policy instruments for more sustainable eating out could include, for instance, subsidies or tax breaks for businesses with more transparent climate-related disclosures. Similarly, food banks and charities could be encouraged to source more responsibly for greater consumer awareness and behavioral change. At a consumer scale, vouchers and cash-back offers could be provided for more climate-friendly purchases. These activities may lead to a ripple effect through the food supply chain with greater supply of food that is both healthy and environment friendly. This, in turn, could help achieve sustainability and resilience targets simultaneously.

Several insights have been gained from the results of this study. First there exist significant differences among different regions and countries related to the subject emissions thus indicating differences in food consumption behaviors. This shows clearly that a one size fits all food policy will not be efficient. Each country and region needs diet optimization strategies based on local culinary tastes and food habits apart from the environmental and economic criteria. Studies focusing on shift towards healthier diets have used such criteria in past at albeit at national scales to recommend policy actions. As compared to UK regions and countries, a 2012 study found the Chinese city of Beijing to have annual food-based carbon footprint corresponding to 310. 0 kg/ cap or 5.72 kg CO_2-eq per capita per week (Wu et al., 2012). A recent study shows how food related carbon footprint in Beijing to have risen from 2.15 kg CO_2-eq per capita per day in 1980s to 3.04 kg CO_2-eq per capita per day in 2017. The above two studies show that differences in methodologies can result in wide variations in estimations of GHG emissions for the same city during similar periods of time. As such, it is difficult to make comparisons without limitations. Moreover, few studies have focused solely on emissions from eating-out activities in cities or regions.

Second, the hierarchical position of the countries or regions in emission generation changed over time between the years 2001 and 2018. This shows that there exist possibilities to reduce these emissions through a shift in policy paradigm. However, it must be noted that the results have been presented in the units of kg CO2-equivalent per person per week. If the results are aggregated based on the total population of each country or region, their relative positions in the emissions hierarchy would change. The North East region had the lowest population while the South East had the highest according to the last census conducted in 2011. Thus for 2011, the highest eating-out emissions for the regions in England will come from the South East (2.58E+06 kg CO2-equivalent per year) and the lowest will come from the North East at 8.58E+05 kg CO2-equivalent per year. Once again, many of these changes are not just related to the size of the population but also to consumer choices. As suggested above, these consumer choices are based on demographic variables such as ethnicity, age and urban-rural divides as well as income levels. Similarly, food deserts can be found in relatively more deprived areas in the UK affecting 1.2 million people (Dobson and Atkinson, 2020). People in deprived households with a fast-food environment may ultimately suffer from poor health conditions (Burgoine et al., 2018). Thus, the issue of retail food choice in the UK is multi-faceted and requires greater inspection for policy action.

Third, relatively more urban areas such as London and South East have lesser per capita GHG emissions from eating out. There could be several reasons for this including a greater emphasis on vegetable diets, higher food costs and different demographics. For instance, a closer inspection of the diet patterns in the studied regions and countries show that people in London and South East consume less meat products than those in the North East. Moreover, this difference has been increasing over the years so that in 2018, for instance, the per capita weekly meat consumption in the North East, London and the South East regions stood at 100.21 grams, 69.40 grams and 58.92 grams respectively.

Fourth, Covid-19 has reduced restaurant activity sharply thus reducing the GHG emissions. This shows that the restaurant industry was ill prepared to meet the Covid-19 challenge thus exposing the vulnerabilities in the business model. Had there been systems in place for a quick transition to contactless or drive through food purchase, the restaurant industry might have been spared the economic onslaught. In order to survive, the restaurant could also their business model to include grocery supply along with the provision of home deliveries of prepared foods.

As discussed earlier, eating out may have been replaced with greater cooking at home in the UK. The evidence in favour of this argument includes greater grocery buying. However, evidence also indicate that this was primarily panic buying which subsided with time to indicate sharp decrease in overall spending across all regions (Surico et al., 2020). Such a change has also been experienced in other countries such as the United States of America and Canada (Nicola et al., 2020; Richards and Rickard, 2020). Thus, with overall reduction in spending, there has been a gradual global reduction in GHG emissions (Forster et al., 2020). However, this improvement in environmental conditions is only temporary. The accompanying social changes however might have far reaching impacts. For instance, COVID-19 has exposed deep inequalities in the UK food system where food access to the vulnerable through charities and food banks have been severely affected (Power et al., 2020). This includes groups such as children that otherwise have access to free meals in schools (Parnham et al., 2020). As such the results presented in this preliminary analysis present only one aspect of the current research on the impacts of Covid-19. The reduction in GHG emissions stemming from a decrease in eating out activity may not be considered as a “blessing in disguise” or a “necessary evil” as some have pointed out (Muhammad et al., 2020b; Shehzad et al., 2020). Rather a more sombre assessment of the triple bottom line impacts of Covid-19 are necessary for a holistic assessment. As such the present study may prove to be valuable for researchers and policymakers interested in assessing the different impacts of Covid-19 on the eating out industry in the UK.

5. Conclusions

This study was aimed at exploring the historical trend of GHG emissions from eating out in the UK regions and countries. Moreover, two scenarios were evaluated based on (a) business as usual and (b) to account for reduction in eating out due to Covid-19. This study is timely as analyses of the impacts of Covid-19 have formed a critical research domain and future studies can use the present study for benchmarking and comparison purposes. The findings conclude that the UK regions and countries differ each other in terms of consumption patterns and hence the GHG emissions. More interestingly, it can be seen from the results that the relative position of the regions and countries as the highest emitter varied during the study period. This calls for further exploration into the factors responsible for these changes. Moreover, changes in emissions as a consequence of transition to healthier diets could also be determined to inform policymaking. A customizable algorithm can be developed to optimize ideal diets based on environmental, economic and cultural factors. While such studies are available at a national scale, it is necessary to focus on a local scale to replicate such.

Once again, there haven't been enough studies on this topic to present more specific policies catering to the individual needs of the regions. We hope that this study helps initiate a debate on the topic for more tangible outcomes. For instance, this study showed how emissions from eating out have changed due to the disruption caused by the Covid pandemic. Future studies could help understand how much they could actually change under 'normal' circumstances through effective policymaking considering other aspects such as food security, economic and social impacts.

Future research can also take into account the change in grocery buying behavior, once relevant data becomes available. This study has a few limitations considering the assumption that all regions and countries had similar reduction in eating out while estimating the emission reductions due to Covid-19. The assumptions can be verified and tested further once more data becomes available. Overall, this study provides an interesting insight into a hitherto unexplored topic related to environmental impacts of eating out which might be able to aid better policymaking in the future.

6. Acknowledgments

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