Setting the agenda in research

Comment

Supplementary information to:

Analysis: the biodiversity footprint of the University of Oxford

A Comment published in *Nature* **604**, 420–424 (2022)
https://doi.org/10.1038/d41586-022-01034-1

Joseph William Bull, Isobel Taylor, Elizabeth Biggs, Henry M. J. Grub, Tom Yearley, Harriet Waters & E. J. Milner-Gulland

This Supplementary information comprises:

1. Supplementary report – Full report for the 2019–20 environmental impact assessment of the University of Oxford's operations
2. Supplementary appendix – Characterisation factors and assumptions used in the supplementary report

A secondary assessment of the environmental impact of the University of Oxford's Operations

September 2021

Title	:	"A secondary assessment of the environmental impact of the University of Oxford's operations"
Date	:	21.09.21
Project	:	Oxford University 'EP&L' assessment
Submitted to	:	Oxford University Estates Management
Attention	:	H. Waters, T. Yearley (Oxford University Estates Management)
Prepared by	:	E. Biggs, I. Taylor and J. W. Bull (Wild Business Ltd)

Suggested citation: Biggs, E., Taylor, I., Yearley, T., Waters, H., Milner-Gulland, E.J., Bull, J.W. (2021). A secondary assessment of the environmental impact of the University of Oxford's operations. Wild Business Ltd for the University of Oxford; London, UK.
Contact for more information: joe@wildbusiness.org; ej.milner-gulland@zoo.ox.ac.uk
Cover image: Turl Street (credit: Elizabeth Biggs)

Acknowledgements: In addition to all of those listed above, to whom we are grateful for valuable feedback and comments, we would also like to thank Dr Michael Clark for assistance with the analysis on food consumption, Hannah Austyn for her contributions concerning the Zoology department at OU, and members of OUES (particularly the Environmental Sustainability team) and UPD who assisted with this project. Data relating to the composition and environmental impact of purchased food where indicated was provided under license by the FoodDB project (Harrington et al. 2019), and may not be shared without permission from the owners of the associated database.

Contents

List of abbreviations used

BIS	Biodiversity Impact Score
CF	Characterisation (conversion) factor
CH	Conservation Hierarchy
COVID-19	Coronavirus Disease-19
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DBEIS	Department for Business, Energy & Industrial Strategy
Defra	Department for Environment, Food & Rural Affairs
EEA	European Environment Agency
EEIO	Environmentally-Extended Input Output Analysis
EE MRIO	Environmentally-Extended Multi-regional Input Output
EMR	Estates Management Record
Eq.	Equivalent
ESOS	Energy Savings Opportunity Scheme
GHG	Greenhouse Gas
HEFCE	Higher Education Funding Council for England
HESCET	Higher Education Supply Chain Emissions Tool
IOT	Input Output Table
KG	Kilogram
LCA	Life Cycle Analysis
LCIA	Life Cycle Impact Assessment
MPG	Miles Per Gallon
N	Nitrogen
NAEI	National Atmospheric Emissions Inventory
NO_x	Nitrogen Oxides
OUEM	Oxford University Endowment Management
OUES	Oxford University Estates Services
OUP	Oxford University Press
P	Phosphorus
PM	Particulate Matter
PO_4^{3-}	Phosphate
SO_2	Sulphur Dioxide
SO_X	Sulphur Oxides
SUPC	Southern Universities Purchasing Consortium
T	Tonnes
UPD	University Purchasing Department
1,4- DCB	1,4-dichlorobenzene

Executive Summary

This report details the outcomes of a secondary assessment of key environmental impacts associated with the activities of the University of Oxford within the academic year 2019-20. This follows a preliminary assessment carried out for the academic year 2018-19, which established a baseline of environmental impacts caused by the University. Following completion of the original preliminary assessment, the University launched its Environmental Sustainability Strategy, which aims to achieve two principal objectives by 2035: (1) net zero carbon dioxide emissions; and, (2) biodiversity net gain. By calculating the approximate relative impact on greenhouse gas emissions and biodiversity associated with different aspects of the University's activities, it is possible to prioritise actions that can most effectively mitigate impacts and meet these ambitious objectives. Moreover, by calculating these impacts annually, trends in activity data and correlative impacts can be observed.

A conceptual framework underlying the assessment presented here is captured in Figure 1. Crucially, the scope of assessment was limited to Oxford University operations (Oxford University Press, Oxford University Endowment Management and the Colleges were excluded). Five key environmental aspects, and impacts associated with these, were assessed. Impacts were split into two spheres: sphere I (under direct University control or directly influenceable through staff and key contractors) and sphere II (indirectly influenceable through students and supply chains). Note, that this categorisation into two spheres differs from the previous assessment for ease of communication. Activity data were collected, converted to mid-point impacts, and aggregated into end-point outcomes for greenhouse gases and biodiversity.

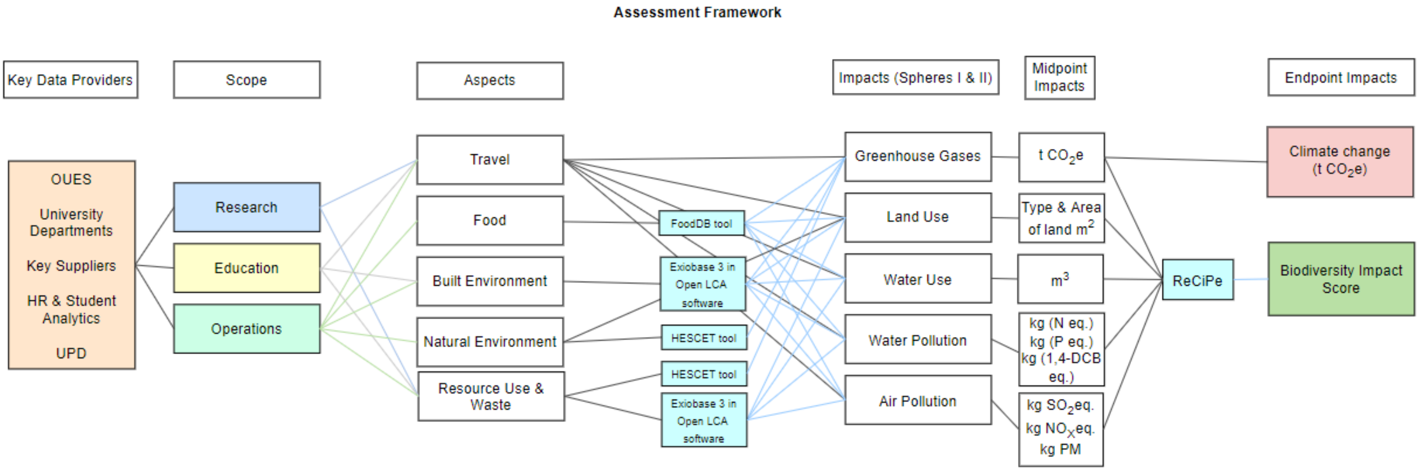
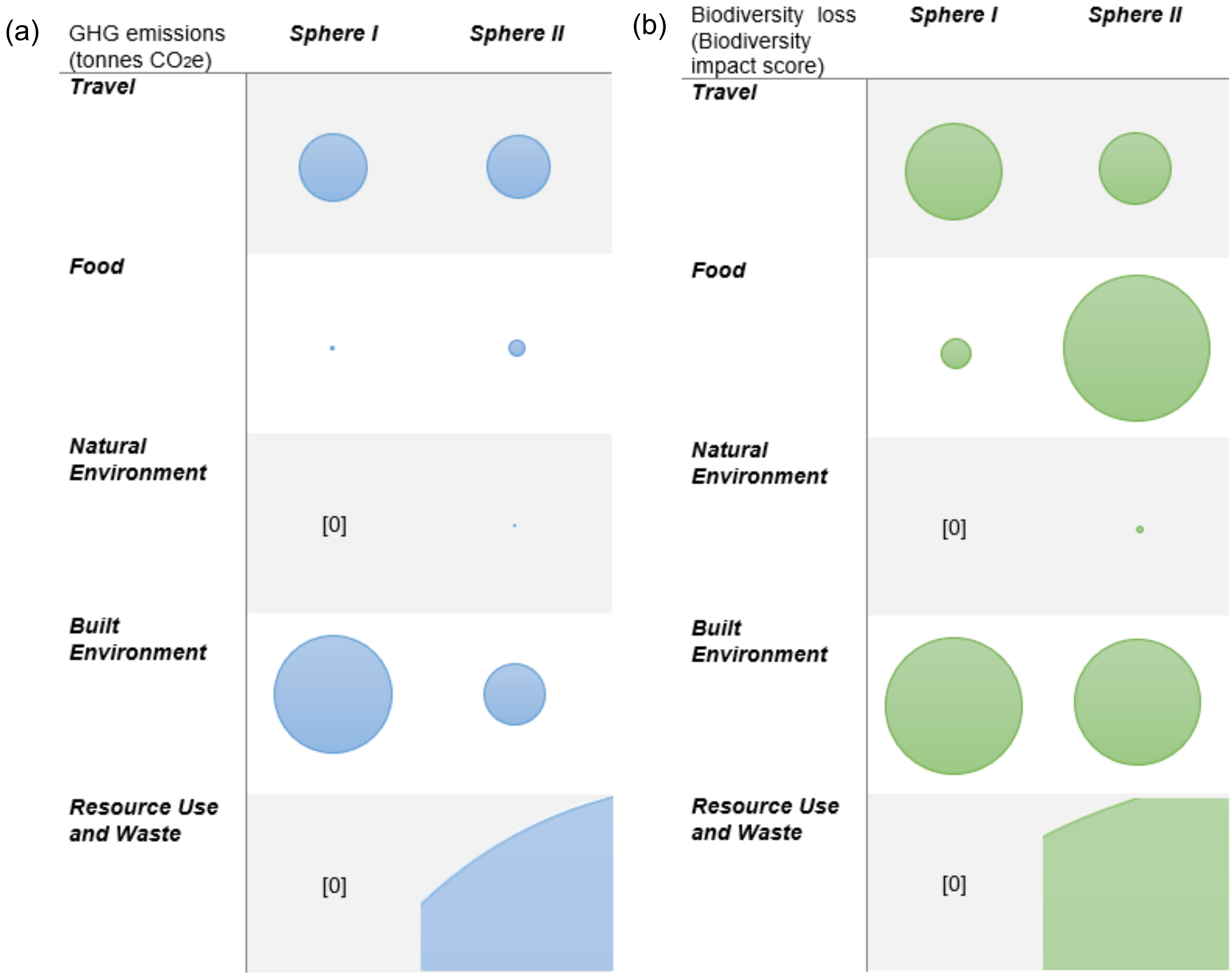


***Figure 1**: schematic capturing the assessment framework used, including organisational scope of assessment, aspects, impacts and mid-point/end-point metrics.*

In addition to the datasets collected under the preliminary assessment, we incorporated new datasets including undergraduate fieldtrips & years abroad, and domestic student travel data. Furthermore, updated methodologies were used to calculate the mid-point impacts of supply chains associated with the Built Environment and Resource Use & Waste Aspect of this report. There are multiple merits of this updated methodology, including being able to geographically estimate locations of and quantify all mid-point impacts embedded within global supply chains. Finally, this report considers the impact of the COVID-19 pandemic on the university's activities and thus environmental impacts. This is evident in the novel activity of 'Online Education' whereby the environmental impacts of streaming lectures and video calls are quantified.

Quantitative results are summarised in the figure below, which combines end-point impact results for both (a) greenhouse gas (GHG) emissions in blue and (b) biodiversity loss in green. In total, the end-point impacts are **417,000 tonnes CO_2e** and a biodiversity impact score (BIS) of **1.6**. The variation between aspects is considerable, but it is abundantly clear that the vast majority of impacts for both are found in sphere II and associated with the 'resource use and waste' aspect. The relative impacts of each sphere and aspect remain the same across the preliminary and secondary assessment. The only exception to this trend is within the built environment aspect, whereby sphere II impacts were larger than sphere I impacts in the preliminary report. However, this difference is likely to result from a change in methodologies used to calculate the sphere II impacts within the built environment aspect. Overall, the end-point impacts between the two reporting years decreased by 2,571 tonnes CO_2e and 0.4 BIS, representing a decrease of GHG emissions by 0.6% and biodiversity impact of 20% respectively. However, interpreting these differences should be approached with caution as updated methodologies and datasets were used across both assessments, with differences in scope and approach.



(c)

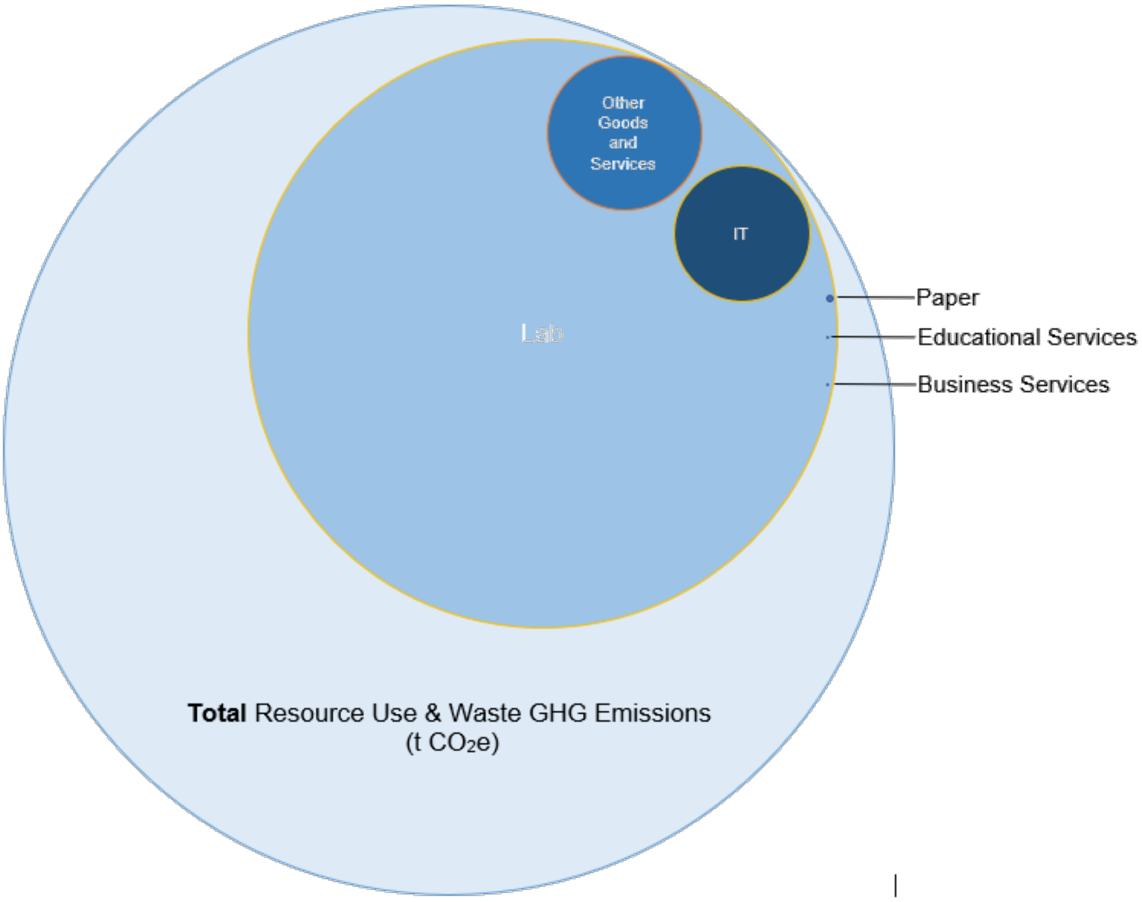


***Figure 2**: summary of end-point impacts for (a) GHG emissions, (b) biodiversity loss, and (c) GHG emissions from resource use and waste. The diameter of each circle gives the relative size of impact, although GHG emissions and biodiversity loss are not directly comparable. In (a), Sphere II (resource use & waste) gives a small section of a larger circle, which is fully represented and broken down proportionally in (c) GHG emissions from waste are negligible. [0] = negligible impacts.*

As detailed in Table 1 below, data gaps remain in relation to every aspect. Priority data gaps relate to resource use & waste, built environment, and travel – given that these are the aspects with the largest impacts. In the meantime, efforts to reduce impacts could be usefully directed at minimising (a) sphere I impacts from international flights and staff commuting, and (b) spheres I and II impacts associated with utilities consumption in the built environment. However, it is unlikely that the University will meet the 2035 objectives (i.e. 1 and 2 above) without substantial efforts to reduce environmental impacts through the supply chain: particularly embodied environmental impacts associated with research-related procurement (sphere II resource use & waste). Figure 2 above – breaking down impacts by aspect and sphere – makes this abundantly clear; and in the main text these impacts are usefully broken down in various other ways (e.g. by organisational scope).

Table 1*: Summary of the key impact areas and sources, data gaps and recommended actions for the main aspects of the University's environmental impact. [] = relevant impact mitigation measures (A=avoid, M=minimise, R=restore, O=offset, PCA=proactive conservation action).*

Aspect	Key impact areas	Data gaps	Main impact sources	Recommendations	Headline comparisons between preliminary and secondary assessment
Travel	GHG emissions; Air pollution	Frequency of international student flights; Frequency of educational flights (year abroad and graduate fieldtrips); Impacts of delegate travel to Oxford-hosted conferences; Accuracy of business flight estimates; Midpoint impacts for water pollution	Flights (business and international students); Staff commuting	Focus on reducing flights taken by staff and students [M]; Liaise with Faculties that coordinate fieldtrips or year abroad programmes to reduce flights taken by students for educational purposes [M]; Encourage more sustainable commuting options [M]; Carbon offsetting [O]	The activities with the largest impact remain the same. COVID-19 is likely to have stopped travel from 23rd March 2020 until the end of the academic year, likely explaining the 38% less GHG emissions from flights and 40% less GHG emissions from student and staff commuting. 5 less cars were purchased in 2019-20, resulting in less vehicle supply chain emissions than 2018-19.
Food	Land use; GHG; Water use; Water Pollution and air Pollution	Food sourced externally but consumed on campus; Ingredients, portion size and source for food sold on campus	Food sourced off campus; Embodied land use in all food consumed	Awareness/nudge campaigns aiming to shift staff and student consumption away from animal-based food products [M]; Active encouragement to switch away from animal products in departmental purchasing [A/M]	Departmental food purchasing end point biodiversity impacts decreased by 56%, likely due to all events being cancelled after 23rd March 2020. Biodiversity impacts from University café sales only reduced by 8%. Sphere II Staff and student meal end point impacts similarly reduce by 42% as staff and students did not consume food on campus after 23rd March 2020.

Built environment	Land use; GHG; Water use; Water Pollution and air Pollution	Detailed construction impacts by supply chain; Miscellaneous emissions sources (e.g. Fluorinated GHG gases); Information on pockets of urban greenspace; Midpoint impacts for water pollution.	Energy consumption (utilities); Embodied impacts in construction supply chains	Reduce energy consumption [A/M]; Carbon offsetting [O]; Better understand and seek to reduce the embodied impacts of construction projects [A/M]; Biodiversity net gain on new construction projects [R/O] Biodiversity enhancement within urban greenspaces [R/O].	Electricity consumption decreased by 12%, likely due to building closures. Construction supply chain mid-point (and thus end point) impacts were significantly lower, but this is likely due to the aforementioned change in methodology rather than annual change in construction supply chain impacts.
Natural environment	GHG; Land use	Non-UK land holdings; detailed information of natural environment related procurement and management	Embodied GHG emissions in Natural Environment related procurement	Seek on-site biodiversity conservation (primarily as a communication and awareness tool, and to contribute to local biodiversity networks/Nature Recovery Network) [PCAs]; Seek partnerships with other landowners to restore habitats and create biodiversity gains [R/O]	The rural land holding footprint of the university has been updated, and GHG emissions are non-comparable between reports (see section 3.4.5 for more detail).
Resource Use & Waste	GHG; Land use; Water use; Water pollution; Air pollution	Coding accuracy and completeness (staff data input); Waste destination; Transport (freight delivery) impacts	Research related procurement	Improving coding and completeness of procurement records [n/a]; Seek out impact assessments from individual suppliers [n/a]; Seek to reduce embodied impacts of procured laboratory equipment [A/M]; Increase proportion of waste recycled, diverting from waste-to-energy [M]	Waste GHG emission decreased in all waste categories. GHG emissions increased in research and IT related categories, but decreased in Paper product and other procurement categories.

Since reductions in the environmental impacts of procured goods will still leave residual GHG and biodiversity impacts, meeting the 2035 environmental sustainability objectives will require some degree of offsetting. In the appendices of this report, the approximate locations of biodiversity impact are mapped, providing an indication of where biodiversity offsetting could be implemented.

In Table 1, recommendations are classified into the relevant section of the Conservation Hierarchy (CH): a framework for prioritising impact mitigation measures in a way that enables tracking of aggregated progress towards overall objectives.

On the basis of this assessment, priorities over the coming 12 months should include efforts to fill key data gaps that have been highlighted throughout, with an emphasis on those associated with the procurement data provided by UPD. It is also recommended that the University begins to focus on its biodiversity net gain strategy, as this assessment begins to locate and quantify with more consistency the mid-point impacts associated with supply chains.

Over a longer timescale of approximately 4 years, it would be reasonable to expect many key data gaps to have been filled; meaning that focus could have turned to implementing more involved or slow-moving interventions. These might include investment and even active participation in ecological restoration through carbon and biodiversity offsetting, incorporation of ambitious biodiversity net gain measures into new construction and renovation projects, and on-site biodiversity restoration programmes wherever feasible.

1. Introduction

This report details key environmental impacts associated with the activities of the University of Oxford within the academic year of 2019-20. This assessment follows on from a preliminary assessment carried out for the academic year 2018-19, which formed a quantitative baseline of the University's environmental impacts. This preliminary assessment is referred to throughout this report, and used as a benchmark to measure annual change in environmental impacts. Since the publication of this preliminary assessment, the University has approved its Environmental Sustainability Strategy which aims to achieve by 2035: (1) net zero carbon dioxide emissions, and (2) biodiversity net gain. This strategy is underpinned by four main 'enablers', including this *reporting* of annual carbon emissions and biodiversity impact, which will be disseminated within the Universities' Annual Review and financial accounts (6.2.2).

Whilst setting of carbon neutral targets has been mainstreamed across universities in the UK[1], the target of biodiversity net gain by the University of Oxford is sector-leading. Although some universities have biodiversity action plans[2], these are typically limited to university owned estate or local areas. Such plans do not generally consider, and thus mitigate the biodiversity impacts of their respective universities' operations beyond the university estate - for example, biodiversity impacts associated with procurement supply chains. Contrastingly, this report aims to consider the biodiversity impacts of the University of Oxford's operations, both within and beyond the borders of the University Estate.

Overall, the aim of the assessment reported here is to estimate the relative impacts of University activities both in terms of the emission of greenhouse gases and in terms of contributions towards biodiversity loss. Moreover, this assessment provides an overview of annual change in impacts, with considerations of how the COVID-19 pandemic may have altered the University's activities, and thus environmental impacts.

Having identified key areas of environmental impact and their relative size, a framework that could be employed to prioritise measures for reducing those impacts, in line with the University's 2035 objectives, is the Conservation Hierarchy (CH). The CH has been developed by University researchers alongside multiple collaborators worldwide (e.g.[3,4]), based upon decades of research into biodiversity impact mitigation. The framework is built around the categorisation of sustainability interventions into preventative or compensatory measures that are tied to impacts, as well as those measures that are proactive and not implemented in response to impacts. Multiple measures can then be aggregated to track overall progress towards the central objective/s. A full application of the CH to University impacts is not included in this report, but it is highlighted here as an important potential next step in implementing the Sustainability Strategy, and we touch upon it again in the final section.

---

[1] A full list of carbon neutral targets and other sustainability commitments made by UK universities can be found here: https://www.eauc.org.uk/sustainability_commitments

[2] See The University of Cambridge Biodiversity Action Plan: biodiversity_summary_baseline14112019_report_0.pdf (cam.ac.uk), the University of Leeds Biodiversity Standard: Biodiversity-Standard-Nov-2020.pdf (leeds.ac.uk) and other exemplary biodiversity plans here: Research_ Exemplary Biodiversity Plans .pdf (illinois.edu)

[3] Bull et al. (2020)

[4] Milner-Gulland et al. (2020)

2. General Methods

2.1 Defining the Scope

Effective targeting of the sustainability strategy requires attribution of environmental impacts to categories that are meaningful and relevant to the University's structure and purpose. Like the previous assessment, this report aggregates university activities into scopes (table 2), and excludes activities associated with colleges, the OUP and OUEM.

***Table 2**: scope of the University's own activities and its influence on wider society.*

Scope	***Activities***
Research	Activities relating to conducting and disseminating of research, both within the University and activities of research staff at external institutions on behalf of the University
Education	Activities relating to the education of the student body and the activities of students themselves, where these are attributable to being enrolled at the University
Operations	Activities that support the running and delivery of University services and the maintenance of its estate & capital.

University activities are also categorised into environmental ***aspects***, based upon standard practice in environmental management[5]. These aspects are designed to capture all relevant University activities relevant to this assessment, and include:

- **Travel** (including commuting as well as travel for research, study, or operational reasons);
- **Food** (all food consumed by University staff, students and visitors on campus);
- **Built Environment** (buildings, utilities, and urbanised land owned, managed or leased by the University);
- **Natural Environment** (greenfield or agricultural land owned, managed or leased by the University);
- **Resource Use & Waste** (associated with goods and services supplied to the University, from supply through to disposal); and

Impacts associated with these aspects are under varying levels of operational control. Each of these levels of influence are defined as ***spheres*** of impact, categorised into sphere I and II impacts respectively. Firstly, sphere I impacts occur as result of activities that are carried out directly by or on behalf of the University (e.g. pollutant emissions resulting from business travel associated with the University fleet, biodiversity impacts associated with water consumption on the University estate). Sphere I impacts are within the University's direct sphere of influence, for example via staff policies or contractual arrangements (e.g. emissions from staff commuting, impacts from owned land and buildings leased to third parties). Contrastingly, sphere II impacts are those that are outside of the University's direct or contractual control but can be indirectly influenced through engagement with third parties (e.g. student bodies, suppliers). Further examples are given in table 3 below.

---

[5] See for example the ISO14001 standard (https://www.iso.org/iso-14001-environmental-management.html)

It is important to clarify that spheres I and II as used in this report modify the different tiered framework employed for previously published EP&L accounts (e.g.[6]). This report follows a two sphere approach, which simplifies the preliminary report's approach. It is also important to note that these spheres are **not** comparable to the 'scopes' used in the Greenhouse Gas Protocol (herein, the GHG Protocol). The GHG Protocol categorises GHG emissions from corporate activities into three scopes[7], which reflect direct emissions (scope 1), indirect emissions from electricity use (scope 2) and other indirect emissions (scope 3). The reason for using spheres here is for alignment with previous EP&Ls. The sphere system was also necessitated over the GHG Protocol framework as this report was not only considering GHG emissions, but also biodiversity impacts, to which the GHG Protocol is not applicable.

Impacts were assessed for the 2019-20 academic year (i.e. the most recent reporting year for which complete datasets were available).

Table 3: *environmental aspects considered in this assessment, including definition and examples across the three spheres of impact. Activities that are newly assessed in this secondary assessment are marked with a star (*).*

Aspect & Definition	***Sphere I (examples)***	***Sphere II (examples)***
Travel *Impacts of domestic and international travel of University staff, students and visitors*	- Business travel - *Undergraduate student field trips and year abroad trips arranged by the University - Staff commuting	- Student commuting - International student travel - *Domestic student travel - Embedded upstream impacts from the supply chain of fuel and vehicles owned/ purchased by the University
Food *Impacts associated with the consumption of food*	- Departmental food purchases (e.g. for catering events, meetings etc) - Food sold in University cafeterias	- Daily food consumed by staff and students during working hours
Built Environment *Impacts associated with utilities (i.e. energy and water use), maintenance and construction of University owned buildings and infrastructure, including value chain impacts of raw building materials*	- Gas and oil consumption - Electricity consumption - Water Consumption - Urban land use of University-managed buildings and site areas - Urban land use of buildings and site areas (commercial & residential buildings) - Electricity consumption due to Online Education	- Upstream energy supply chain (Well-to-Tank & Transmission/ Distribution losses) - Water supply chain (water supply and wastewater treatment) - Supply chain of building construction materials and services
Natural Environment *Impacts associated with the management and maintenance of University owned land, including on-campus green spaces, farms, natural areas etc.*	- Occupation and management of University parks, green spaces and natural areas - Occupation and management of the commercial (agricultural) estate	- Supply chain of goods used in University land management (e.g. fertilizers, pesticides, forestry products etc.) - Indirect effects of the University's decisions on other landholdings (e.g. developments adjoining University-developed land)

---

[6] Kering (2017)
[7] See the GHG Protocol Corporate Standard for more details (https://ghgprotocol.org/corporate-standard)

Resource Use & Waste *Impacts associated with the procurement and disposal of goods and services (excluding those included under other aspects)*	- Onsite resource use (e.g. the use of chemicals and cleaning products) - Resource delivery/freight transport	- Resource supply chain (research and operational supply chains) - Resource disposal and waste management

2.2 Estimating Impacts

Impacts were estimated based on contributions made both to (1) climate change and (2) biodiversity loss. Impacts were estimated based upon pre-existing data that were collated from different sources within the University, in addition to educational transport data that was newly collated for this report.

Metrics

The contribution of University activities to climate change is assessed in relation to the release of greenhouse gases (GHG). Methods to quantify GHG emissions associated with the full range of environmental aspects considered here are measured in terms of the global warming potential (GWP) of key emitted GHGs, quantified relative to the emitted mass in **tonnes of carbon dioxide equivalent** (tCO_2e). Hence tCO_2e is the key metric used in this assessment.

Quantifying the impacts of an organisation's activities on biodiversity trends is not standardised like the contributions it makes to climate change. Biodiversity is an imprecise term describing the variation in biotic components at different scales (e.g. ecosystems, habitats, species, genes, functionality), affected by many pressures, with no consensus on the single best metric for tracking change. Here, a measure for biodiversity is used based on cumulative local species lost per year, which is summarised by a **biodiversity impact score** (BIS). Though far from perfect as a means for evaluating *absolute* impacts on biodiversity, the choice of biodiversity metric for this assessment was made based on its consistency, since the focus of this assessment is *relative* impacts on biodiversity across different aspects. However, as this BIS is calculated from species loss estimates, this metric will work less effectively for situations in which species loss is a lagged or biased proxy for biodiversity as a whole. Researchers, including those at the University, are actively developing better measures for biodiversity impact, and so the availability of more robust biodiversity metrics is expected to increase over coming years.

'tCO_2e' and 'Biodiversity Impact Score' are the metrics used to aggregate and report the University's overall impacts in this report. In terms of estimating biodiversity impacts, a common framework underlies several other leading approaches[8], which is also applied in this assessment. This uses the following three-stage process:

---

[8] Lammerant (2019)

1. **Gathering relevant activity data** from available operational datasets (e.g. the total passenger kilometres travelled by aeroplane for business travel purposes);
2. **Quantification of environmental pressures that a occur as a result of those activities ('*mid-point' impacts***; e.g. the global warming potential of flight GHG emissions, or terrestrial acidification potential of sulphur dioxide emissions);
3. **Estimating the effect of each of these pressures on biodiversity ('*end-point' impacts, or outcomes)***; e.g. the impact on local species richness as a result of global warming or acidification associated with organisational activities).

This process, as applied in the assessment framework for this report, is summarised in Figure 3. The conversion of activity data into equivalent GHG emissions is relatively standardised, so the remainder of this section primarily focuses on the issue of how to convert activity data into end-point biodiversity outcomes, following the three-stage process described above. At the end of this section, some additional explanation is provided regarding the process of estimating impacts from University resource consumption (sphere II impacts), as this was a particularly complex process.

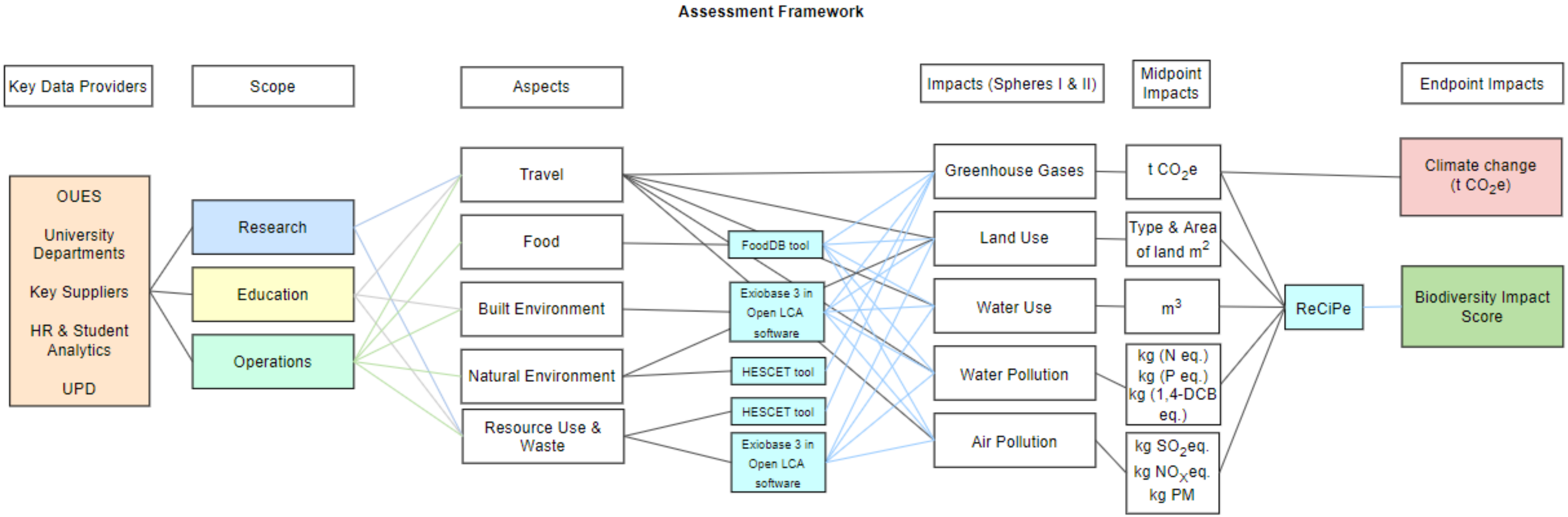


Figure 3: *schematic capturing the assessment framework used, including scope of assessment, aspects, impacts and mid-point/end-point metrics. Blue boxes denotes tools with embedded sets of characterisation/emissions factors that were used to calculate midpoint and endpoint impacts. Where no tools are denoted, raw characterisation factors were used to directly calculate midpoint and endpoint impacts as listed in the supplementary material.*

*(1) **Gathering activity data (data sources)***

Firstly, most of this analysis is based on existing datasets already collected in some form by the University, with key data providers summarised in table 4.

***Table 4**: outline of data sources used in the assessment, the environmental aspects they relate to, and the relevant organisational scope. New datasets that haven't been used in the preliminary impact assessment are marked with a star (*).*

Data Source	Dataset Title	Relevant environmental aspects	Organisational Scope
OUES	Estate Management Record (EMR) 2019-20	- Travel - Built Environment - Resources & Waste	Functional Estate
OUES	Energy Savings Opportunity Scheme (ESOS) 2019	- Travel	Functional Estate (OUP & subsidiaries excluded from the dataset)
OUES	University Fleet List 2020	- Travel	Functional Estate
Key Travel	Key Travel Scope 3 Carbon Report 2019-20	- Travel	Functional Estate
Student Data Management and Analysis Services	Student domicile and headcount statistics 2020	- Travel - Food	Includes all undergraduate, taught and research postgraduates & Visiting and Recognised students (VROs)
Student Data Management and Analysis Services	*Domestic Student Postcode Data 2020	- Travel	Includes aggregated postcode areas for all domestic (UK) students
University HR Systems	Staffing figures 2020	- Travel - Food	Headcount of all full-time and part-time staff. Figure for the number of full-time equivalent staff also provided.
OUES (Asset & Space Management)	Building footprint and urban site area data 2020	- Built Environment	Functional, commercial, and residential properties
OUES (Asset & Space Management)	Area of owned land (non-urban) 2020	- Natural Environment	Functional and Agricultural estate
UPD / SUPC	Higher Education Supply-Chain Emissions Tool Scope 3 Carbon Report (HESCET) 2019-20	- Built Environment - Resources & Waste - Natural Environment - Food	Functional estate
UPD / SUPC	*Procurement Data 2019-20	- Built Environment - Resources & Waste - Natural Environment - Food	Functional estate
Compass Group PLC	Compass Sales Data 2019-20	- Food	Sales for cafeterias on the main University campus
University Departments	*Departmental Fieldtrip and Year Abroad Dataset 2019-20	- Travel	Flight data for Year Abroad trips and Fieldtrips by Undergraduates
IT Services	*Online Lecture Delivery	- Online Education	Hours of content delivered online and average data usage of online content

Key limitations to datasets that contained estimates of activity data, rather than actual measured of activity data, are briefly outlined below in table 5. Detailed explanations of how these estimates were calculated (e.g. how COVID-19 was accounted for) can be found throughout this report and in the Summary.

Table 5: *outline of key assumptions of datasets used in the assessment whereby estimates, rather than actual data measurements are used.*

Dataset Title	Key Limitations
Estate Management Record (EMR) 2019-20	- The Estate management record included a mixture of estimated and actual measures of activity data. For example, consumption of grid electricity was the actual measurement across the functional estate, whilst total energy generated on site by CHP was estimated. - It is important to note that the staff and student commuting activity data was also estimated, accounting for travel behaviour change due to COVID-19.
Energy Savings Opportunity Scheme (ESOS) 2019	- As ESOS is only completed on a four-year cycle, business travel data (university fleet) had to be estimated from the 2019 ESOS report, accounting for travel behaviour changes due to COVID-19 and changes in university fleet size.

(2) Quantification of mid-point impacts from activity data

Mid-point impacts are grouped into five categories: greenhouse gases, land use, water use, water pollution and air pollution, each with their own associated metrics (see Figure 3 and Table 5). Note that the 'greenhouse gases' midpoint is reported here both in its own right (to demonstrate impacts on climate change), as well as in terms of the biodiversity endpoint (to capture the impact of climate change on biodiversity). It is also worth noting that the terms water pollution and air pollution are used here for ease of communication. In reality, these categories encompass a broad range of environmental pressures, which are listed in table 5.[9]

For practical reasons, this analysis did not assess all mid-point impacts potentially associated with every aspect (as indicated by the connecting lines in Figure 3). Instead, for each aspect, the focus for impact assessments was on those considered to be of high relative importance, on the basis of extensive experience in organisational environmental management. However, there is potential to expand the midpoint impacts considered in aspects such as Travel and Built Environment in future assessments, as discussed in each relevant aspect.

Estimating mid-point impacts from activity data (e.g. converting from 'kilometres travelled' to tCO_2e) requires *characterisation factors*, which are collected from a range of sources, including:

- **Government publications** – For example, annually published GHG emissions factors from the UK Departments for Environment, Food and Rural Affairs

---

[9] Note that soil pollution (e.g. terrestrial ecotoxicity) is not considered as an impact category in this report for practical reasons, as useable data was difficult to identify during the assessment period.

(Defra) and Business Energy & Industrial Strategy[10], or air pollutant factors from the National Atmospheric Emissions Inventory[11].

- **Life Cycle Analyses (LCA) & 'footprinting' literature** – there is a growing body of literature that estimates the embodied environmental impacts of commodities, processes or organisations by assessing each stage of their life cycle. The results of these studies are often expressed as impact values per functional unit (e.g. volume of water consumed per tonne of office paper produced). For example, Poore and Nemecek (2018) conducted a detailed meta-analysis of life cycle studies and estimated a broad range of impacts per kilogram or litre of various types of food.
- **Environmentally extended input-output (EEIO) literature** – EEIO is a methodology often used in environmental accounting. It estimates the upstream embodied environmental impacts of economic activities (such as the consumption or production of goods and services) based on the economic and/or material flows between industries and sectors.[12] Characterisation factors from EEIO are presented as impacts per monetary value (e.g. kg CO_2e per £ spent in the construction sector). This report uses Multi-regional EEIO (EE MRIO) to quantify country-specific mid-point impacts of University purchasing, which is summarised in the final part of this 'Estimating Impacts' Section.

All specific characterisation factors, databases and tools that are used in this analysis (along with their source) are listed in supplementary material alongside this report, and are summarised in figure 3 above.

In some cases, these characterisation factors can be paired directly with available data from the University to estimate mid-point impacts (e.g. building energy use measured in kwh, or travel estimates measured in km). For other activities, this is less straightforward. For example, data on resources procured by the University is collated in terms of spend categorised by commodity, rather than in terms of the actual mass or quantity of items procured. A typical approach to estimating environmental pressures based on spend would be to use an EE MRIO model (as described above). This approach is used to calculate other mid-point impacts associated with University spend, using the EE MRIO database: Exiobase 3, which is explained in detail below. It is not yet feasible to employ a full EE MRIO analysis on all aspects of this assessment.

For aspects whereby EE MRIO analysis was not yet feasible, characterisation factors from the LCA literature have been used to estimate mid-point impacts from the consumption of resources, in turn making a series of assumptions. All assumptions are described in detail throughout the report and are also listed in supplementary material. However, it is important to note here that this assessment uses characterisation factors from a range of sources, representing several different methodologies, with no attempt being made to correct for methodological differences between these studies. Estimates based on sources that employ EEIO/EE MRIO analysis, for example, may be larger than equivalent estimates made by LCA - given

---

[10] 2020 DEFRA CFs Available at - https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

[11] Available at - https://naei.beis.gov.uk/data/ef-all

[12] Kitzes (2013)

that an EEIO/EE MRIO is generally broader in scope (see section 3.2.3 for an example. Further discussion of this issue is provided in the appendix).

Where possible, characterisation factors were preferably taken from industry publications, government publications, or scientific meta-analyses.

Estimating mid-point impacts from University Procurement

As mentioned above, estimating impacts from the supply chains of goods and services consumed by the University (e.g. laboratory equipment, paper, construction services for capital projects etc) is a complex task. To do this, two key sources of information were used: 2019/20 Higher Education Supply-Chain Emissions Tool report (herein, the HESCET report) and the Procurement Report for 2019-20, supplied by the UPD.

The HESCET report provides a useful breakdown of spend on goods and services procured by the University and an estimate of GHG emissions from the relevant supply chains. The Procurement Report supplies highly granular information of university spend within the financial year 2019-20, categorising invoices into purchasing categories and subdividing each of these categories into different supplier locations by city or country. This geographical supplier data permitted the use of the EE MRIO database 'Exiobase 3', which is discussed further in the appendix ('A Brief introduction to Exiobase 3').

Since both datasets underpin many of the calculations across all aspects of this report, a description is provided here to clarify (1) how the HESCET report and procurement data analysis categorises spend and calculates mid-point emissions, (2) how these values were used in the context of this report, and (3) the limitations of these methods. A brief overview of Exiobase 3 is provided in the latter part of this section. In general, the HESCET report is used to calculate GHG emissions, whilst the procurement data analysis is used to calculate all other mid-point impacts.

HESCET Report

(1) Spend data from the University purchasing department (UPD) is first coded and grouped into a broad range of categories.[13] Spend for each category is then mapped to one of 311 National Accounts sectors (henceforth referred to as the 'Defra 311 sectors'). Each Defra 311 sector has an associated GHG emissions intensity factor (measured in kg CO_2e / £), which is derived from environmentally extended input-output analyses (EEIO). The aggregated University spend for each Defra 311 sector is then multiplied by the appropriate emissions intensity factor to obtain total supply chain CO_2e emissions.

(2) For the purposes of this assessment, the total CO_2e values for each Defra 311 sector were then allocated to a relevant aspect (Natural Environment or Resource Use). Within the resource use category, CO_2e values for each Defra 311 sector were allocated a relevant group (Lab, Paper, IT, Business Services and Educational Services). These groups of Defra 311 sectors mirror the preliminary assessment's groups, however, as the Defra 311 sectors are significantly different from the Defra 75

---

[13] According to the 'Proc-HE' coding standard

sectors used in the previous report, the exact allocation of Defra sector to group has changed. Thus, results from 2018/19 and 2019/20 must be compared with caution. The Defra 311 sectors assigned to each group is listed in the supplementary material.

Note that the sectors of the HESCET report that related to travel and building utilities were not included, since more accurate alternative data sources were available (this in line with the recommendations of the HESCET report itself). It is also important to note that the HESCET reporting method has been significantly updated from the previous reporting year 2018/19, as conversion factors have been updated from 2009 to 2020 DEFRA company reporting conversion factors[14].

(3) The following are some key limitations of the HESCET report:

- The report uses a broad, top-down methodology, which identifies potential emissions 'hot spots' by combining top-level University spend with industry average emissions data. Therefore, any bottom-up detail on existing sustainable procurement measures (for example, the proportion of purchased paper or laboratory plastic goods that are recycled) is not necessarily captured;
- The report relies upon accurate categorisation/coding by those submitting invoices, and according to the UPD, incorrect categorisation is common; and,
- Total spend recorded for the financial year 2019/20 in the HESCET report was ~1/4 of the total spend for the same period in purchasing data provided directly from UPD, indicating there may be large amounts of purchasing unaccounted for in the HESCET report. This could be due to a combination of procurement data not fitting neatly into Defra 311 sectors and spend data being left unclassified in the procurement data. Unclassified spend is accounted for through error bars found in figure 29 and 32 in the Resource Use and Waste Aspect.
- There is no detailed methodology provided by the Higher Education Procurement Association (HEPA) regarding how GHG emission intensity factors are calculated or have been updated. This is being further investigated by a parallel carbon accounting project being carried out by Maria Marinari within the OUES.

Nonetheless, the HESCET report was identified as a suitable and consistent source for calculating the mid-point impact of GHG emissions for this secondary analysis, as this reporting style will be repeated annually. To calculate other mid-point impacts of University procurement, the procurement report 2019/20 was analysed using an EE MRIO database (Exiobase 3), as outlined below.

Procurement data analysis

(1) To begin the analysis on spend data provided by the UPD for the financial year of 2019/20, individual invoices were classified into different purchasing categories by the UPD. Approximately half of the spend data was unclassified ("Missing Value"), and due to time constraints, these unclassified invoices were omitted from the subsequent analyses. The remaining £431m of spend data was categorised into 245 different purchasing categories, which aggregated spend into services (e.g. 'Repair, Alterations

---

[14] For more information see: the Updated scope 3 emission data context in the appendices.

and Decorating Services') or physical items (e.g. 'Chemicals, Chemical Elements & Chemical Reagents'). These categories were then matched to either industry or product flows in the Exiobase database and aggregated by aspect and scope (Table 6). To match the procurement categories to the Exiobase database, the EU NACE categorisation system was used as a guide[15].

To calculate the mid-point impacts of spend data using Exiobase 3, the supplier country location is required for each industry or product flow. In the procurement data, the supplier city/country location is provided, thus spend in each industry and product was further broken down into country location. For the purpose of time, product categories were ranked by spend, and the largest spend invoices (totalling to 80% of the categorised procurement data) were categorised into country locations. The other 20% of spend was thus assumed to be supplied from the UK.

Aspect	***Scope***	**Exiobase 3 categories**	**Country locations of suppliers**	**Total attributable spend**
Built Environment	Operations	- Construction work (45)	UK	£101,697,008
Resource Use and Waste	Operations	- Animal products nec - Animals - Construction Work (45) - Electrical machinery and apparatus nec (31) - Furniture; other manufactured goods nec (36) - Glass and glass products - Hotels and restaurants (55) - Insurance and pension funding, except compulsory social security (66) - Manufacture of electrical machinery and apparatus nec (31) - Manufacture of furniture; manufacturing nec (36) - Manufacture of office machinery and computers (30) - Manufacture of radio, television and communication equipment and apparatus (32) - Manufacture of rubber and plastic products (25) - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20) - Meat animals nec - Other land transportation services - Other non-ferrous metal products - Paper - Post and telecommunication services (64) - Publishing, printing and reproduction of recorded media (22) - telecommunications - Wheat	UK USA Portugal Netherlands Italy Germany China	£25,657,176

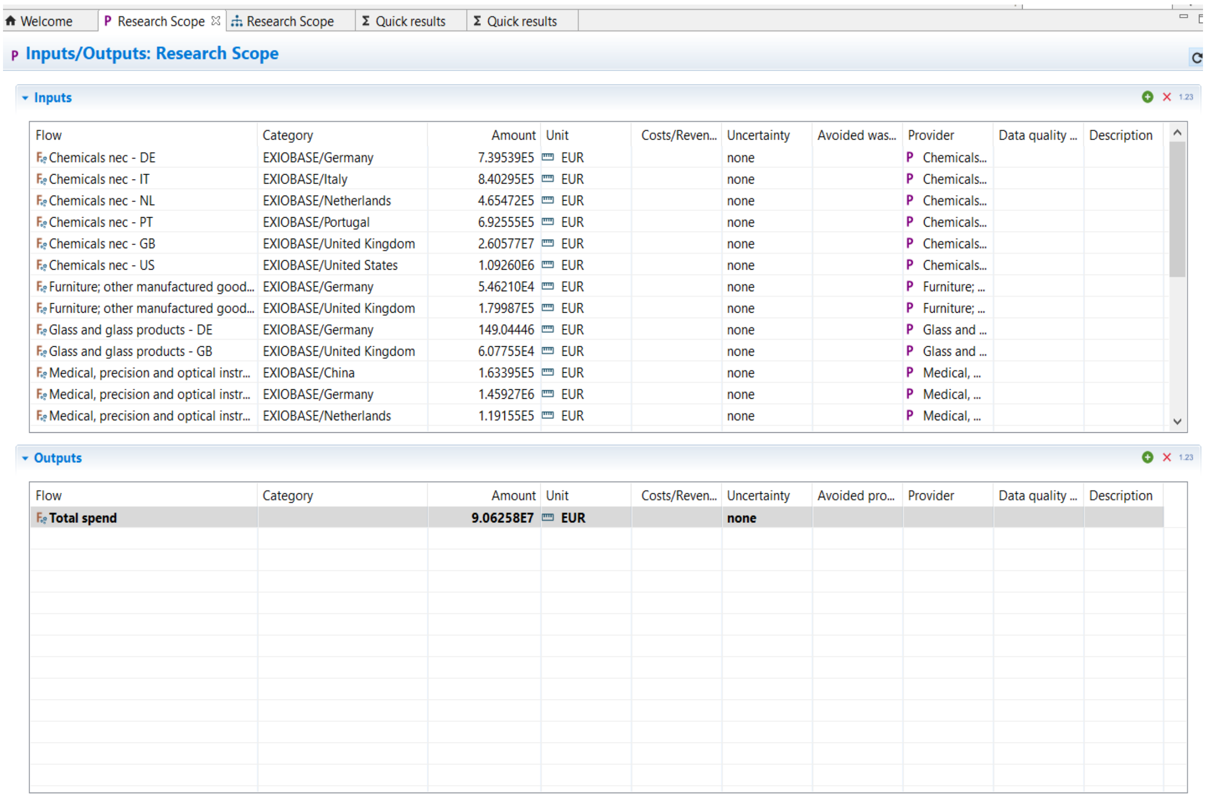
---

[15] Available here: Europa - RAMON - Classification Detail List

Resource Use and Waste	Research	- Manufacture of medical, precision and optical instruments, watches and clocks (33) - Chemicals nec - Research and development (73) - Manufacture of rubber and plastic products (25) - Manufacture of furniture; manufacturing nec (36) - Glass and glass products	UK USA Germany China Italy Netherlands Portugal	£97,062,293

Table 6: *Total spend in each aspect and scope, with an indication of which Exiobase 3 categories and countries this spend is then distributed between.*

Once the procurement data spend was split into relevant Exiobase industries/products and countries, spend was corrected for inflation and converted to euros before being inputted for impact assessment. This is due to the Exiobase database only incorporating supply-use tables (SUTs) from 1995-2011, using Euros as the standard currency across all SUTs. Therefore, spend data accounted for inflation between the years 2011-2019, using the bank of England inflation calculator[16], and was converted from Pounds to Euros using the average 2011 conversion rate[17]. On completing these calculations, spend was inputted into an input/output table (IOT) in OpenLCA, an open-access LCA software that can be used to handle the Exiobase database to calculate the magnitude and location of mid-point impacts (Figure 4).



Inputs/Outputs: Research Scope

Inputs

Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoided was...	Provider	Data quality ...	Description
Chemicals nec - DE	EXIOBASE/Germany	7.39539E5	EUR		none		Chemicals...		
Chemicals nec - IT	EXIOBASE/Italy	8.40295E5	EUR		none		Chemicals...		
Chemicals nec - NL	EXIOBASE/Netherlands	4.65472E5	EUR		none		Chemicals...		
Chemicals nec - PT	EXIOBASE/Portugal	6.92555E5	EUR		none		Chemicals...		
Chemicals nec - GB	EXIOBASE/United Kingdom	2.60577E7	EUR		none		Chemicals...		
Chemicals nec - US	EXIOBASE/United States	1.09260E6	EUR		none		Chemicals...		
Furniture; other manufactured good...	EXIOBASE/Germany	5.46210E4	EUR		none		Furniture; ...		
Furniture; other manufactured good...	EXIOBASE/United Kingdom	1.79987E5	EUR		none		Furniture; ...		
Glass and glass products - DE	EXIOBASE/Germany	149.04446	EUR		none		Glass and ...		
Glass and glass products - GB	EXIOBASE/United Kingdom	6.07755E4	EUR		none		Glass and ...		
Medical, precision and optical instr...	EXIOBASE/China	1.63395E5	EUR		none		Medical, ...		
Medical, precision and optical instr...	EXIOBASE/Germany	1.45927E6	EUR		none		Medical, ...		
Medical, precision and optical instr...	EXIOBASE/Netherlands	1.19155E5	EUR		none		Medical, ...		

Outputs

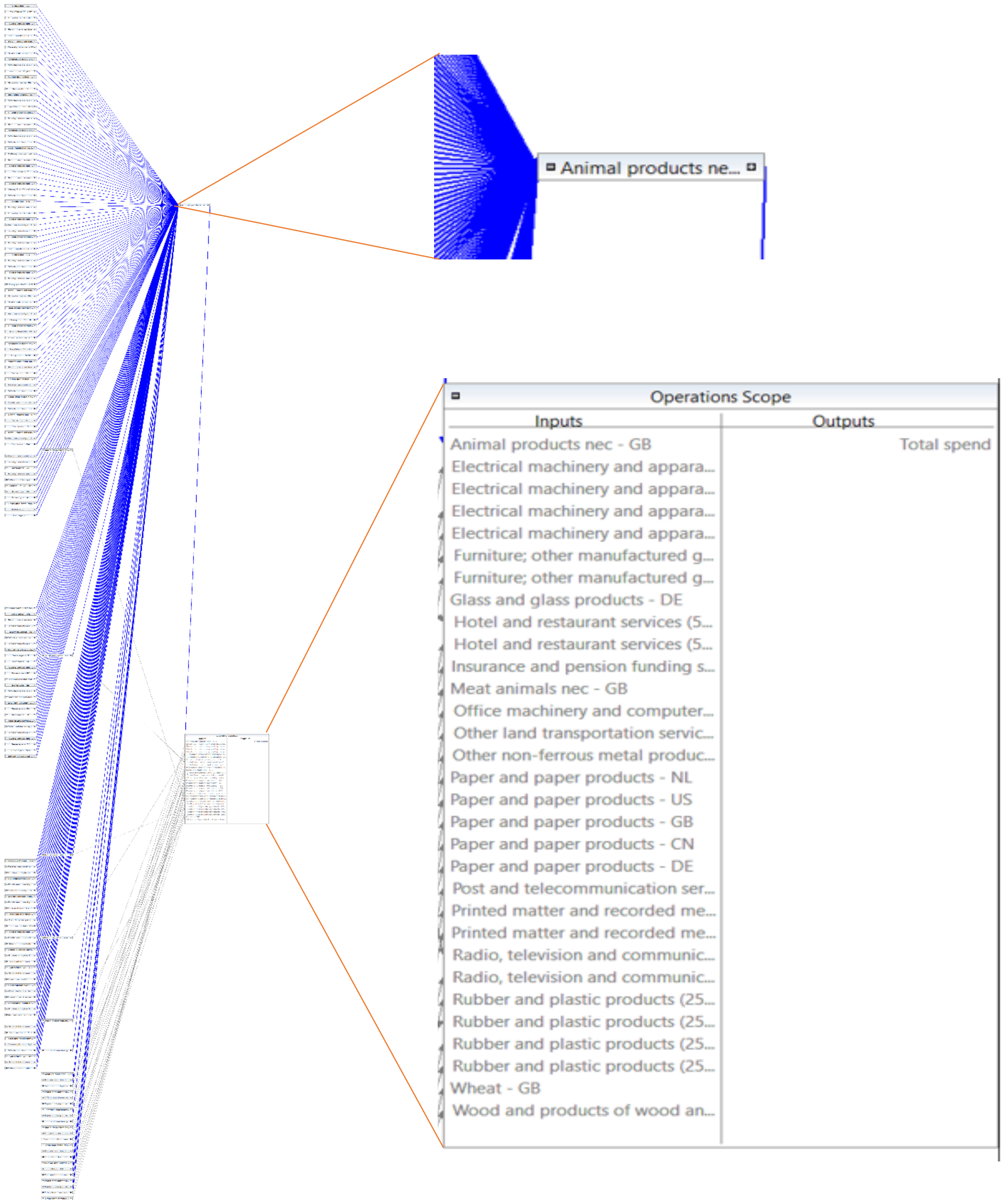
Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoided pro...	Provider	Data quality ...	Description
Total spend		**9.06258E7**	**EUR**		**none**				

Figure 4: *Input/Output table in OpenLCA, whereby the inputs are total spend in each industry/product flow in each country, and the output is the sum of all the inputs*

---

[16] https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator?number.Sections%5B0%5D.Fields%5B0%5D.Value=1&current_year=1139.3&comparison_year=927.8
[17] British Pound to Euro Spot Exchange Rates for 2011

To produce separate mid-point impacts by aspect and scope, separate IOTs were constructed for spend in construction, research and operations. Once IOTs were completed, supply chain graphs could be constructed[18], such as the supply chain graph represented in figure 5.



Operations Scope

Inputs	Outputs
Animal products nec - GB	Total spend
Electrical machinery and appara...	
Electrical machinery and appara...	
Electrical machinery and appara...	
Electrical machinery and appara...	
Furniture; other manufactured g...	
Furniture; other manufactured g...	
Glass and glass products - DE	
Hotel and restaurant services (5...	
Hotel and restaurant services (5...	
Insurance and pension funding s...	
Meat animals nec - GB	
Office machinery and computer...	
Other land transportation servic...	
Other non-ferrous metal produc...	
Paper and paper products - NL	
Paper and paper products - US	
Paper and paper products - GB	
Paper and paper products - CN	
Paper and paper products - DE	
Post and telecommunication ser...	
Printed matter and recorded me...	
Printed matter and recorded me...	
Radio, television and communic...	
Radio, television and communic...	
Rubber and plastic products (25...	
Rubber and plastic products (25...	
Rubber and plastic products (25...	
Rubber and plastic products (25...	
Wheat - GB	
Wood and products of wood an...	

***Figure 5**: Left - Supply Chain for spend in the scope of Operations, focussing on the first input (top right – 'Animal products nec – GB). The supply chain is cut-off to one product flow/process step for the Animal products input. Bottom right – IOT for the operations scope.*

---

[18] It is important to note that when constructing supply chains and carrying out the LCIA, a product system cut off of 1e-5 had to be inputted to create a product system. This cut-off had to be put in place to access the large database of Exiobase 3. Only computers with a large enough memory and processing power would not require a cut-off point in the supply chain construction.

Following the construction of supply chains, different impact assessment (LCIA) methods were implemented, including 'CML 2001[19]' and 'Exiobase 3 – Other Impacts', to quantify mid-point impacts. These impacts include acidification, eutrophication, toxicity (to marine, freshwater and terrestrial ecosystems), land use[20] and water consumption[21]. Moreover, these impacts could be allocated to different countries, based upon the spatially explicit supply chain data that Exiobase 3 contains. This could help inform and shape the University's biodiversity net gain Strategy, as these data estimate which regions of the world, and thus which ecosystems, the university may be deleteriously affecting. Achieving biodiversity net gain across the University will require some degree of offsetting, and best practice (as well as financial feasibility) dictates that offsets should be as close as possible to the point of at which the biodiversity loss for which they compensate is caused. Consequently, having some understanding of the geographical location of residual impacts is necessary to decide where offsets should be implemented.

(2) Due to time constraints, this method is only used in the Resource Use & Waste and Built Environment aspect of the report to quantify mid-point impacts of supply chains from purchasing data. However, the use of Exiobase to quantify and locate mid-point impacts could be used in other aspects of the report in the future. For example, this method could be used to analyse the supply-chain impacts of electricity consumption, which falls under the Built Environment Aspect. Therefore, the use of Exiobase 3 is likely to be a useful tool for future environment impact assessments.

(3) The following are some key limitations of the Procurement Data Analysis:

- Approximately 59% of all invoices in the Procurement Report were labelled under 'Missing Value', with no detailed indication of how and where the money was spent. Therefore, this data couldn't be interpreted for analysis, but potential impacts were considered in the error bars found in figures 29 and 32. Of the remaining spend data, not all purchasing categories could be matched to an Exiobase 3 flow or industry. In particular, financial, electronic and rental services couldn't be matched. Of all classified spend data, only 28% could be matched to a relevant Exiobase flow or industry.
- As a result of both these limitations, only ~22% of spend data being entered into an IOT for LCIA, with the impacts of the other 78% of spend data unaccounted for. Whilst this may present a large data gap, there are currently less LCA data available for service industries, which may produce smaller mid-point impacts due to their reliance on intellectual, rather than physical goods.
- Like the HESCET report, the procurement data analysis relies upon accurate categorisation/coding by those submitting invoices, and according to the UPD, incorrect categorisation is common.

---

[19] CML 2001 is an impact assessment method developed by the Institute of Environmental Sciences, Leiden University.

[20] This mid-point impact was taken to be land use occupied by annual crops, as no land use type was specified by the LCIA method 'Exiobase – other impacts'. This was taken to be an accurate representation of land use as the LCIA outputs for land use could be further broken down into previous steps in the supply chain, which for the most part, included agricultural activities. However, this land use mid-point is taken to only account for land occupation, rather than transformation.

[21] The sum of Blue and Green Water Consumption.

(3) Converting mid-point impacts into end-point outcomes for biodiversity

In order to convert mid-point impacts into outcomes for biodiversity (i.e. stage 2 → 3 above), characterisation factors are employed from a widely used set of pressure-impact models called ReCiPe (2016)[22]. The ReCiPe biodiversity metric used in this analysis is measured in terms of *local* species loss integrated over a year ('species.year').[23] In this report, 'species.year' is referred to as 'biodiversity impact score' (BIS), to prevent the misinterpretation of this biodiversity metric as an absolute measure, rather than a relative measure of biodiversity loss. ReCiPe was developed for and is widely used as a Life Cycle Impact Assessment (LCIA) methodology[24], and has been applied as part of other biodiversity foot-printing approaches[25] – such as the Biodiversity Footprint for Financial Institutions (BFFI) tool[26] and 'BioScope[27]' tool.

In this analysis, the ReCiPe 'mid-to-endpoint' characterisation factors for 'ecosystem quality' were applied to each mid-point impact that was estimated. Biodiversity end-point impacts on terrestrial, freshwater and marine species are then summed for each mid-point category and compared between activities. For clarification, the ReCiPe methodology publishes three sets of factors based on different scenarios/perspectives:[28] for the purposes of this analysis, characterisation factors from the global average 'hierarchist' perspective were used[29]. The mid-point impacts assessed in this project, the resultant pressures on biodiversity, and their associated metrics and characterisation factors are all summarised in the supplementary material.

It is important to emphasise that this indicator is used to identify *potential* sources of pressure on biodiversity, rather than to quantify impacts in an absolute sense. Furthermore, biodiversity impacts are highly spatially variable, and often depend significantly on the location, size and type of habitat where they take place. In this analysis, spatially explicit mid-point impacts could only be considered for university procurement/spend data, whereby an EE MRIO was used to calculate mid-point impacts. All other aspects of this report estimated mid-point impacts using global averages due to a lack of spatial granularity, meaning that the potential mid-point and thus end-point impacts calculated should be interpreted with caution.[30] As spatially explicit mid- and end-point indicators continue to be developed, future use of EE MRIOs could be extended to all aspects of this report. Nevertheless, the use of EE

---

[22] Huijbregts et al. (2017)
[23] This is modelled based on the relative potentially disappeared fraction (PDF) of species integrated over time and space: PDF of species in a m^2 over a year for terrestrial species, and PDF of species in a m^3 over a year for aquatic species. To convert these to a common metric for both terrestrial and aquatic species ('species.year'), ReCiPe incorporates species densities for terrestrial, marine and freshwater ecosystems. More information can be found here https://www.rivm.nl/en/life-cycle-assessment-lca/recipe. See also Huijbregts et al. (2017)
[24] Hauschild et al. (2011)
[25] Lammerant (2019)
[26] Berger et al. (2018)
[27] The bioscope tool uses the Exiobase 2.2. database, along with ReCiPe to calculate biodiversity end-point impacts: https://pre-sustainability.com/legacy/download/Supply-Chain-Biodiversity-Tool-BioScope.pdf . Pre consultancy are currently updating this tool to incorporate the Exiobase 3 database which is used in this assessment.
[28] (1) The 'individualistic' perspective is based on the short-term interest, impact types that are undisputed, and technological optimism with regard to human adaptation. (2) The 'hierarchist' perspective is based on scientific consensus with regard to the time frame and plausibility of impact mechanisms. (3) The 'egalitarian' perspective is the most precautionary perspective, taking into account the longest time frame and all impact pathways for which data is available.
[29] Except where country specific conversion factors are available for Eutrophication, Acidification and Water Consumption. These country specific factors were used for supply chain midpoint impacts, where country specific values were available.
[30] See Crenna et al. (2019) for a similar discussion

MRIOs in aspects of this report is an important first step in formulating a spatially-explicit biodiversity net gain strategy for the university.

3. Impacts by Environmental Aspect

This section explores each aspect of the University's activities in turn (Travel, Food, Built Environment, Natural Environment, and finally Resource Use & Waste). Each section begins with a brief overview of the aspect, including a description of current and proposed actions described in the University's draft Sustainability Strategy. Following this is a description of the relevant activity data sources, categorised by sphere (I and II) and organisational scope (research, education, operations), and any assumptions made to estimate activity data values. Next, the methods and results for mid-point impacts and end-point impacts on biodiversity are described and visualised in turn. Finally, key data gaps are highlighted and recommendations for actions to be taken are suggested.

3.1 TRAVEL

3.1.1 Aspect Overview

National and international travel is integral to the delivery of operations, research and education at the University. It is also a highly visible environmental aspect, particularly given the degree to which transport is focused upon because of its contribution towards global greenhouse gas emissions.

This section relates to the direct and indirect impacts associated with University travel, including: business travel; student and staff commuting; international and domestic student travel; and the upstream impacts associated with the procurement of fuel and vehicles. Note that transport for the delivery of goods and services in the University supply chain (freight) is not included in this section, as this would be considered under the 'resource use and waste' aspect of this report.

The focus here is on greenhouse gas emissions and air pollution as key impacts of travel. This is partly because these impact categories are the ones for which travel is considered likely to make a relatively large impact compared to other aspects. Contributions made by travel in the other impact categories are likely to be primarily associated with transport *infrastructure* (e.g. roads, railways, airports), which is not part of this assessment, as that is generally already in place and outside of the University's sphere of influence, so is not assessed here.

Nonetheless, though quantification of the impacts of travel in sphere I focused on greenhouse gas emissions and air pollution, other impact categories were included using the life cycle literature in relation to sphere II impacts (primarily upstream fuel impacts, and embodied impacts in the manufacture of purchased vehicles).

Travel in the current draft Environmental Sustainability Strategy

Within the Universities' environmental sustainability strategy, travel is broken down into international (7.7) and local (7.8) travel commitments. Regarding international travel, the University has committed to develop a travel policy which incorporates a 'Travel Hierarchy' framework (7.7.2) for all domestic and student travel as follows:

- Avoid travel;
- Reduce travel demand to and from the University;
- Travel without flying; and
- Fly when there are no alternatives and offset these emissions through the Oxford Sustainability Fund.

This policy sits amongst other travel related pledges, such as rolling out engagement programmes to encourage the use of the travel policy (7.7.3) and levying a sustainability charge on business flights to contribute towards the Oxford Sustainability Fund (7.7.5).

Concerning local travel, commitments relate to supporting the construction (7.8.1) and use (7.8.3, 7.8.4 and 7.8.5) of sustainable travel infrastructure, in addition to reducing the requirement for staff commuting (7.8.2).

Data Gaps Addressed from previous report

1. Undergraduate Fieldwork Flights: All faculties that organised undergraduate fieldwork trips were contacted, and data regarding fieldwork destination, mode of transport and number of students were gathered. Although all international undergraduate fieldtrips had been cancelled due to COVID-19, the ability to collect this data suggests that it will be a useful source of travel data in future impact assessment reports.

2. Undergraduate Year Abroad Flights: On contacting the Faculty of Medieval and Modern Languages, Year Abroad location data was collected and travel data could be estimated. This travel data is a new addition to this report, so will provide additional mid-point impacts in the sphere I category of Travel impacts. A detailed description below of how these mid-point impacts were calculated can be found below in the 'Data notes and Assumptions' section.

3. Domestic Student Travel Estimates: using aggregated postcode data provided by the Student Data Management and Analysis team, this report was able to calculate the average driving distances of each student from home to Carfax Tower, Oxford. Assuming that all individuals took two return trips home by car in the academic year 2019-20, mid-point impacts of air pollution and GHG emissions were then calculated.

3.1.2 Data Sources

Table 7 provides a summary of activity data sources, organisational scope and sphere for each activity considered within the travel aspect. Assumptions made in collating, processing and analysing the data are listed after the table.

***Table 7**: Available data on University travel by source, categorised by sphere and scope*

Sphere	Activity Description	Scope	Activity data source(s)	Data description
I	Business travel: University-owned vehicle fleet mileage	Operations	ESOS 2019	*Estimates for mileage and fuel consumption for the University fleet of 2019.*
I	Business travel: flights	Research	Key Travel Scope 3 Report 2019-20	*Distance (in passenger kilometres) and carbon emissions for each flight booking made through Key Travel, the University's preferred travel company. This takes into account different classes of flight, as well as long or short haul flights.*
I	Business travel: grey fleet mileage	Operations	ESOS 2019	*Estimates for mileage and fuel consumption from employee-owned vehicles used for University purposes, as well as University motor rentals in 2019.*
I	Business travel: rail	Research	Key Travel Scope 3 Report 2019-20	*Distance (in passenger kilometres) and carbon emissions for each rail journey booked through Key Travel, the University's preferred travel company. This considers whether each trip was domestic or international.*

I	Undergraduate Educational Travel	Education	Departmental Fieldtrip and Year Abroad Dataset 2019-20	*The Placement locations of each student completing a year abroad in 2019-20.*
II	Staff Commuting	Operations	EMR 2019-20	*Estimates for annual passenger kilometres travelled and carbon emissions from staff commuting, based on travel survey data from 2019.*
III	Student Commuting	Education	EMR 2019-20	*Estimates for annual passenger kilometres travelled and carbon emissions from student commuting, based on travel survey data from 2019.*
III	International Student Flights	Education	Student domicile and headcount statistics 2020	*Student headcount data categorised by country of domicile. Includes all undergraduates, taught and research postgraduates & visiting students (VROs).*
III	Domestic Student Travel	Education	Domestic Student Postcode Data 2019-20	*Home Postcodes of all students, including undergraduates, taught and research postgraduates and visiting students (VROs).*
III	Purchased vehicle fuel (upstream impacts)	Operations	ESOS 2019	*Estimated fuel consumption in 2019 based on either (1) actual fuel consumption recorded by departments, (2) predicted fuel consumption based on mileage provided by departments and average mile-per-gallon provided by vehicle manufacturers or HM Department for Transport, or (3) estimated fuel consumption based on cost of fuel.*
III	Purchased vehicles (upstream impacts)	Operations	University Fleet List 2020	*New vehicles added to the University fleet in 2019-20.*

Data notes and assumptions

<u>Estimates of mileage and subsequent fuel consumption of grey and university fleet:</u> As the ESOS report is only returned every 4 years, the estimates of mileage and fuel consumption from both fleet types had to be calculated from the latest 2019 report. A major assumption in this report includes that the grey fleet mileage reduced by 37% between 2018-19 to 2019-20, accounting for the fact that no business travel took place for 19 weeks between 23rd March – 31st July due to COVID-19. This estimate was made by the Travel Team within the OUES based upon knowledge of business travel behaviours. Moreover, there is an underlying assumption here that grey fleet size has not changed annually, as this data is only collected in the ESOS report, and thus is unavailable for 2019-20.

A different assumption is made for university fleet mileage, as it assumes that per vehicle fuel consumption has remained constant between 2018-19 and 2019-20, with COVID-19 not inhibiting operational transport. Moreover, university fleet mileage accounts for an increase in fleet size as the fleet list for 2020 is available, assuming that the new fleet vehicles have the same average fuel consumption rates and mileage as the fleet of 2019.

<u>Student and staff commuting calculations:</u> Total passenger kilometre data was used here that had been calculated previously for the University Estate Management

Records (EMR)[31]**.** These estimates are based on travel surveys undertaken at the University and use average distances travelled per mode of transport, considering differences in the number of working days for staff and different types of student (i.e. undergraduate vs. postgraduate). As no travel survey had taken place in 2020, calculations from 2019 had to be used, using updated conversion factors (DEFRA/DBEIS 2020 and NAEI 2019 conversion factors) and student and staff headcounts to estimate mid-point impacts. Moreover, to account for COVID-19, the assumption that staff and students only travelled for 33 weeks of the academic year was made, leading to a reduction in passenger kilometres travelled by 36.5% from 2019.

Undergraduate Educational Flights: Due to COVID-19, all undergraduate fieldtrip flights were cancelled as many fieldtrips were planned to go ahead in Trinity Term, thus no fieldwork flights were accounted for in this report. However, the Faculty of Medieval and Modern Languages confirmed that undergraduate students undertaking a language degree were able to undertake ~2/3rds of their Year Abroad before March 23rd (the beginning of the first UK Lockdown[32]). Therefore, 2/3rds of all Year Abroad flights were accounted for in this report.

Several assumptions were made in the estimation of frequency and distance of Year Abroad flights taken, as only 'placement location' data for each individual student was available. This meant that each student could have 1-3 placement locations across a single year, giving no indication of the frequency of travel to each location. However, after discussion with the faculty Year Abroad Office, two likely scenarios were constructed:

(1) One return flight was afforded for each student placement, and to account for COVID-19, students that had a 3rd placement did not travel to that location as it was likely to take place after international flights were halted.
(2) One return flight was afforded for each student placement, and for those students that only had one placement, two return flights were afforded to that placement location. In line with the above scenario, it was assumed that no travel was made to the 3rd placement.

In addition to the above assumptions, it was assumed that all students travelled to their Year Abroad Placements by flying, and not by other modes of transport such as rail. This assumption was suggested by the Year Abroad Office as flights are often the cheapest, and most direct mode of transport to placement locations.

To more accurately account for Year Abroad student travel behaviours, it is recommended that a travel survey is integrated into the year abroad data collection by the Year Abroad Office. This survey could collect data on the frequency and modes of travel by Year Abroad Students.

Domestic Student travel: It was assumed that all domestic (non-international) students took two return trips by car from home for the academic year 2019-20. Driving distances from home were calculated by averaging the minimum and maximum 'as the crow flies' distance from Carfax Tower to each student postcode, which is likely to

---

[31] Available at https://www.hesa.ac.uk/data-and-analysis/estates/environmental
[32] More information available here: timeline-lockdown-social (instituteforgovernment.org.uk)

be an underestimate of the actual driving distance from student homes to Oxford. Moreover, this 'two-return trip' scenario is a conservative scenario, with each return trip counting for one trip to or from Oxford (assuming that a student is dropped off and the car returns home without the student). In addition, this method assumes that no other mode of transport by students is used to travel to Oxford.

Scope of business travel: Rail and air travel are assumed to be carried out primarily for research purposes, since more than ~95% of flights and rail journeys in the Key Travel dataset are associated with research departments (i.e. not University Administrative Services, Student Services, or University-Owned Colleges). Mileage from University-owned vehicles ('University fleet') or from vehicles owned by staff ('grey fleet') is assumed to relate to operational purposes, since the majority of vehicle mileage came from operational vehicles (in the case of the University fleet) or could not be distinguished between operational and research departments (in the case of grey fleet) based on the data provided.

International student travel: the total passenger kilometres from international student travel to and from the University were calculated using domicile and headcount statistics for the whole student body (in 2020)[33]. It was assumed that all listed international students were based in Oxford, that all international journeys were undertaken by air, and that the same number of journeys were made regardless of student status (i.e. undergraduate, postgraduate, visiting students etc).

Since survey data on international student travel is not currently available, assumptions were made regarding the number of flights and flight routes taken by students. In terms of flight distances, the simplest linear flight distances between England and country of origin were estimated, using the CEPII GeoDist database, which provides bilateral distance values between countries.[34] For the 9 countries whereby distances weren't available on this database, the website 'distance.to' was used to provide linear flight distances between countries[35]. These distances were doubled to calculate the total passenger kilometres per return trip (i.e. one trip to Oxford, and one returning to the country of domicile). Student journeys were separated into two categories based on the distance between countries, whereby trips >3700km = 'long-haul', and trips <3700km = 'short haul'[36], see table 8 for breakdown). Total passenger kilometres travelled per year were then calculated based on the following candidate scenarios:

(1) One return flight per year for all international students (taken here as the main estimate);
(2) One return flight per year for students taking long-haul journeys and two return flights per year for students taking short-haul journeys[37];
(3) Two return flights per year for all international students; and
(4) Three return flights per year for all international students.

---

[33] Available at https://public.tableau.com/views/UniversityofOxford-StudentStatistics/DomicileNationalityDetail?:embed=y&:display_count=yes&:showVizHome=no
[34] Mayer & Zignago (2011)
[35] Available here: Distance calculator - Calculate the distance online!
[36] Threshold taken from the 2019 Government Greenhouse Gas Conversion Factors for Company Reporting Methodology Paper for Emissions Factors (Hill et al. 2019)
[37] Accounting for the fact that students from closer countries (e.g. within Europe) may be likely to travel more frequently than students from more distant countries.

International student travel survey data from Glasgow Caledonian University[38] indicate that students are more likely to select cheaper and indirect flights, rather than the fastest flight routes available. By way of incorporating this information, 10% is nominally added to the distance for scenarios (2), (3) and (4) to provide a rough proxy for indirect flight paths.

University owned departmental vehicles: A newly purchased vehicle was defined as a vehicle that was newly registered under the University fleet list of 2020 in comparison to 2019. This includes 11 new vehicles. Some of these may have been replacements/upgrades for leased vehicles, but this was ignored for the purpose of the assessment. Mileage for electric vehicles was not provided and emissions from charging electric vehicles is assumed to be included within 'electricity consumption' under the Built Environment aspect of this report.

Key Travel: Roughly 40% of bookings associated with staff travel are thought to be made through Key Travel, the University's preferred supplier for travel bookings. Mileage and carbon estimates provided by the Key Travel Scope 3 Carbon Report are therefore assumed to be representative of all business travel (flights and rail) and factored up to 100% to estimate total mileage and emissions.

3.1.3 Mid-point Impacts

GHG emissions: Sphere I

All GHG estimates for travel under sphere I have been calculated using the 2020 Government Greenhouse Gas Conversion Factors for Company Reporting provided by Defra/DBEIS (see supplementary material for all specific factors used). The vast majority of GHG emissions data were taken directly from estimates provided by the University (as listed in Table 7), with the exception of international student flights.

For international student flights, the estimated number of passenger kilometres travelled was multiplied by the Defra/DBEIS GHG conversion factors for the appropriate flight category – i.e. long-haul or short-haul. Note that factors for the 'average passenger' are used here, and that these are inclusive of radiative forcing. A breakdown of estimated emissions for each scenario described above is provided in table 8.

GHG emissions: Sphere II

Much of the literature relevant to sphere II emissions has focused on 'well-to-tank' (WTT) GHG emissions, i.e. upstream emissions associated with the extraction, refining, and transportation of fuels. Defra/DBEIS publish WTT emissions factors, which have been used here in combination with fuel consumption data from the University vehicle fleet and for the grey fleet (provided in the ESOS 2019 data) to estimate this sphere II impact. Similarly, the production of vehicles is a carbon-intensive process, with average European cars consuming 5-11 tCO_2e and 7-15 tCO_2e per vehicle manufactured, for internal combustion and electric vehicles respectively[39]. The number of cars added to the University fleet in 2019/20 was 9 (8 internal

---

[38] Cruz (2014)
[39] European Environment Agency (2018)

combustion and 1 hybrid). GHG emission were obtained by multiplying these figures by the average CO_2e value for the relevant kerb weight class, as quantified in a meta-analysis of European vehicle life-cycle CO_2e emissions by (Ellingsen et al. (2016). The results for GHG emissions from travel are summarised in Figure 6.

Figure 6: *GHG emissions from University travel, summarised by sphere and activity. For international student travel, the bar chart represents the baseline scenario of one return trip per international student, with the error bar indicating the most impactful flight scenario (3 return trips per student, plus 10% to account for indirect flight routes). A more detailed breakdown of these scenarios is shown in Table 8 below. For domestic student travel, the error bar represents the GHG emissions of 6 return trips.*

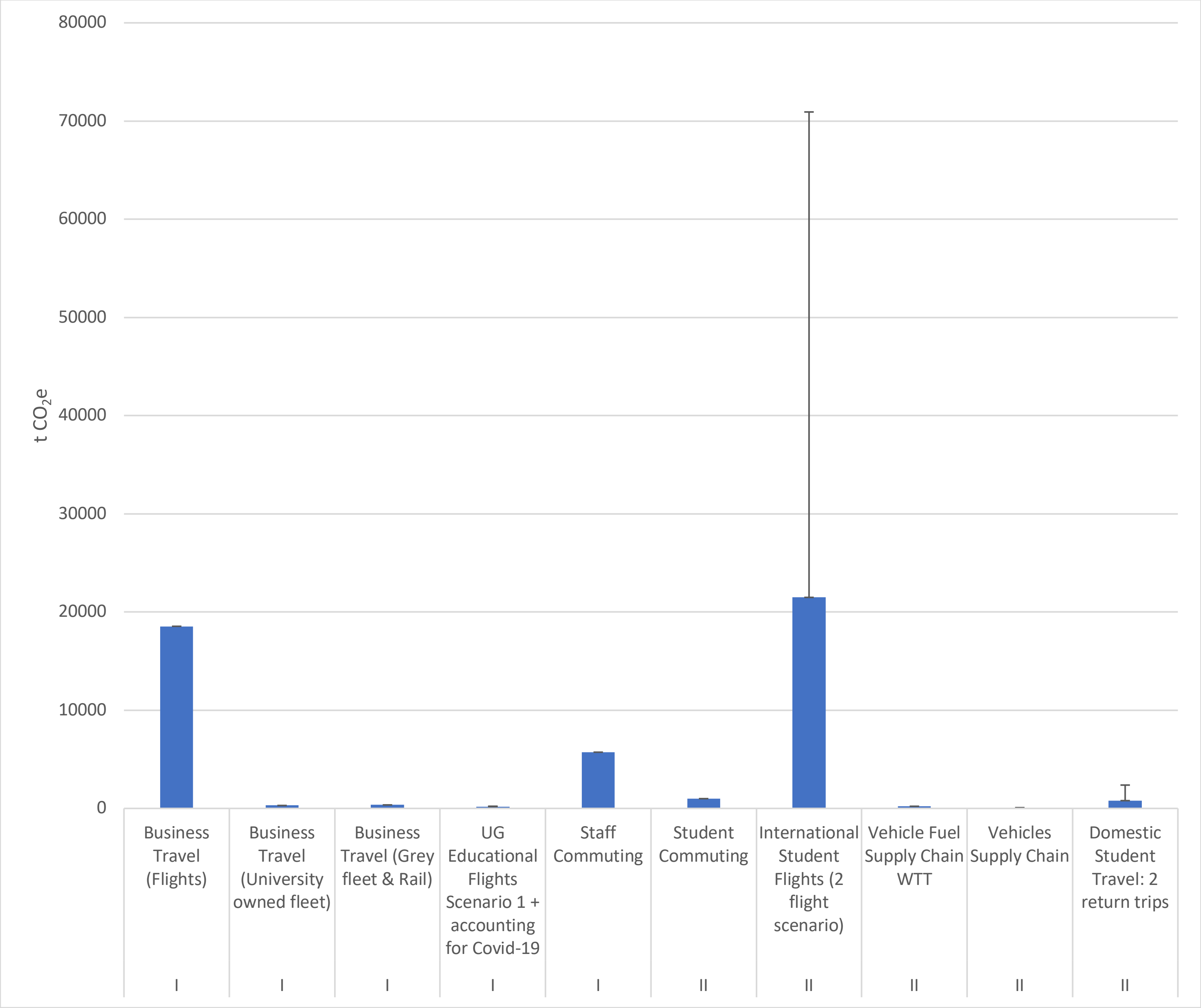


Table 8: *Estimated carbon emissions from student flights, assuming different potential scenarios for number and distance of flights taken per student.*

Number of international students	***Scenarios: number of flights taken***	***Total estimated distance (passenger.km)***	***Estimated emissions based on Defra/DBEIS emissions factors (t CO_2e)***
Total: **Number of students travelling short-haul (<3700km):** **Number of students travelling Long-haul (>3700km):**	*1 return trip per student*	114204152.9	21492.51445
	2 return trips for short-haul, 1 return trip for long-haul	122708415.4	22817.22998
	2 return trips for short-haul, 1 return trip for long-haul, plus 10% to account for indirect flight routes	134979256.9	25098.95298
	2 return trips per student	228408305.9	42985.0289
	2 return trips per student, plus 10% to account for indirect flight routes	251249136.5	47283.53179
	3 return trips per student	5501693.143	64477.54335
	3 return trips per student, plus 10% to account for indirect flight routes	6051862.458	70925.29769

Air Pollution

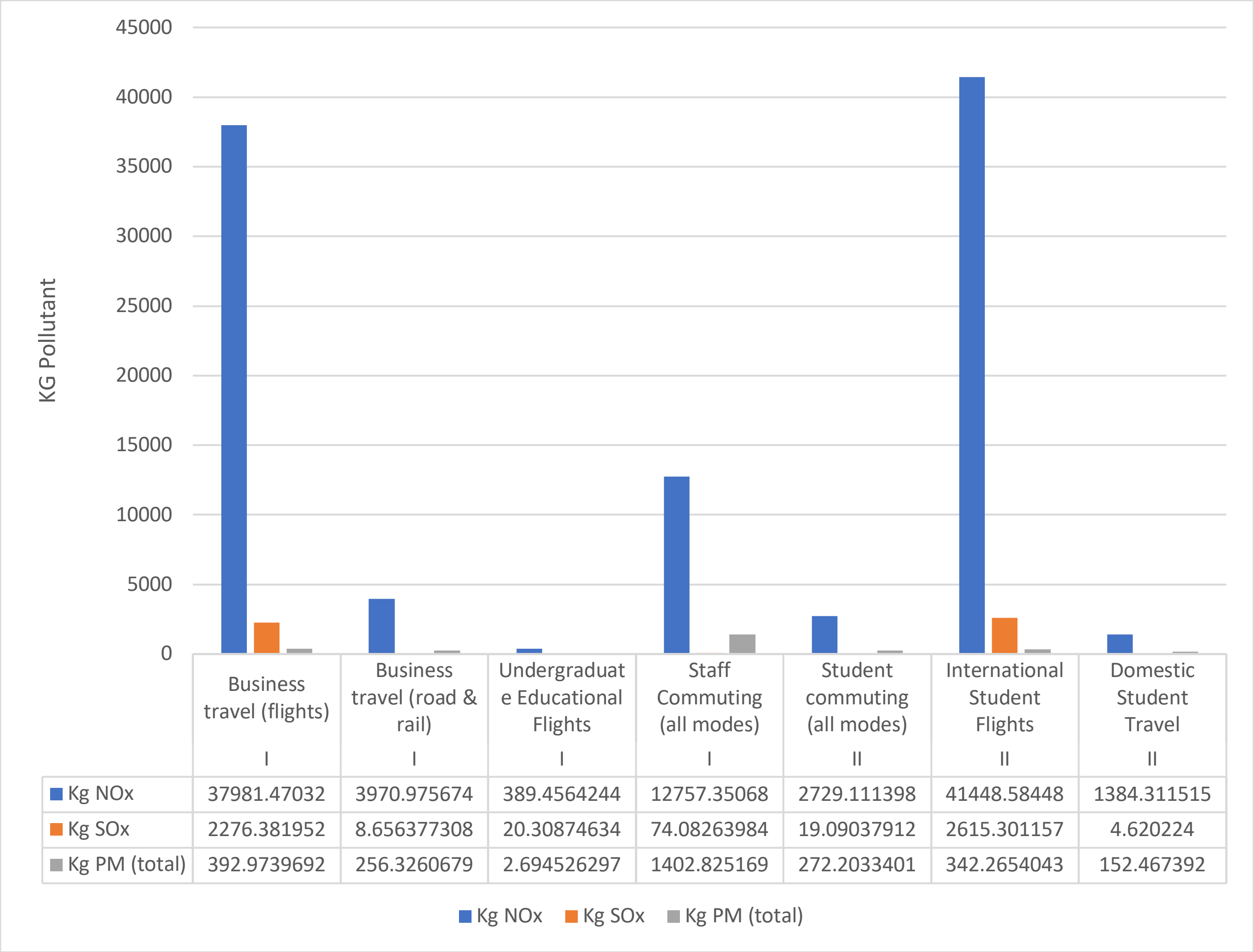
In this category, activities causing air pollution (i.e. all other pollutants to air aside from GHGs) are split into spheres I – II in the same way as for GHGs above, and the same activity data are used as the basis for calculations. Here, each form of transport is explored in turn. Note that all specific conversion factors and their sources are listed in the main supplementary material accompanying this report.

Road: Road transport includes University-owned and grey fleets, and all student and staff commuting by any mode (car/bus/motorcycle). Estimated mileage was paired with the UK fleet-weighted conversion factors provided by the National Atmospheric Emissions Inventory (NAEI). These are broken down by (a) exhaust emissions (combined hot exhaust and cold start, averaged across road types), and (b) emissions from brake, tyre and road abrasion (i.e. particulate matter). NAEI emissions factors are provided per km, rather than per passenger km. Emissions from buses were therefore divided by the average passenger occupancy for local buses in England in 2019/20 as reported by the Department for Transport (= 12.58 passengers).

Rail: This includes all known student and staff commuting by rail. Emissions factors were estimated from air pollution inventory data for various transport modes as published by the Department for Transport.

Aviation: Emissions factors for air pollution from aviation (business travel and international student travel) are not as readily available as those for other modes of transport, since emissions vary depending on the length of the flight, the relative amount of time spent in the 'landing and take-off' (LTO) phase, and the aeroplane model/engine type. These were therefore calculated based on a reference flight, using the average flight length and a reference aeroplane model for domestic, short-haul and long-haul flights (models listed in the supplementary material). Air pollutant emissions per kg of fuel burn could then be calculated for each reference flight using the 'master emissions calculator tool' published alongside the European Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2019).[40] This tool estimates the total pollutant emissions and mass of fuel burnt, based on the distance travelled and aeroplane model type.

The total fuel consumption from business and student aviation (assuming the basic 'one return flight per student per year' scenario) was calculated using the average fuel per passenger kilometre value published in the European Aviation Emissions Report (2019) (0.027 kg fuel per passenger.km[41]). Total fuel consumption was then paired with the emissions factors from reference flights to estimate air pollutant emissions as a result of University activities. Here, results are reported for NO_x, SO_x, and PM (combined PM2.5 and PM10) only. The rationale is that: (i) they are the most frequently reported pollutant emissions for travel; (ii) NO_x and SO_x have important links to ecosystem impacts through acidification and photochemical ozone formation; and (iii) other types of pollutant (e.g. volatile organic compounds) are not reported consistently between different vehicles, so are extremely hard to compare even in a relative sense.



	Business travel (flights) I	Business travel (road & rail) I	Undergraduate Educational Flights I	Staff Commuting (all modes) I	Student commuting (all modes) II	International Student Flights II	Domestic Student Travel II
■ Kg NOx	37981.47032	3970.975674	389.4564244	12757.35068	2729.111398	41448.58448	1384.311515
■ Kg SOx	2276.381952	8.656377308	20.30874634	74.08263984	19.09037912	2615.301157	4.620224
■ Kg PM (total)	392.9739692	256.3260679	2.694526297	1402.825169	272.2033401	342.2654043	152.467392

---

[40] See part B section 1.A.3.a Aviation 1 Master emissions calculator 2019 (https://www.eea.europa.eu/publications/emep-eea-guidebook-2019)
[41] EASA, EEA & EUROCONTROL (2019)

***Figure 7**: Air pollutant emissions for NO_x, SO_x and PM by activity and sphere, with data table*

Other impacts: Sphere II

The fuel and vehicles purchased and used for University purposes also cause various embedded environmental impacts, such as the release of pollutants during the mining and processing of raw metals, or the emissions of NO_x, SO_x, and PM as a result of energy consumption during manufacture and assembly. These have been addressed by the LCA literature, although not as extensively as GHG emissions. LCA studies in this area often express life-cycle environmental impacts of a vehicle per kilometre driven, allowing for easier comparison between different vehicles. This requires making assumptions regarding the lifetime mileage of the vehicle (which can be a significant source of uncertainty), but it also means that results could be paired with fleet mileage to broadly estimate the whole life-cycle environmental impacts associated with vehicle use and fuel consumption.[42]

Emissions factors were identified from the LCA literature (primarily Hawkins *et al.*, 2013 and Stephan and Crawford, 2016) and were paired with mileage data for the University-owned and grey fleets (split by fuel type) to provide an order-of-magnitude approximation of sphere II environmental impacts (see Table 9). Data from Hawkins *et al*. was recently incorporated into the European Environment Agency TERM Report (EEA, 2018), and results are of a similar order of magnitude to other studies mentioned in the same report.

***Table 9**: conversion factors used to estimate embedded impacts from the University fleet, and associated estimates for a range of mid-point impacts.*

Source	Conversion Factor - Diesel (quantity of pollutant per km)	Conversion Factor - Petrol (quantity of pollutant per km)	Impact based on fleet mileage & fuel type	Environmental Impact Metric	Mid-point impact
Hawkins et al., 2013	0.00079	0.00089	2767.00	kg SO_2 eq.	Terrestrial acidification
	0.00005	0.00005	167.62	Kg P eq.	Freshwater Eutrophication
	0.00009	0.00008	289.85	Kg N eq.	Marine Eutrophication
	0.00146	0.00151	4593.79	Kg 1.4- DCB eq.	Freshwater ecotoxicity
	0.00188	0.00194	6373.66	Kg 1.4- DCB eq.	Marine Ecotoxicity
	0.1346	0.1398	4838.88	m^2.annual crop eq.	Land use
Stephan & Crawford, 2016	n/a	0.0064	19779.08	m^3 water	Water Consumption

It should be noted that in this case conversion factors are 'cradle-to-grave', and therefore include: Mining; Manufacture/Production & Transport; Use stage (Well-To-Wheel impacts associated with fuel consumption); and End of Life (EoL) (impacts from waste to landfill are therefore included in the assessment).

---

[42] See European Environment Agency (2018) for a useful summary

3.1.4 End-point Impacts on Biodiversity

The mid-point impacts for each of the activities described above were combined with the ReCiPe characterisation factors to estimate their relative impacts on biodiversity, following the method described in the general methodology section ('estimating impacts'). A breakdown of impacts on biodiversity from travel, categorised by sphere, is shown in Figure 8. Note that estimates for PM are not included in these calculations, as the appropriate characterisation factor is not provided in the ReCiPe methodology.

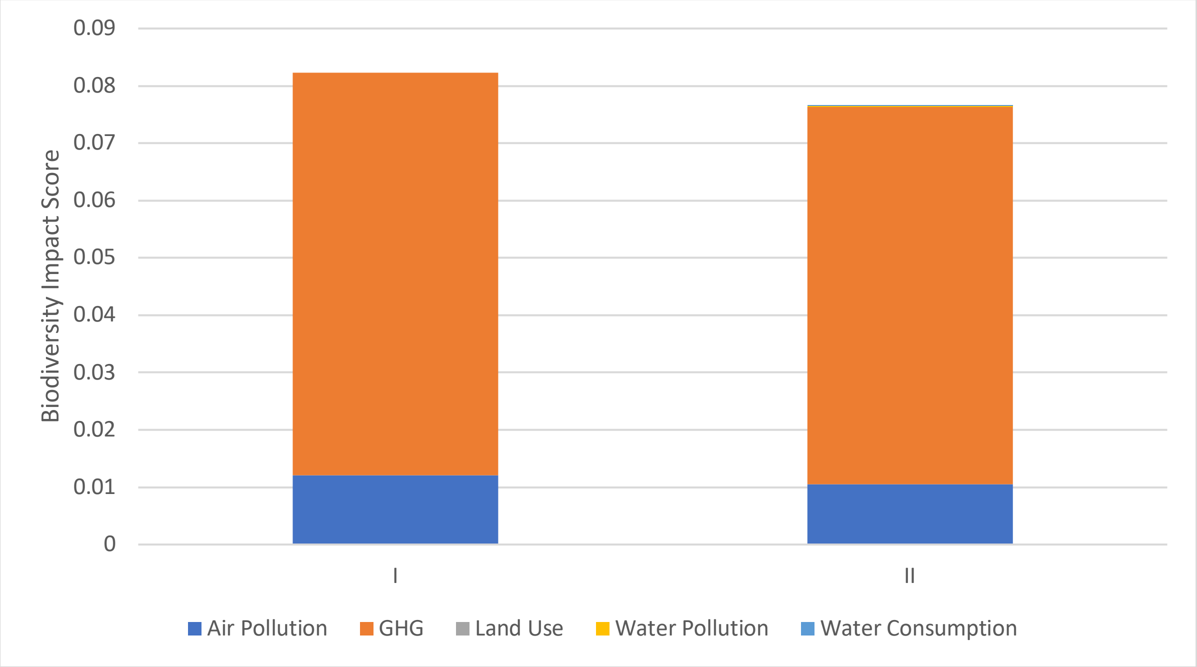


Figure 8: *Biodiversity impacts associated with University travel, categorised by mid-point impact and sphere.*

3.1.5 2018-19 vs 2019-20 Report Comparisons

The following section compares and explains the changes in mid-point impacts and subsequent end-point impacts on biodiversity from the previous preliminary assessment report. Explanations for annual change can be found in tables 10, with reductions in mid-point impacts largely due to COVID-19 reducing flight travel. It is important to note that the mid-point impact and end-point biodiversity impact comparisons do not include undergraduate educational flights or domestic student travel. This is for ease of comparison as both travel activities were not included in the preliminary assessment.

Mid-Point Impacts: GHG emissions

Figure 9 summarises the annual changes in GHG emissions, with table 10 providing brief explanations for these changes. These explanations are expected to broadly account for changes for Air Pollutant Emissions too. The largest absolute reduction in GHG emissions was for business travel flights, reducing carbon emissions by 11,451 t CO_2e.

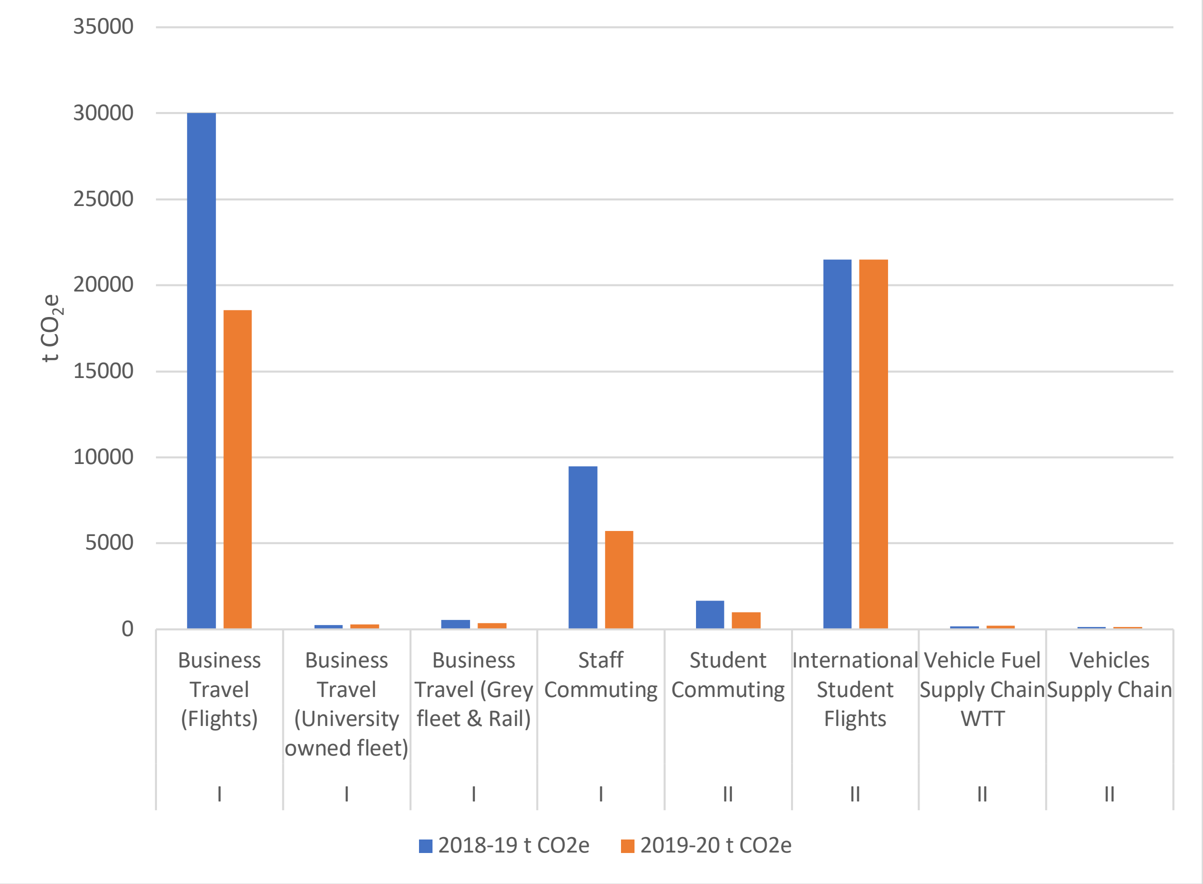


Figure 9: *Comparison of 2018-19 and 2019-20 GHG emissions from University travel, summarised by sphere and activity.*

Description	***Change t CO_2e emissions (%)***	***Reason for annual change***
Business Travel (Flights)	*-38.1727*	*Approximately 6% of flights were cancelled, with of these 86% flights cancelled after March 2020. It is expected that less flights were booked through Key travel after the first March lockdown.*
Business Travel (University owned fleet)	*+20.21006*	*Increase is expected with fleet size increase, with the OUES expecting that key operational travel by university owned fleet to continue throughout COVID-19 pandemic.*
Business Travel (Grey fleet & Rail)	*-34.21*	*Grey fleet mileage was assumed by the OUES to have reduced by 37% between 2018-19 and 2019-20, combined with cancelled rail journeys in the Key Travel Scope 3 report.*
Staff Commuting	*-39.5837*	*No commuting was estimated to have occurred after March 23rd, resulting in only 33 weeks of travel in 2019-20. Additional change can be accounted for by annual changes in DEFRA conversion factors.*
Student Commuting	*-39.9638*	*No commuting was estimated to have occurred after March 23rd, resulting in only 33 weeks of travel in 2019-20. Additional change can be accounted for by annual changes in DEFRA conversion factors.*
International Student Flights	*-0.09526*	*Change due to shift in international student home country locations and total number of international students. COVID-19 was not expected to change the fact that students had to return home at the end of the academic year.*

Vehicle Fuel Supply Chain WTT	*-4.03436*	*Overall, there was a decrease due to the 37% reduction in grey fleet mileage, counteracting the increase in mileage expected from the increase in university fleet size.*
Vehicles Supply Chain	*-46.5292*	*Only 9 new cars were purchased in 2019-20, in comparison to the 14 new cars that were purchased in 2018-19.*

***Table 10:** Description of University activity, annual change in GHG emissions and a brief explanation for the annual change.*

Mid-Point Impacts: Air Pollutants

Figure 10 and table 11 summarises the annual changes in air pollutant emissions, which can be accounted for by the explanations found in table 10. The largest reductions in air pollutant emissions are mainly due a reduction in Business Travel Flights, as illustrated in figure 10.

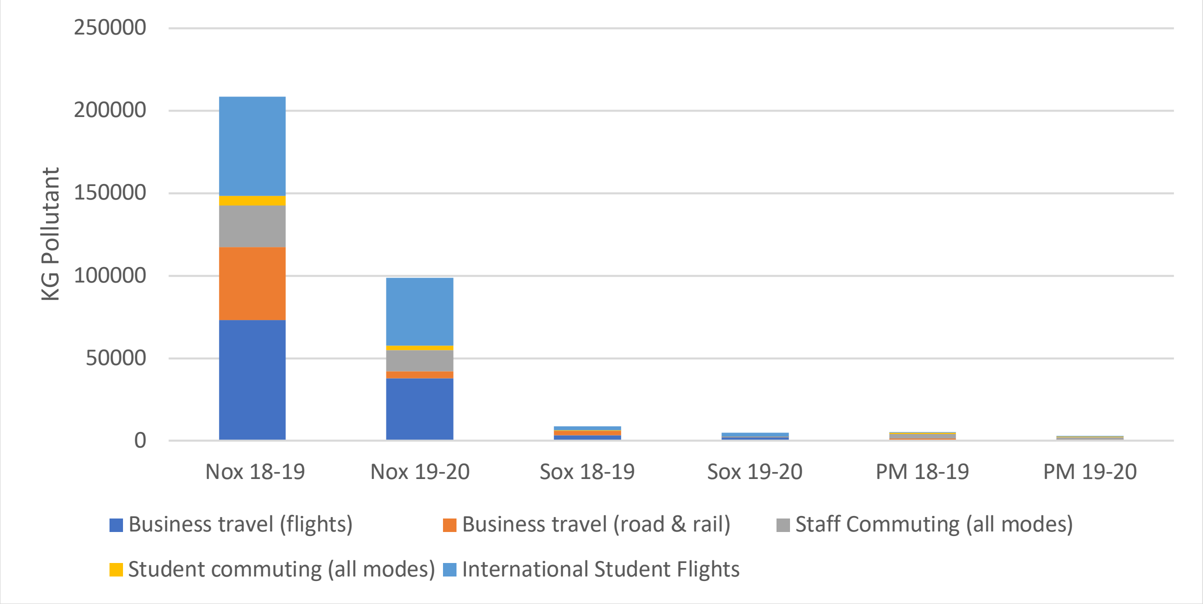


***Figure 10:** Comparison of 2018-19 and 2019-20 air pollutant emissions from University travel, summarised by air pollutant and activity.*

Pollutant	**Change in pollutant emissions (%)**
NO_x (kg)	-52.57
SO_x (kg)	-42.71
PM (kg)	-48.76

***Table 11:** Description of pollutant and associated annual change in emissions.*

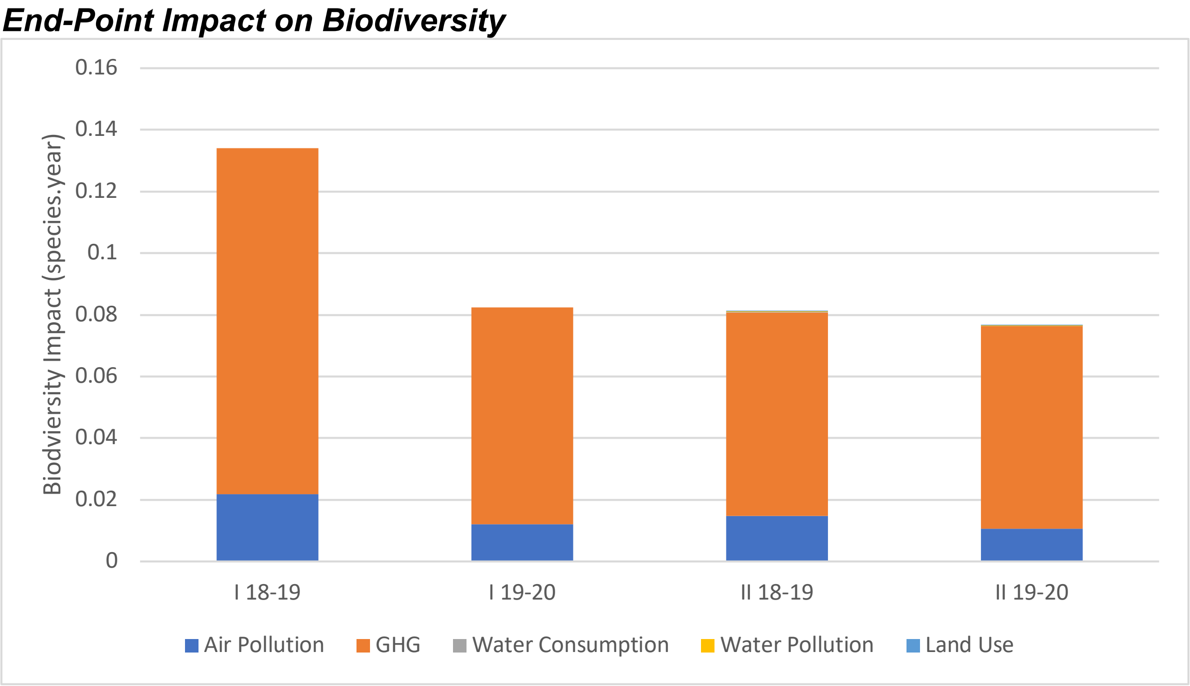


Figure 11: *Comparison of 2018-19 and 2019-20 end-point biodiversity impacts from University travel, summarised by sphere and contributing mid-point impact. Excluding undergraduate educational flights and domestic student travel.*

Sphere	***Change in biodiversity impact score (%)***	***Absolute change in biodiversity impact score***
I	-36	-0.05
II	-7	-0.005

Table 12: *Description of percentage and absolute changes in biodiversity impact from 2018-19 to 2019-20*

3.1.6 Data Gaps

Travel to conferences hosted by Oxford University: University departments hold multiple conferences/symposia each year. Travel by conference attendees (in particular, flights from international attendees) are likely to be a relatively large source of GHG emissions, but there is currently no way of making a reasonable estimate of these emissions. Information on conference attendees (e.g. number of guests, and organisation/institution/country of origin, whether options were available for tele-conferencing etc.) may be held at the departmental level, or at least by conference organisers within departments. However, there is no single dataset for all conferences hosted by the University.

Graduate fieldwork: No complete dataset of all field trips undertaken by graduate students was gathered. Only the Geography Department had the capacity compile a complete dataset on all Graduate fieldtrip locations, transport and number of students. As graduates tend to travel in smaller groups, or individually to fieldtrip locations, it is expected that this data would be more difficult to gather on a departmental scale. To address this data gap, it is suggested that more time is given for departments to complete departmental surveys (determining number of trips, destination, method of travel, and number of students).

International student flights: the estimates made here are intended to represent an order of magnitude, and are based on simplified scenarios rather than actual student travel data. Work is currently being carried out (i.e. travel surveys via the colleges) to gain more detailed insight on flight routes taken by students and the frequency of travel. This will enable the University to improve on these estimates in the future.

Business travel: there is more work necessary to estimate emissions from travel on the basis of travel insurance data, which in theory accounts for all business travel flights, but which does not yet have any link to associated distance travelled or GHG emission estimates.

Water Pollution midpoint impacts: this aspect calculated the midpoint impacts of GHG emissions and air pollution, but didn't calculate other midpoint impacts such as water pollution. By assessing the impacts associated with Exiobase 3 flows such as 'Air transport services (62) - GB', 'Railway transportation services – GB' and 'Other land transportation services - GB', it becomes clear that each activity results in acidification, eutrophication, and aquatic & terrestrial ecotoxicity impacts. These midpoints are not included in this report, but should be included in future assessments to holistically calculate endpoint biodiversity impacts. For example, if all procurement spend data under the spend category 'Travel Tickets' is plugged into the Exiobase database as 'Air transport services', then eutrophication, acidification and ecotoxicity impact estimates are within the same magnitude as those produced by sphere I food consumption. As these impacts are substantial, it is important that future reports assess water pollution midpoint impacts, which will only be possible if spend on each travel activity is available.

3.1.7 Recommendations

Given the substantial contribution made by flying to overall impacts from travel, clearly some of the priority data gaps to fill are those that relate to uncertainty around flight data (international student travel behaviours, hosted conferences and postgraduate educational travel).

The suggestion from this secondary analysis is that the overwhelming sources of impacts from travel are via release of GHG, NO_x and SO_x resulting from flights in spheres I and II. Therefore initiatives based around encouraging staff and students to fly less often and to less distant locations should be prioritised (particularly business travel, since the COVID-19 outbreak has shown it is possible to hold meetings remotely). It is also suggested that the Sustainability Team could liaise with faculties that coordinate fieldtrips or year abroad programmes to reduce flights taken by students for educational purposes. In particular, the Faculty of Medieval and Modern Languages expressed interest in reducing the impacts of travel associated with year abroad programmes.

Conversely, the main source of particulate matter, as a local air pollutant causing impacts on human health, is staff commuting by car. This is also reflected in the preliminary report, and remains true despite COVID-19 reducing staff commuting by an estimated 36.5%. Staff commuting also produces a significant amount of GHGs (albeit, not as significant as flights). Therefore, measures being put in place by the University to encourage use of alternative transportation modes to cars (such as staff parking charges) are clearly well-placed, and other similar initiatives are to be encouraged.

3.2 FOOD

3.2.1 Aspect Overview

The environmental impacts of food and beverage (in this report collectively termed 'food') production are substantial and far reaching, as comprehensively demonstrated by Oxford University researcher Joseph Poore.[43] Given the significance of agricultural land use in food supply chains, and given also the ubiquity of food consumption by staff and students across all University activities, it was expected that environmental impacts (particularly for biodiversity) associated with the food aspect would be significant.

Included within scope are all upstream environmental impacts caused by the production and transport of food products that are then consumed by any University stakeholders in the process of carrying out University activities (Research, Education and Operations). This includes food that is purchased directly by University departments, such as for catering events and meetings (sphere I); food that is sold to staff and students in University cafeterias, most of which are run by the catering company Compass Group PLC (herein "Compass") who are the University's preferred catering supplier (sphere II); and finally, consideration is given to food from other sources but consumed by members of staff and students on campus during working hours (sphere II).

Data Gaps Addressed

<u>1. Compass sales data</u>: Compass were able to provide a full set of sales data for the academic year of 2019-20. Whilst last year's sales dataset only accounted for three months' worth of sales which had to be factored up to account for a full year, this year's dataset accounted for 12 months, in turn acknowledging seasonal change in patterns of food purchasing. The 2019-20 data also contained sales data of Breakfast items, Jacket Potatoes and Fruit & Veg, which were not included in the previous year's data. This increase in data available impacted the final impact results for sphere I, as explained in table 13.

Food in the current Environmental Sustainability Strategy

Sustainable food consumption forms section 7.5 of the environmental sustainability strategy. Commitments to reducing the biodiversity and carbon impact of food consumed on university campus includes active interventions such as default vegan or vegetarian food at university catered events (7.5.3) and the end of using bottled water on campus (7.5.4). In addition, the university aims to use externally verified certification schemes to assess the sustainability credentials of food offered at the university (7.5.5), ensuring social and environmental sustainability within food supply chains.

---

[43] Poore & Nemecek (2018)

3.2.2 Data Sources

Table 13 provides a summary of data sources, organisational scope, and sphere for each activity associated with the food aspect. All assumptions and methods used in collating and analysing the activity data are described in the following section.

Sphere	Activity description	Scope	Activity data source(s)	Data description
I	Consumption of food purchased by University departments (e.g. for events catering)	Operations	HESCET Scope 3 Carbon Report 2019-20	*Defra 311 sector:* 11.1.5 Contract Catering (which could be further broken down into the Proc-HE codes CU-Catering Hospitality and YR- Catering Services Outsourced at a fixed site')
I	Consumption of food served in University cafeterias	Operations	Compass Cafeteria Sales Data	Type of food product and quantity sold
II	Student and staff meals, excluding those purchased at University cafeterias	Operations	Compass Group Cafeteria Sales Data	Type of food product and quantity sold

***Table 13**: available data on University food consumption, categorised by sphere and scope*

3.2.3 Mid-point Impacts

The basis of this analysis is a database containing a large range of supermarket food products and their associated environmental impacts (per kg or litre of product). This database was developed by the FoodDB project[44] (Harrington et al. 2019), and the associated environmental metrics were calculated as part of the LEAP project[45] based on a comprehensive meta-analysis of food life cycle studies carried out by Poore & Nemecek (2018). The environmental impacts included in this dataset are GHG emissions, water consumption, land use, eutrophication and acidification. These values were provided on two levels: at the individual product level (i.e. for a specific product and brand), and also at the more generic product 'shelf' level (i.e. average environmental values for a category of products, such as 'chocolate', 'milk' or 'cheese').

All mid-point impacts were calculated following a similar methodology using the FoodDB data tool. This is described below and is separated into Sphere I and Sphere II food impacts. Results for all spheres and impacts are listed after the methods.

---

[44] The contents of this database are confidential. Data from FoodDB was used under an agreed license between FoodDB and Wild Business Ltd. (Harrington et al., 2019)

[45] See for information - https://www.leap.ox.ac.uk/home

Methods

Sphere I: Food purchased by University departments

Food is often purchased directly by University departments, including catering for events, conferences and meetings, as well as regular purchases of tea, coffee, biscuits etc. In theory, all food and catering purchases should be accounted for by the University purchasing department (UPD) and represented in the HESCET report. The analysis for this category is therefore based on University-wide spend on food products, which is accounted for in the HESCET report. Due to changing in reporting methods for the HESCET report (namely the changes in Defra Sectors as mentioned in the 'General Methods'), large assumptions regarding the sphere I breakdown of food purchasing had to be made. This is due to all Departmental Food purchasing falling under a single new Defra 311 sector "11.1.5 Catering Services", rather than the separate food categories that are described by the Defra 75 sectors.

Therefore, the sum of spend in the Defra 311 sector "Contract Catering" was broken down into the Defra 75 food category sectors (as detailed in table 14), using the same proportions of spend in each category as the previous academic year (2018-19). This assumes that there has been no annual change in types of food items purchased by Departments. Thus, any notable change between the preliminary and secondary assessment of sphere I food mid-point and end-point impacts will be due to change in the total spend on Food between the two assessment years.

In the HESCET 2018-19 report, spend on food is captured under the 'food and drink products' Defra 75 category. This is broken down by spend on different categories of food items, as shown in table 14. The proportional annual spend for 2019/20 is also indicated in table 14, calculated by dividing the total spend on catering into each food category as outlined above. For each category of food provided in the HESCET 2018-19 report, a representative product was selected based on a scan of relevant 2018-19 invoice descriptions provided directly by UPD; these are also listed in table 14. For each food category, the total spend was divided by the estimated cost of the representative product in order to very roughly estimate the quantity of food being purchased.

***Table 14**: Categories of food listed in the HESCET 2018-19 report, the associated allocated spend for 2018/19 and proportional spend for 2019/20, and the product chosen to represent each category based on purchasing invoices with its associated price and mass/volume.*

Food Category	***Annual spend (2018/19) (£)***	***Proportional Annual Spend (2019/20) (£)***	***Representative product***	***Product price (£) (based on UPD invoices)***	***Assumed product mass or volume***
Beers, Wines, Spirits, Alcoholic drinks	7,333,205	3,255,231.18	Bottle of wine	5.50	0.75 L
Bakery Products	273,790	121,536.18	Traybake	1.5	0.1 kg
Dairy Produce	50,061	22,222.22	Milk (semi-skimmed)	0.7	1 L
Groceries	330,787	146,837.32	Sandwich platter	22	1.05 kg
Meat, Poultry, Offal	21,695	9,630.47	Meat platter	22	1 kg
Soft and Non-alcoholic Drinks	36,748	16,312.54	Fizzy drink cans	8	7.92 L
Fruit and Vegetables	18,146	8,055.06	Individual fruit (apple, banana, orange)	0.9	0.1 kg
Fish and Seafood	37,560	16,672.99	Salmon	15	1 kg
Confectionery, Sweet and Savoury	47,266	20,981.52	Crisps	0.9	0.04 g
Total Spend	**8,149,258**	**3,617,479.50**			

Each food category was then paired with the appropriate supermarket 'shelf' from the FoodDB/LEAP dataset (e.g. the 'traybake' product would be paired with the 'cakes and slices' supermarket shelf). The associated environmental values were then multiplied by the estimated portion size and quantity of items purchased, and summed across all products.

It is assumed here that food considered under this sphere is additive to daily food consumption by staff and students. While there may be some crossover (e.g. if a department arranges lunch for staff), this is likely to be small – particularly since the vast majority of departmental spend has been allocated to alcoholic beverages, which are not accounted for in the staff/student meals calculations.

It is also important to note that these estimates for departmental food purchases *are extremely approximate* and should be interpreted with caution, particularly because it was not clear how spend had been allocated to each of the food/catering categories in either the 2018-19 or 2019-20 HESCET report, nor was it confirmed by UPD whether these values represent all departmental catering purchases. This is superimposed by the assumption that the spend in each of the Defra 75 sectors in 2018-19 is proportionally mirrored by purchasing in 2019-20. In addition, this analysis assumes that the Defra Sector 311 "Catering Services" could only be broken down into spend in the food categories described in table 14, rather than other food categories or catering activities.

Overall, a more detailed assessment of departmental catering purchases would therefore need to be undertaken to provide a more reliable estimate of sphere I food purchasing. Estimates provided here are simply intended to provide an order of magnitude comparison with other aspects based on data that was available.

Sphere I: Food served in University cafeterias

Estimates for this category are based on sales data obtained from the University's preferred catering supplier, Compass, who run the majority of cafeterias across the campus. This data represents total sales across all 19 cafes run by Compass and provides quantities of items sold for individual products. These products were categorised into eight groups: hot meals, sandwiches & wraps, cold drinks, hot drinks, crisps & confectionary, bakery goods, breakfast items and fruit & veg. Unlike the preliminary assessment's dataset, this Compass dataset covers all purchasing data in the academic year of 2019-20. This included 303, 827 individual sales for hot meals, sandwiches and wraps (i.e. main meals), of which 52% were vegetarian. While a brief description of each product was provided, no information was available from Compass on ingredients or portion sizes at the time of writing.

As above, Compass products were matched to similar supermarket products to estimate environmental impacts. For all food categories, the top ten items purchased were paired with individual items in the Food DB database. Where there was no exact item match, an item was matched with a supermarket shelf. The exception to this pairing method were foot items in the hot meal category, whereby the top 20 items were chosen, and all paired with an individual item in the Food DB database. In cases where an equivalent supermarket product was not available, environmental values were instead taken for the main ingredients presumed to be used for that particular dish (e.g. for a Compass 'Veg and Lentil Casserole', values would be combined for the shelf categories 'Carrots & root vegetables' and 'Pulses & beans' and roughly weighted according to the quantity of each ingredient).

Portion sizes (i.e. mass or volume) were then estimated for each product. Where available, these were based on product descriptions provided in the Compass sales data. Otherwise, portion sizes were based on information published online by food retailers - for example, hot meals were assumed to weigh 400g, based on average portion sizes of ready meals listed online by major supermarket brands. Table 15 gives all portion size assumptions made in this analysis. Note that for milk-based drinks (mostly coffees), no indication of type of milk used was provided in the sales data, so it was conservatively assumed that all milk was dairy (which is likely to be more environmentally impactful than non-animal alternatives such as soy, almond or oat milk).

***Table 15**: Product categories provided in the Compass sales dataset and their estimated portion sizes.*

Product Category	***Product sub-category***	***Assumed portion size***
Hot Meals	Hot Meal Portion	400 g
	Jacket Potato	173 g
	Jacket Potato Topping	50 – 100 g
Breakfast	Breakfast Item	100 g
Sandwiches & Wraps	Crusty Roll	70 g
	Sandwiches and baps	175 g
	Panini	250 g
	Quiche	100 g
	Naan Pizzas	250 g
	Filling	50 g
	Bagel	165 g
	Wraps	170 g
	Baguettes	200 g
Bakery & Desserts	Cakes, Slices, Muffins, crumble	120 g
	Snack bars (where weight not stated)	40g
	Pasty	283 g
	Pastries	80 g
	Scones	70 g
	Donuts, Pies & Meringues	65 g
	Cookies	45 g
	Ice cream	125 ml
	Fruit pots	160 g
	Sausage roll	100 g
	Yoghurt	120 ml
Hot and Cold Drinks (actual portion sizes provided in sales data)	All drinks	120 ml – 850 ml
	Canned drinks	330 ml
	Coffee	450 ml
	Black Coffee	Assumed standard ratio of 1 g coffee beans:17 ml water
Crisps & Confectionary (actual portion sizes provided in sales data, no assumptions made)	All Crisps and Confectionary	15-55 g
	Crisps (where weight not stated)	27 g
Fruit & Veg	Fruit	50 g
	Potatoes	100 g
	Salads	200 g

Environmental values taken from the FoodDB dataset were then multiplied by portion size and by number of items sold per top ten or twenty products to estimate the total environmental impact of the top ten or twenty food items sold in each category in Compass cafeterias. These mid-point impacts were than factored up to represent the impact of all food items purchased in each category for the year 2019-20, thus the top ten or twenty items in each category were taken to be representative of all items purchased in each category. Table 16 provides a quantitative indication of how each top ten or twenty food items were representative of the total mass/volume of food items spent in each category.

Table 16*:* The proportion of total mass or volume accounted for by the top ten or twenty purchased items in each food category (%)

Food Category	***Proportion of total mass or volume accounted for (%)***
Cold Drinks	46.67002997
Hot Drinks	67.35644054
Sandwiches and Wraps	34.47068725
Hot Meals (top twenty hot meals)	62.6249894
Bakery	42.08784708
Breakfast	87.74776622
Crisps and Confectionary	33.47880898
Fruit and Veg	82.19021186

In addition to the 19 sites run by Compass, a further 9 University cafeterias were identified that are run by other catering companies (based on information provided by OUES), shown in table 17.

Table 17*: University Cafeterias that are not run by Compass*

Building Name	***Catering Provider***
Weston Library	Benugo
Bodleian Library Readers Library	Benugo
Ashmolean Museum cafe	Benugo
Ashmolean Museum Restaurant	Benugo
Museum of Natural History	Mortons
St Cross Building	Missing Bean
Said Business School ground floor	Baxter Storey
Said Business School restaurant	Baxter Storey
Weatherall Institute of Molecular Medicine (WIMM)	Direct labour

Assuming that the sales figures for Compass were representative of these additional cafes, total figures were factored up by an additional 50% to estimate total food sales across all on-site cafeterias and restaurants. This is a broad assumption, since menus and opening times may differ, and also since three of these additional sites are based in University museums and so would receive additional sales from the general public.

Sphere II: Additional food consumption by staff & students

It is important to consider that values for University cafeteria sales represent a very small portion of the total food and drink that would be consumed by University staff and students on a daily basis – which would include food purchased from external sources or provided by colleges. In 2020, students 25,820[46] and 13,340 full time equivalent staff[47] were registered at the University. If it is assumed that all staff and students consume one main meal during working hours of each working day on

---

[46] Available at https://academic.admin.ox.ac.uk/student-statistics
[47] Available at https://hrsystems.admin.ox.ac.uk/staffing-figures

University Campus during 2019-20[48], this would amount to a total of 5,117,514 meals consumed per year.

By comparison, main meals (including hot meals, sandwiches and wraps) sold by Compass, amount to 303, 827 main meals per year. On that basis, Compass meal sales would account for 5.9% of the total annual meals consumed by staff and students.

Therefore, annual estimates for mid-point and end-point impacts from the Compass data are factored up from 5.9% to 100% in order to provide an approximate but more realistic order of magnitude estimate of total impacts from food consumed by staff and students during working hours. Values for food sold in University cafeterias are subtracted from this total value in order to distinguish between cafeteria and daily meal impacts.

Results

Results for the five mid-point impacts estimated for this this section, followed by end-point impacts on biodiversity, are displayed below. Each graph gives impact values for departmental food purchases (sphere I), sales made in University cafeterias (sphere I), and daily staff and student food consumption (sphere II).

GHGs

GHG emissions from food consumption are shown in figure 12. Values are higher for food purchased by departments (975 t CO_2e) than for food sold in cafeterias (698 t CO_2e), with the highest values for annual staff and student food consumption (6,262 t CO_2e). It is worth noting that an additional estimate for GHG emissions from food purchased by departments was available for comparison from the HESCET scope 3 carbon report. This report estimates the GHG emissions for food purchased by departments at approximately 1338 t CO_2e, based on an economic input-output method as described in the 'General Methods' Section. Although this is larger than estimates made in this analysis, this is to be expected as the input-output methodology includes a broader range of activities within the scope of 'Contract Catering' – i.e. it produces an estimate based on all inputs to the Contract Catering, sector whereas this analysis deals with the life-cycle impacts of specific food products. However, both estimates are of the same order of magnitude and produce a similar result when compared with other aspects.

---

[48] Assuming 139 working days per year staff and post graduate researchers, 120 working days for part II integrated masters students, and 90 working days for undergraduate, taught post graduate and visiting students. These working days account for COVID-19, whereby all students, researchers and staff remain at home after the 23rd of March 2020 (the beginning of lockdown).

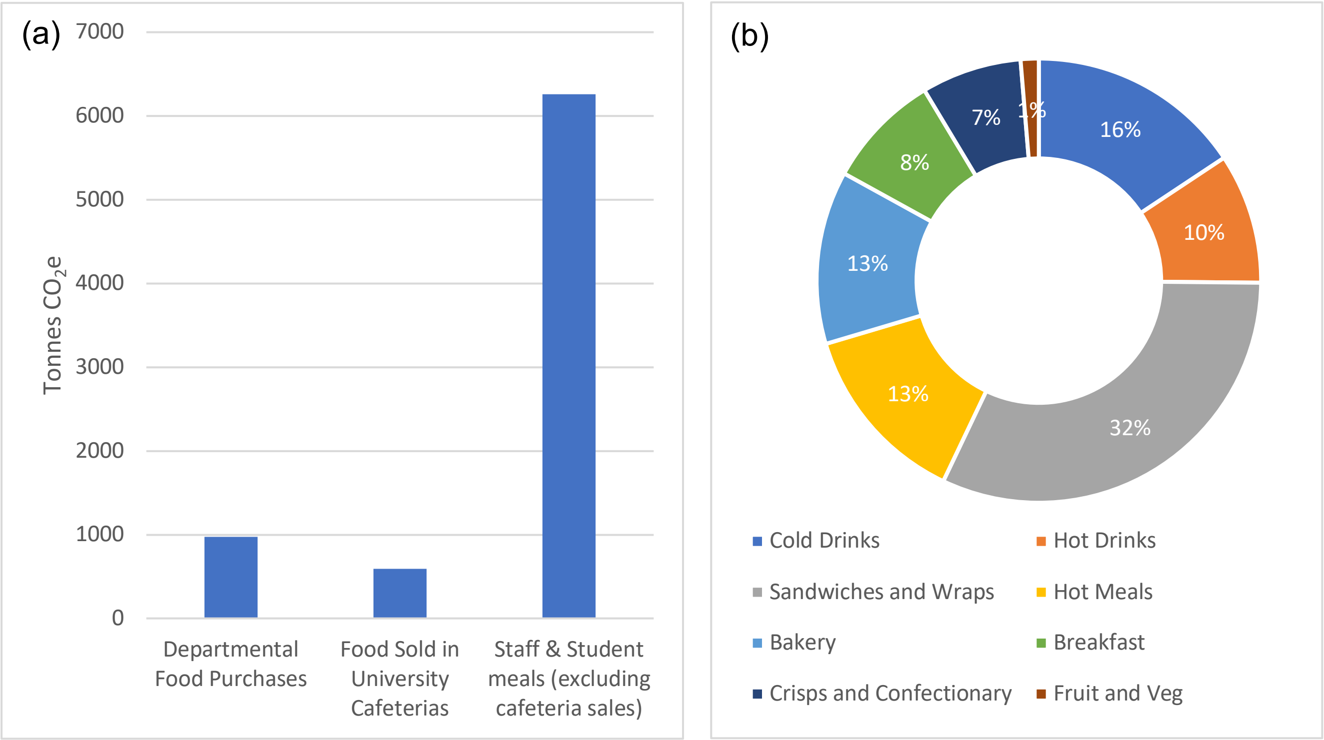


***Figure 12**: (a) Total embedded GHG emissions from food sold in University cafeterias, departmental food purchases, and staff and student meals; (b) GHG emissions for food sold in University cafeterias (~590 t CO_2e) broken down by category of food product sold.*

Land Use

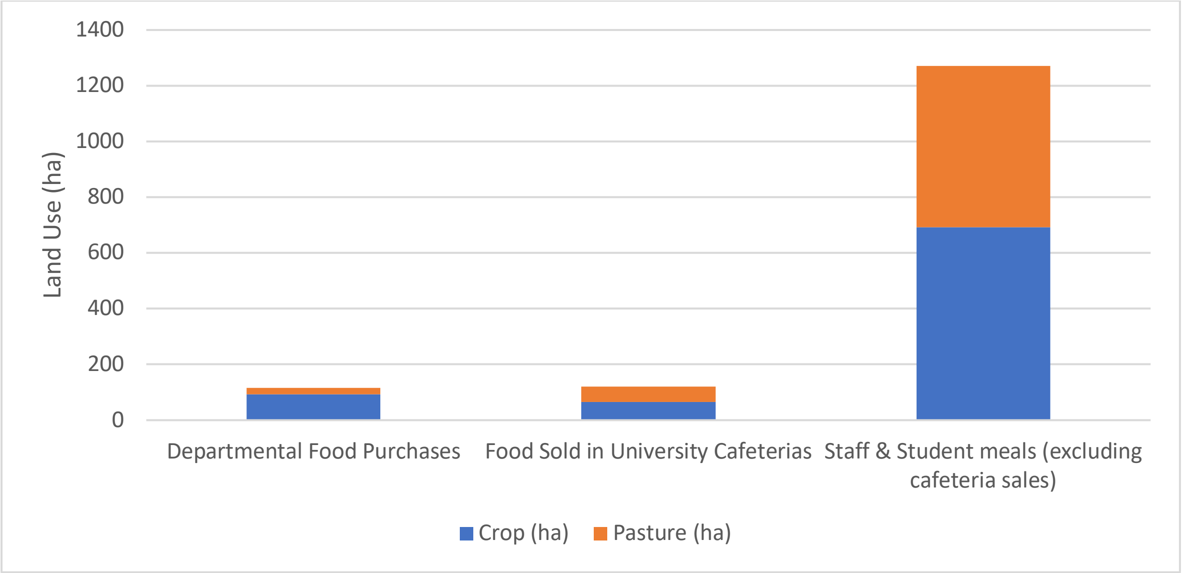


***Figure 13:** Total land use footprint of food sold in University cafeterias, food purchased by departments, and staff & student meals, broken down by agricultural land type.*

Water Consumption, Eutrophication & Acidification

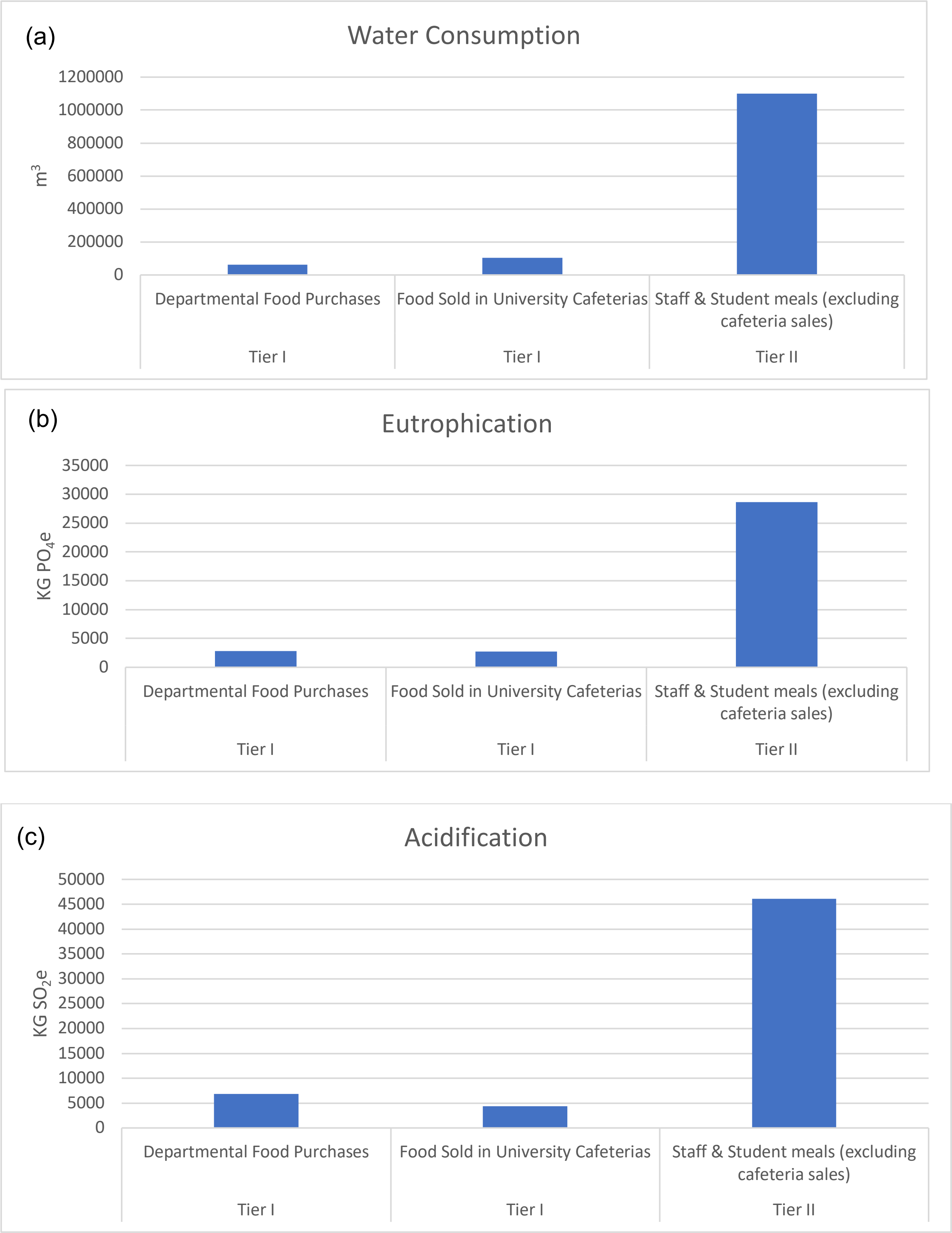


**Figure 14**: (a) Water consumption, (b) acidification and (c) eutrophication estimates for food purchased by departments, food sold in University cafeterias, and staff & student meals. NB – Poore & Nemecek (2018) report scarcity-weighted water consumption in their analysis. However, unweighted values for water consumption

are used here in order to ensure consistency with other aspects included within this report

3.2.4 End-point Impacts on Biodiversity

Results for each mid-point impact described here were characterised using the ReCiPe factors, as described in section 2.2. For land use, areas for pasture and for arable cropland were first characterised in terms of 'annual cropland equivalents' in order to be paired with the endpoint characterisation factor for biodiversity. Note that ReCiPe makes a distinction between land occupation and land transformation: the former is used here, as the underlying dataset measures land use in terms of occupation, rather than transformation.[49]

Estimates for eutrophication had to be converted due to differences in the metric used in the underlying dataset (kg phosphate equivalents, or PO_4^{3-} eq)[50], and the metric used to estimate eutrophication impacts in ReCiPe (kg Phosphorus equivalents, or P eq). To do this, values for kg PO_4^{3-} eq were multiplied by 0.33, because a kilogram of PO_4^{3-} is estimated to have a third of the eutrophication potential relative to a kilogram of P.[51] Importantly, however, this will still likely provide an overestimate due to methodological differences in modelling eutrophication impacts[52] (see the supplementary material for more details).

Results for endpoint impacts on biodiversity from food consumption are displayed in figure 15. The largest impact on biodiversity comes from agricultural land use, as was anticipated given well documented impacts of agricultural land use on biodiversity[53]. Sandwiches and wraps contributed the most to environmental impacts for food sold in cafeterias, mainly due to a greater mass of food consumed relative to other categories. Whilst 42,000 L of hot drinks were sold, 104,307 L of cold drinks were sold, resulting in cold drinks having a higher biodiversity impact than hot drinks. This is despite hot drinks having a higher average biodiversity impact per Litre due to the large quantities of milky coffees purchased (although, as mentioned above, no distinction could be made between dairy-based and milk alternatives, so all milk was conservatively assumed to be dairy). End point biodiversity impacts are slightly higher for departmental food purchases relative to food sold in cafeterias, which is predominantly due to a large amount of spend estimated on alcoholic beverages (£3.25 million), which make up 75% of the total impacts on biodiversity from departmental food purchases. Staff and student meals (accounted for before March 23rd 2020) again produce the largest impact here, with a total biodiversity impact score of 0.17.

---

[49] See supplementary materials for Poore & Nemecek (2018)
[50] Characterised using the CML2 baseline methodology (CML, 2001)
[51] Due to this containing a third of the quantity of phosphorus based on molecular weights – see Huijbregts et al. (2017) for more details.
[52] Primarily, the CML method combines marine and freshwater eutrophication, whereas ReCiPe records these separately. A detailed description of differences between methods is provided by Morelli et al. (2018)
[53] For example, a recent study by Crenna et al. (2019) used ReCiPe2016 to estimate relative impacts of various mid-points on biodiversity from European food consumption.

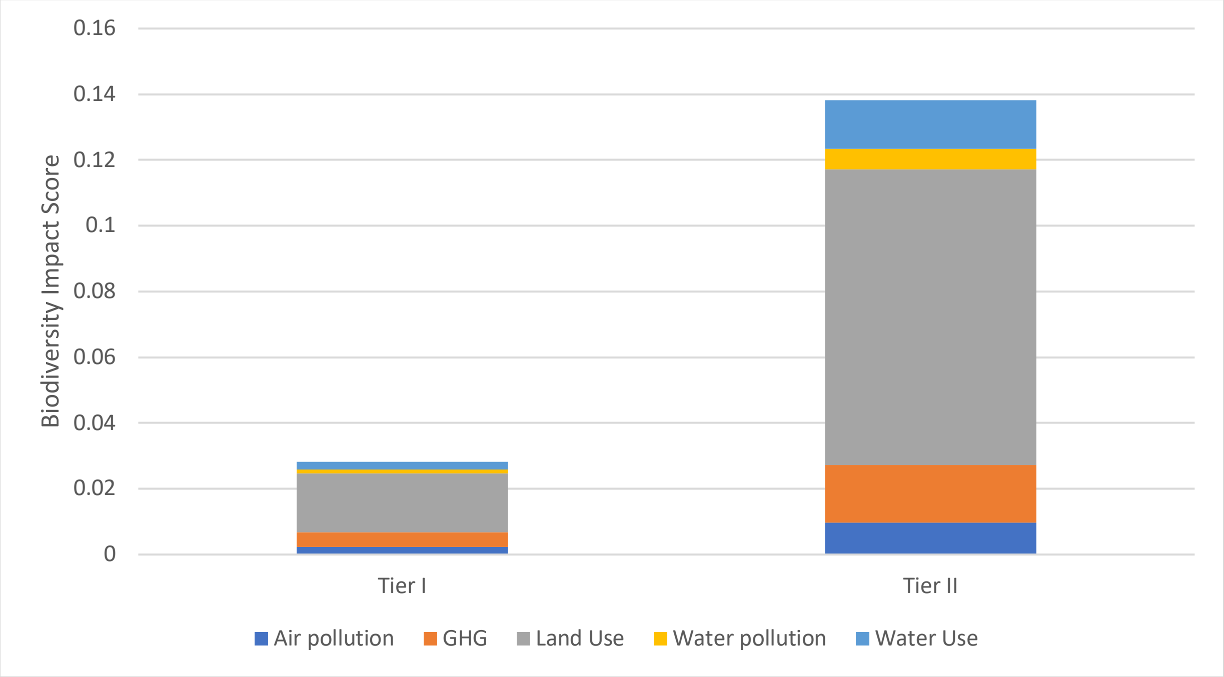


Figure 15*: Embedded biodiversity impacts resulting from consumption of food purchased by departments (sphere I), food sold in University cafes (sphere I), and staff & student meals (sphere II). The values for food sold in cafeterias are factored up to include cafeterias that are not managed by Compass for which no sales data were obtained*

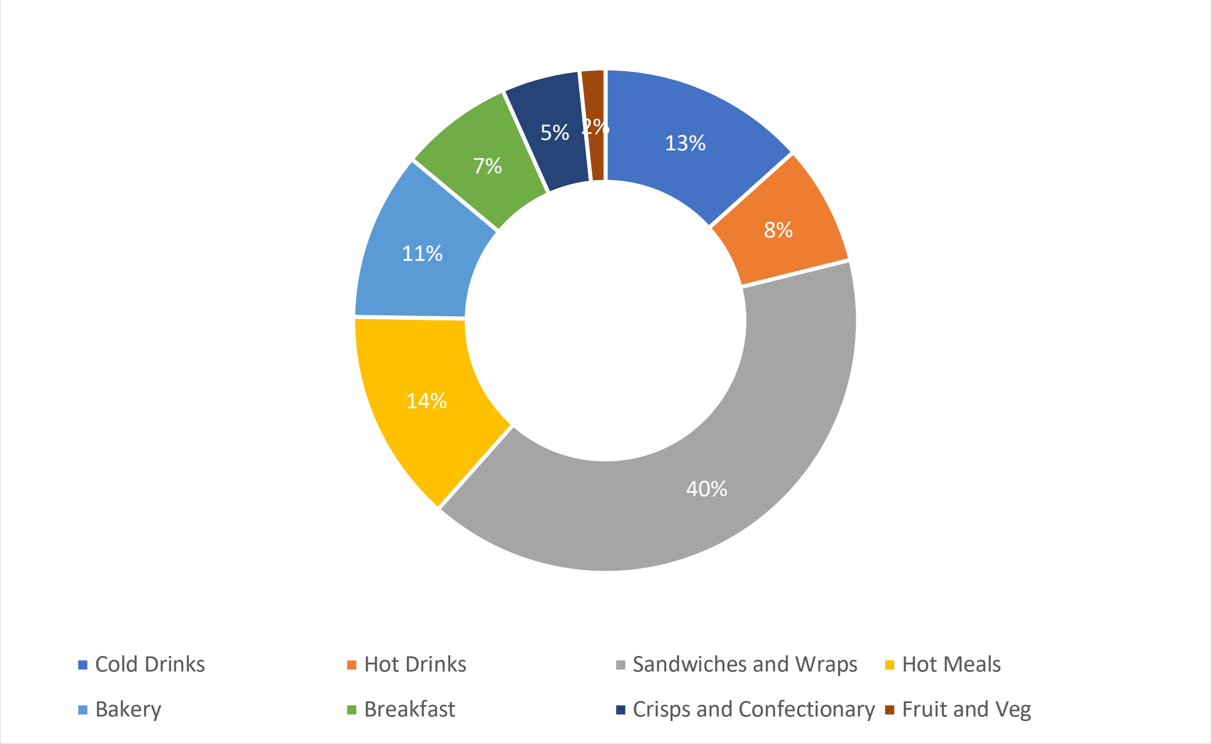


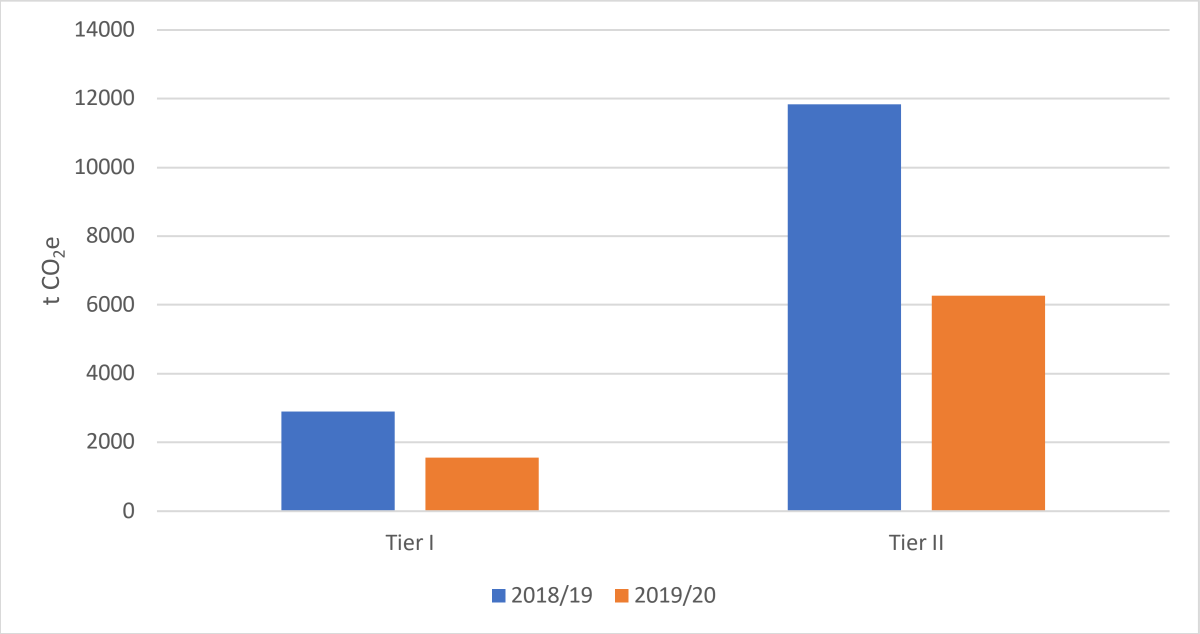
Figure 16: *Biodiversity impacts for food sold in Compass cafeterias broken down by category of food product*

3.2.5 2018-19 vs 2019-20 Report Comparisons

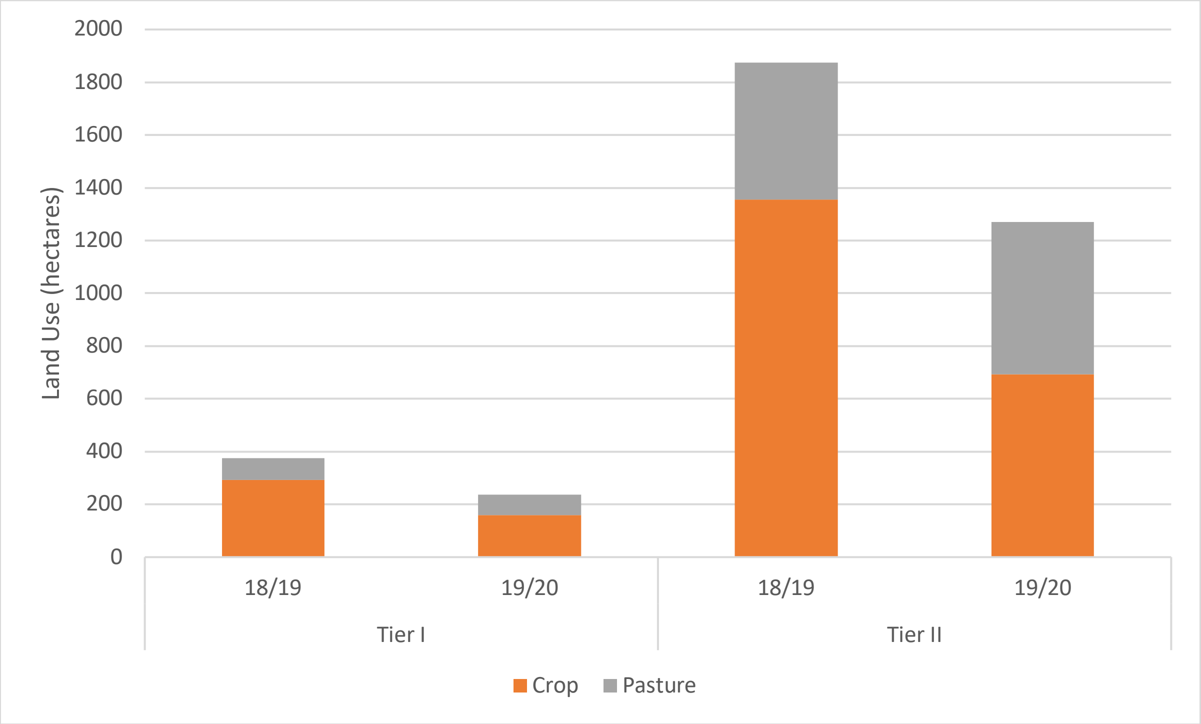
The following section compares and explains the changes in mid-point impacts and subsequent end-point impacts on biodiversity from the previous preliminary assessment report. Explanations for annual change can be found in table 18, with reductions in mid-point impacts largely due to changes in datasets available and methodologies. Therefore, comparing the impacts from each year should be approached with caution.

Mid-Point Impacts

(a)



(b)



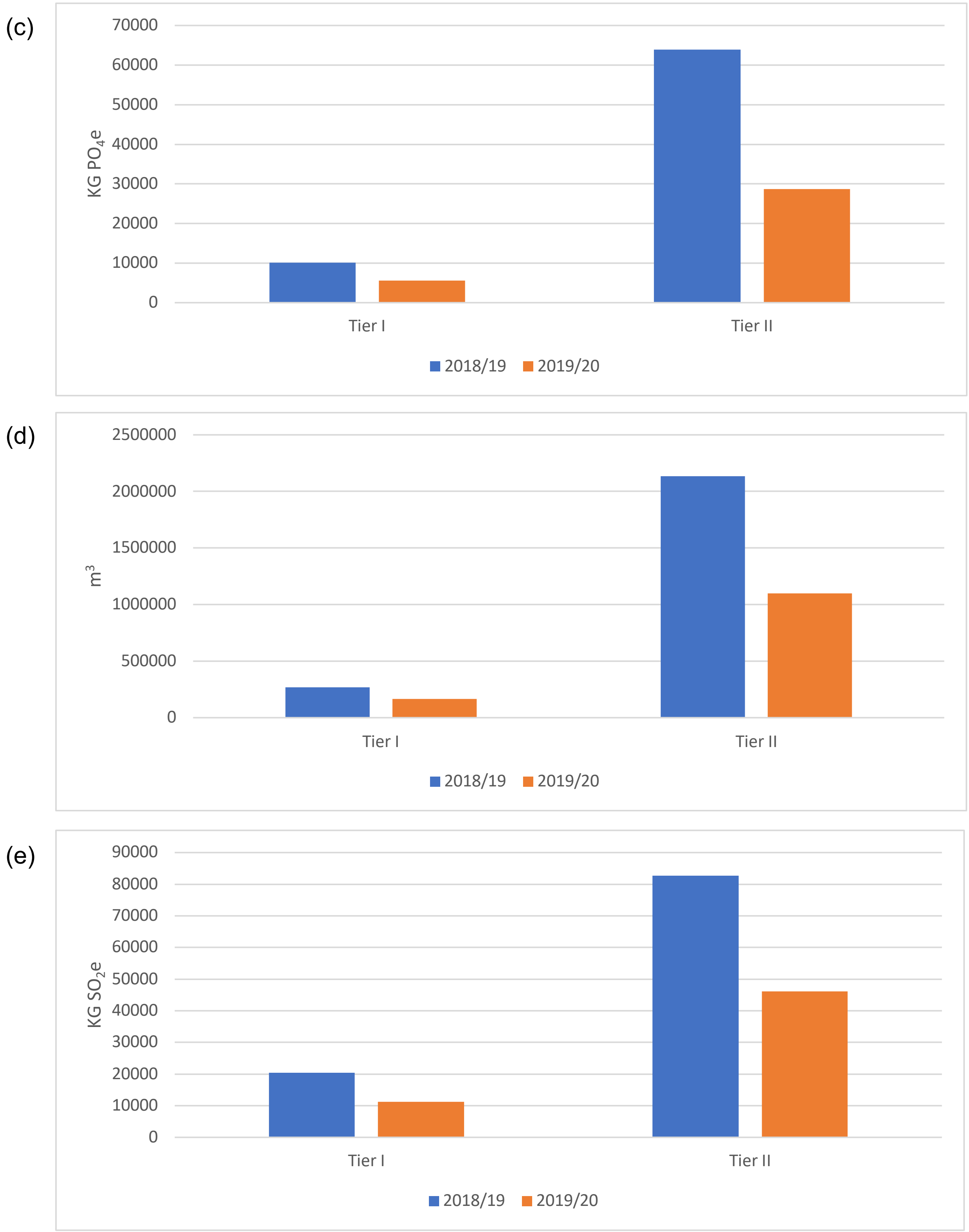


***Figure 17**: (a) GHG emissions, (b) Land Use (c) Eutrophication, (d) Water Consumption and (e) Acidification estimates for food purchased by departments (sphere I), food sold in University cafeterias (sphere I), and staff & student meals (sphere II) for 2018-19 and 2019-20.*

End Point Impact on Biodiversity

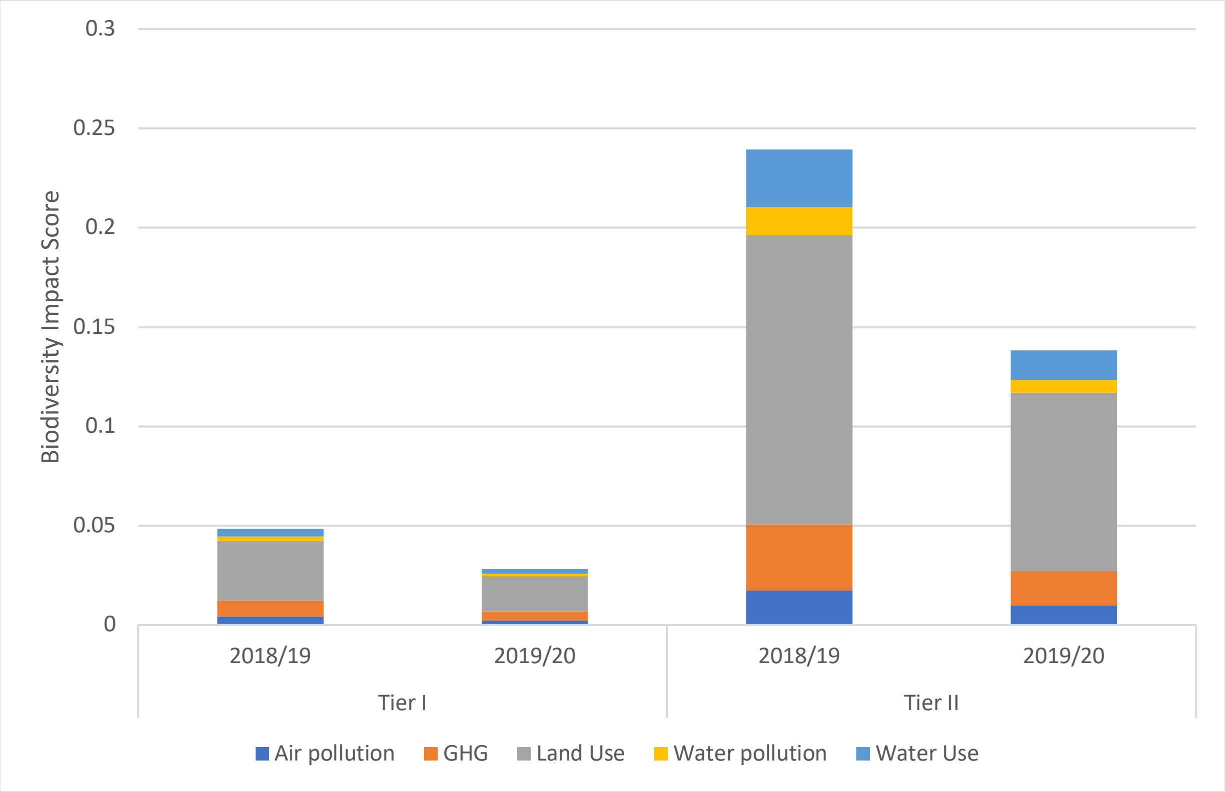


Figure 18*: Embedded biodiversity impacts resulting from consumption of food purchased by departments (sphere I), food sold in University cafes (sphere I), and staff & student meals (sphere II) for 2018-19 and 2019-20.*

Table 18*: Explanations for annual changes in mid-point, and subsequently, end point biodiversity impacts, sorted by sphere and activity.*

Sphere	**Activity**	**Biodiversity Impact Score change (%)**	**Explanations for annual change**
I	Departmental Food Purchases	*-55.6*	- *A reduction in total spend on Catering Services due to COVID-19 as there were no events to cater for beyond the 23rd March 2020 until the end of the academic year. This reduced spend in sphere I from £7.3m to £3.3m, resulting in proportionally lower mid and end-point impacts.* - *Changes in HESCET Defra 311 sectors and reporting methods may have meant that the Defra 311 sector 'Contract Catering' did not capture all Departmental Spend on food in the same way that the Defra 75 sectors did.*

I	Food Sold in University Cafeterias	_-8_	- _All Compass cafes closed after 23rd March due to COVID-19, and remained closed until the end of the academic year. This would have reduced the volume of food sold by Compass cafeterias._ - _This secondary assessment considered full annual purchasing data from Compass cafeterias, rather than just Michaelmas term data (October – December 2018) that was used in the preliminary assessment. Therefore, this full annual purchasing data captures all types of food served across the academic year, and seasonal changes in food consumption._ - _Sales data provided by Compass for 2018-19 did not include Breakfast items, Jacket Potatoes (included as a main meal in this year's assessment) or Fruit & Veg, but were included in the sales data provided in 2019-20. Therefore, this year's sphere I impacts will have accounted for a larger volume of food being sold per day, and thus have larger mid and end point impacts._ - _Annual changes in menus will influence impacts, although the percentage of meat/non-meat 'Main Meals' sold remained the same across 2018-19 and 2019-20._ - _Changes in methodology between the assessments may influence the annual changes in impact. For example, in this assessment only the top ten/twenty items purchased in each food category were matched to the FoodDB database, rather than matching all items sold to FoodDB, as was carried out in last year's assessment. The former method was preferred due to the large volume of sales data provided by Compass for the full academic year 2019-20._
II	Staff & Student meals (excluding cafeteria sales)	_-42_	- _Sphere II impacts did not account for any main meals that were consumed by staff or students beyond the 23rd March. This reduced the number of days accounted for by 45 for undergraduates and taught postgraduates, by 60 and 116 for research-based postgraduates and staff._ - _Calculations from University Cafeterias (detailed above) were used to calculate the impacts of an average main meal. Therefore, any changes in the types of hot meals and sandwiches and wraps sold in Compass cafeterias will change the mid-point, and thus end-point impacts of an average hot meal. For example, as Jacket Potatoes were not included in the 2018-19 sales data, but accounted for the second most popular hot meal in the 2019-20 sales data, the average hot meal impacts were different between the two reports._ - _Previous sales data did not include all food items purchased in Compass cafeterias (for example Breakfast items and fruit and veg), thus these were not included in the preliminary sphere II food impact calculations._

3.2.6 Data Gaps

Departmental Food Purchasing: No detailed procurement data this year was supplied in the HESCET report 2019-20, as all food purchasing was categorised under the Proc-HE categories of:

- CU - Catering Hospitality and
- YR - Catering Services Outsourced at a fixed site

Therefore, last year's departmental food spend had to be used as a reference point to estimate how the sum of the above spend categories would be spread across the food categories of the previous HESCET report. Therefore, estimates for departmental food purchasing impacts (sphere I) are useful for understanding the potential magnitude of impacts of departmental food purchasing, but do not give an absolute value. For future assessment reports, it is suggested that either raw procurement data is used (i.e. by going through the Procurement Report provided by the UPD), or for the UPD to enter spend data by food category Proc-HE codes for future HESCET reports. This would provide a greater insight into how departmental food purchasing changes annually. Unfortunately, due to time constraints, the assessment team could not categorise invoice-level purchasing data from the procurement report into the different food categories.

Procurement coding: the reliability and accuracy of the purchasing data used to estimate impacts from food purchased by departments is questionable. It is not entirely clear where this data overlaps with daily staff and student food consumption and it is reliant on procurement coding accuracy. A more in-depth assessment is required here, perhaps by looking at department level procurement information or information from catering suppliers. Collaboration with the colleges may also be useful, since many University events are hosted by colleges.

Ingredients, portion sizes, and source: this assessment necessarily made assumptions regarding ingredients and portion sizes of food products sold by Compass, and does not consider where ingredients are sourced from. It is recommended that once the relevant resources become available, that this analysis is readdressed in collaboration with Compass, using more detailed product information to provide an improved picture of environmental impacts of food offered on campus.

Food sourced externally: estimates for student and staff food consumption would include food brought in from external sources and also food supplied by the colleges. Therefore, some of the impacts described here will be attributable to the colleges, and some to staff and students personal food purchases. To improve granularity and to properly document and address impacts associated with food consumption, collaboration between colleges and the University is encouraged.

3.2.7 Recommendations

It is likely that the largest source of impacts from food is meals brought by staff or students onto campus, purchased from external vendors. These impacts sit in sphere II, and therefore can only be influenced by University actions to an extremely limited extent. However, they could be targeted by widespread awareness campaigns around the environmental impacts of food, and how to reduce them.

In terms of reducing the environmental impacts of food purchased, one of the few generalisations that can be made is that food from non-animal sources is typically lower impact (Poore & Nemechek, 2018). Therefore awareness campaigns around eating meat and dairy products less frequently would be one approach towards reducing impacts. Such campaigns could be implemented in the context of departmental food purchases too – not only as a means for further limiting environmental impacts, but also as a visible statement of commitment to sustainability.

In addition to awareness campaigns, there are numerous interventions to shift the purchasing and consumption behaviours of individuals to more environmentally friendly food. These interventions are listed in detail in the LMH food report carried out by Wild Business and the research group OxPOCH, which are categorised according to the Conservation Hierarchy[54]. Whilst these interventions have been tailored to a College canteen environment, they are often transferable into other cafeterias.

---

[54] (Taylor et al, 2021)

3.3 BUILT ENVIRONMENT

3.3.1 Aspect Overview

The University owns and leases an extensive area of land that would fall under the category of 'built environment', in which most of its key activities are performed. The environmental aspect of built environment relates to impacts associated with buildings and other grey infrastructure, which includes utilities supplied to the built environment (i.e. energy consumption, water use), the maintenance and construction of existing and new buildings/infrastructure (along with associated materials), and other general impacts of urban land uses.

The principal impacts deemed necessary for inclusion for this aspect were GHG emissions and water use. Additional consideration is given to land use and other impacts linked to the supply chain of construction. Note that, though an argument could be made for placing construction services and materials into the 'resource use & waste' aspect, these were considered to be most logically placed here.

This aspect also includes the impacts of online education, which considers increases in electricity use from internet data centres and transmission due to lecture streaming and online classes/tutorials. These impacts are expected to have increased in response the global COVID-19 pandemic, as the University shifted its educational services from an in-person to online environment, following the announcement of the UK lockdown on the 23rd of March 2020. This change in education style involved lectures and tutorials transferring online in the form of Panopto recordings and online meetings. These online educational services replaced in-person teaching, coupled with department building and university café closures, and a reduction in travel, which has been reflected in other aspects of this report.

Built environment in the current draft Environmental Sustainability Strategy

Both sections 7.3 (carbon emissions from energy consumption on the University estate) and 7.6 (sustainable resource use) relates to the Built Environment aspect of this report. In section 7.3, commitments focus on energy saving engagement programmes (7.3.1) and measures to maximise energy efficiency (7.3.3) and low-carbon energy use (7.3.4, 7.3.5). In section 7.6, there are no specific commitments related to the procurement of construction-related goods, but commitment 7.6.1 pledge the avoidance and reduction of biodiversity and climate impacts of the total supply chain.

There is no single section in the current draft Strategy that deals exclusively with the online education in the sense meant here.

Data Gap Addressed from previous report

1. <u>Mid-point impacts from construction supply chains</u>: using Exiobase 3, the assessment team were able to consider more mid-point impacts from the construction supply chain than in the preliminary assessment. These additional mid-point impacts include Water Pollution and Air Pollution.

3.3.2 Data Sources

A wide range of datasets are relevant to understanding the impacts associated with the aspect of built environment (Table 19).

Table 19: *available data on the built environment by source, categorised by sphere and assessment scope*

Sphere	Activity Description	Scope	Activity data source(s)	Data description
I	Gas & gas oil consumption	Operations	EMR 2019-20	Consumption data (kWh)
I	Electricity consumption (Grid)	Operations	EMR 2019-20	Consumption data (kWh)
I	Water Consumption	Operations	EMR 2019-20	Consumption data (m^3)
I	Urban land occupation – Building site areas and footprints (University managed buildings)	Operations	OUES (Asset & Space Management records)	Site areas and building footprints (m^2)
I	Urban land occupation – Building site areas and footprints (commercial, residential, graduate accommodation buildings)	Operations	OUES (Asset & Space Management records)	Site areas and building footprints (m^2)
I	Online Lecture Delivery	Education	Educational Media Team, IT Services	Hours of content delivered online and average data usage of online content
I	Online Classes/Tutorials	Education	n/a - estimate	Estimate of online classes - two hours per week per student during COVID-19 impacted terms (8 weeks in total),
II	Gas & gas oil supply chain (Well-To-Tank)	Operations	EMR 2019-20	Consumption data (kWh)
II	Grid electricity supply chain (Well-to-Tank & Transmission/Distribution losses)	Operations	EMR 2019-20	Consumption data (kWh)
II	Water supply chain (water supply and wastewater treatment)	Operations	EMR 2019-20	Consumption data (m^3)
II	Supply chain of procured construction services and goods	Operations	Procurement Report 2019-20	Aggregated spend (£) under the Purchasing Categories: - Construction Services - Repairs, Alterations and Decorating Services - Flooring

Data notes and assumptions

Scope of the EMR 2019-20: The EMR covers all buildings on the 'functional estate' i.e. all teaching and research spaces. There are also embedded spaces, which are considered part of the functional estate. These spaces are usually managed by another entity, which can make access to utility data difficult. For example, the embedded spaces within Oxford University Hospitals (OUH) and the NHS Trust.

However, this area of functional estate is a small proportion of the total estate, and OUES are continually working close this utility data gap for future EMR reports.

Natural gas: Gas consumption figures are used as reported and are *inclusive* of gas used as an input for combined heat and power (CHP) systems.

Electricity (renewable energy tariff): Electricity data is used in this assessment as reported by the University. However, it is worthy of note that the University currently purchases electricity on a 100% renewable energy tariff[55] (supporting wind-energy generation), but still reports location-based Scope 2 GHG estimates (GHG Protocol definitions[56]) in alignment with the UK average grid electricity fuel mix. Therefore, electricity consumed by the estate may currently be less carbon-intensive in practice than is actually reported. As such, a market-based reporting approach (using conversion factors derived from onshore wind-generated electricity) has also been included in calculations here for comparison.

Electricity (onsite photovoltaics): An additional 490426.93 kWh of energy is consumed annually from onsite photovoltaic (PV) systems. This is ~0.23% of total grid electricity consumption on the estate, and has therefore not been considered in further calculations. Estimates from EMR show that energy consumption from onsite PV represents 2,103,573 kgCO_2e of avoided sphere I GHG emissions if alternative energy was to be consumed from Grid Electricity.

Water consumption: Figures provided by the University for water consumption across EMR exclude water sourced from recycled grey water or as rainwater (10,800 m^3, or roughly ~3% of total water use).

Built environment sites (land use): It should be noted that for simplicity the total area considered occupied by the built environment was inclusive not only of existing buildings and hardstanding, but also any urban greenspace contained within the boundary of each site. Other than University parks and sports fields (which are included under the 'natural environment' aspect, along with other land uses), pockets of urban greenspace were not treated separately from the surrounding built environment.

Construction Procurement: It should be noted that all construction-related spend data (Construction Services; Repairs, Alterations and Decorating Services; and Flooring) were clustered into single Exiobase 3 Industry spend category 'Construction Work'. For more details on this mid-point impact calculation, see "General Methods".

Online Lecture Delivery: no data was attained regarding the country level location of where the lectures were streamed. Therefore, it was assumed that all lectures were streamed in the UK, so mid-point impact calculations were based upon UK electricity generation emission and water use factors. This may not have been the case, as international students may have returned to their home countries in response to the March lockdowns. However, the differences in country electricity generation emission

---

[55] Evidenced by an independent assurance statement provided by Deloitte LLP to Scottish Power Energy Retail Ltd (dated 2 July 2019) confirming that the latter matched the volume supplied to Top tier CGEP and domestic green energy product customers to energy from renewable sources, and that the Renewable Energy Guarantees of Origin (REGO) sources are 100% from zero carbon wind sources.

[56] See for definitions GHG Protocol Scope 2 Guidance, available at https://ghgprotocol.org/scope_2_guidance

and water use factors are marginal, so the mid-point impacts calculated here provided here are thought to be representative of actual impacts.

Online classes and meetings: no actual data regarding the number of tutorials per student were available, so the conservative estimate of two hours per week per student were made. As with online lecture delivery, it was assumed that all students remained in the UK.

3.3.3 Mid-point Impacts

It was established that most impacts under the built environment fell equally between spheres I and II. Due to the complexity of calculating construction supply chain impacts, a detailed summary of the mid-point impacts of this category can be found at the end of this section. The location of mid-point impacts from construction supply chains (summed with resource use supply chains) are mapped and quantified by country in the appendices.

GHG Emissions: Sphere I

For energy production (building heating) from gas and gas oil, GHG emissions estimates were provided directly as part of the EMR dataset and are based on consumption data combined with Defra GHG emissions factors for 2020 (specific factors used for all calculations are included in the supplementary material).

Location-based GHG emissions estimates for the *generation* of consumed electricity were also taken directly from the EMR data, and are also calculated based on Defra/DBEIS emissions factors for the UK electricity fuel mix. The market-based GHG emissions estimates for electricity generation were taken to be zero, based on the Green Tariff emissions factors listed by the University's electricity supplier[57] (although it is of course highly debateable whether wind energy production could be considered to produce no GHG emissions).

The GHG emissions associated with lecture streaming and tutorials are minimal in the context of this report with the sum of the median emissions of lectures and tutorials (4377 kg CO_2e) represents only 0.001% of the total GHG emissions of the Universities' operations and 0.016% of the GHG emissions of electricity consumption within the Universities' functional estate.

GHG Emissions: Sphere II

Sphere I GHG impacts associated with electricity and gas consumption relate to emissions associated with the actual generation of energy. However, in addition to these are the upstream emissions associated with the energy supply chain[58], which fall under sphere II for the purposes of this assessment. These have all been calculated by combining gas and electricity consumption data with the relevant Defra/DBEIS GHG conversion factors (listed in the supplementary material), incorporating:

---

[57] See footnote 49 above

[58] Identified based on GHG Protocol standards. See for more information - https://ghgprotocol.org/standards/scope-3-standard

- Extraction, production, and transportation of gas and gas oil consumed by the University (well-to-tank);
- Extraction, production, and transportation of fuels consumed in the generation of electricity purchased by the University (well-to-tank); and,
- Generation (upstream activities and combustion) of electricity that is consumed (i.e. lost) in the transmission and distribution (T&D) system.

For the market-based scenario (the renewable energy tariff), estimates for the upstream emissions of purchased grid electricity are replaced with figures for the upstream emissions of electricity generated by wind, based on an average life cycle emissions value for on-shore wind power (15g CO_2e/kWh[59]).

In terms of water utilities supply & treatment, GHG emissions are again calculated by multiplying water consumption figures with the relevant Defra/DBEIS GHG conversion factors for 2020.

Also included within sphere II are any upstream GHG emissions associated with procured goods and services for building construction. These figures are taken from the Procurement Data Analysis, which uses Exiobase 3 (a database of EE MRIOs) within OpenLCA to calculate supply chain impacts.

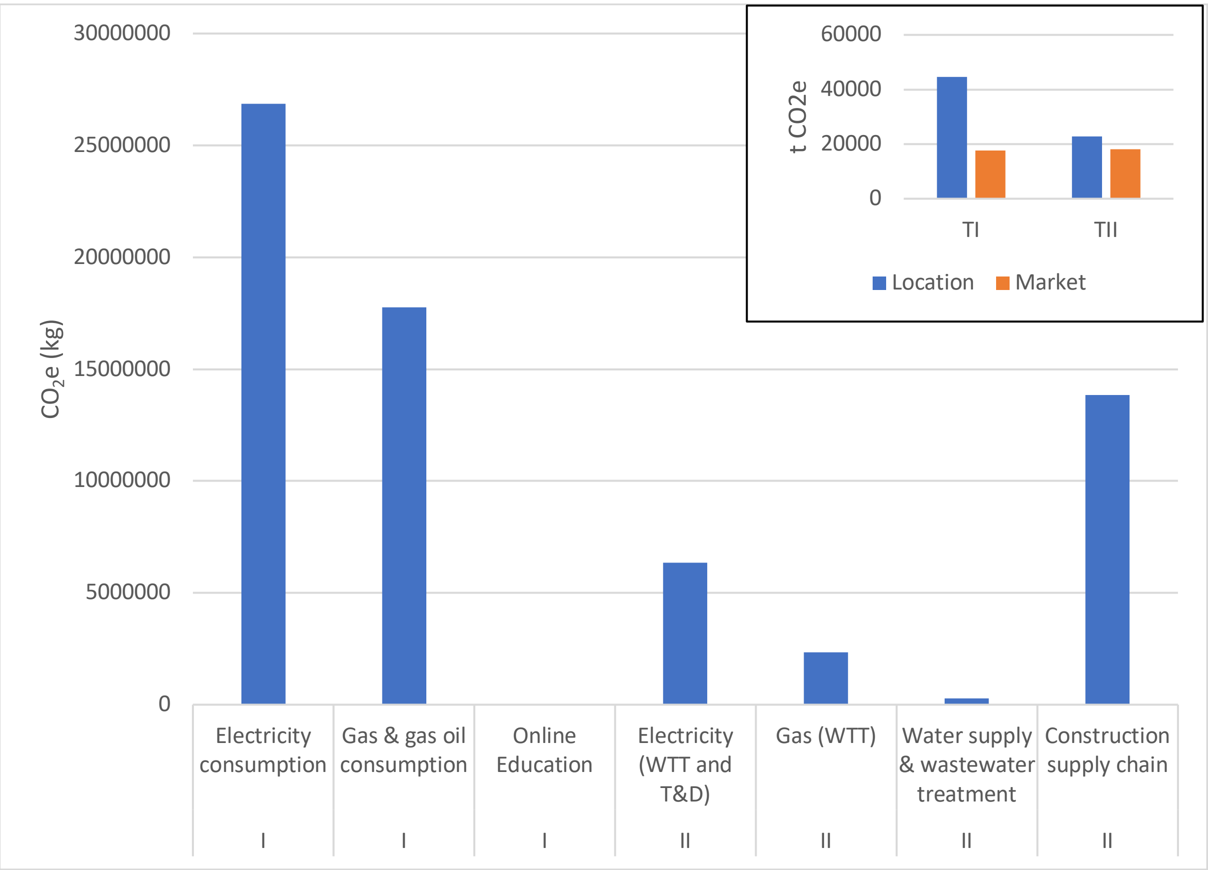


***Figure 19:** mid-point GHG emissions from the built environment aspect, summarised by activity type and sphere. Inset = relative change in GHG emissions for spheres I*

---

[59] Thomson & Harrison (2015)

and II if using the market-based approach (i.e. accounting for lower GHG emissions associated with the University renewables tariff).

Water use: Sphere I

Water consumption data are based on actual consumption data and are taken directly from the EMR dataset for the University estate.

Water consumption estimates associated with lecture streaming and tutorials is minimal in the context of this report, as the sum of the median water consumption (300 m^3) represents only 0.00003% of the total water consumed as a result of the Universities' operations and 0.02% of the water consumed from electricity consumption within the Universities' functional estate.

Water use: Sphere II: Energy Supply and Construction Supply Chain

There is substantial interaction between energy and water use in the supply chain (energy production uses significant quantities of freshwater globally[60]). A commonly used approach for assessing the direct and indirect water use associated with any given activity is to undertake a water footprinting exercise[61]. Here, estimates of embedded water use from University energy consumption are made based on two large-scale water footprint studies by Mekonnen *et al.* (2015) and Vanham *et al*. (2019).

Based on the UK's fuel mix between 2008-2012, electricity produced in the UK has a water footprint of approximately ~3000-4240 m^3/ TJ. [62] This range was converted to m^3/kWh (=0.0130 m^3/kWh) and combined with grid electricity consumption data. For comparison, Wind power has one of the lowest estimated water footprint values, ~1 m^3 / TJ energy produced[63] (=3.60 x10^{-06} m^3/kWh). This indicates that by purchasing a renewable energy tariff, the University is also substantially reducing its water footprint from energy consumption. The average consumptive water footprint for energy produced from gas is 136 m^3 / TJ[64]. This was converted to m^3/kWh (=0.0005 m^3/kWh) and combined with gas consumption data to estimate water use associated with gas consumption.

An estimate for water use associated with construction services and materials in the supply chain was calculated through placing spend data associated with construction services (as outlined in table 12) into an IOT in OpenLCA, using the method described in 'General Methods'. By running the LCAI 'Exiobase – Other Impacts', a range of water consumption impacts are outputted. This report sums the total Blue and Green water consumption to get a total water consumption amount.

---

[60] Spang et al. (2014)
[61] Hoekstra et al. (2011)
[62] Mekonnen et al. (2015)
[63] Vanham et al. (2019)
[64] As above

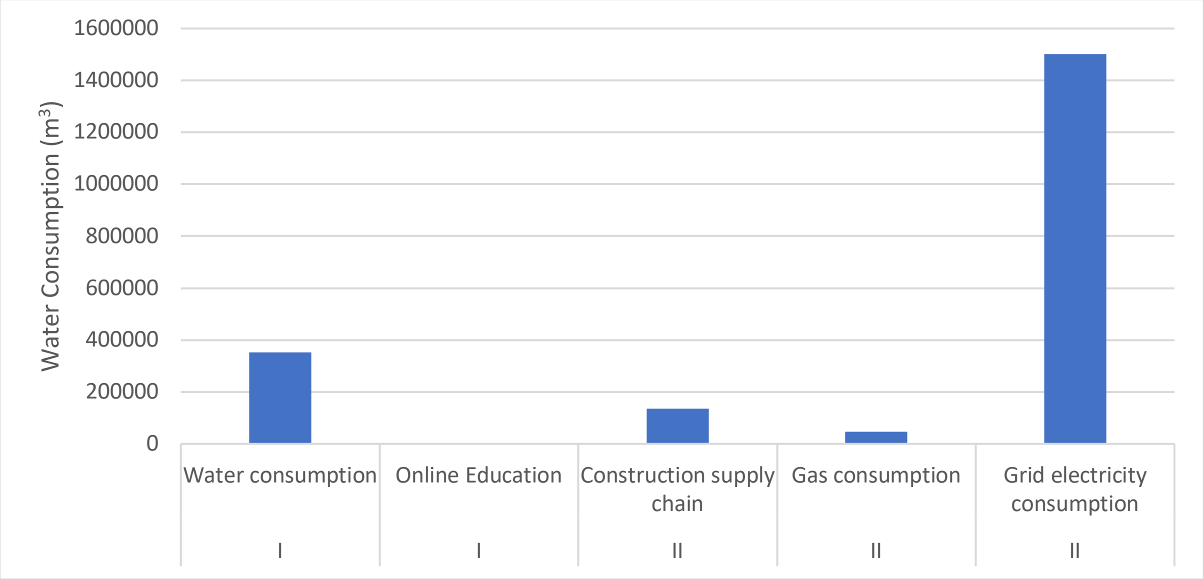


***Figure 20**: Water use from the built environment aspect summarised by activity and sphere, showing the direct water consumption on the University estate compared with the embedded water of University gas consumption, electricity consumption and construction supply chain*

Other Mid-Point Impacts: Sphere II: Construction Supply Chain

Construction supply chain impacts also had other mid-point impacts, falling under the impact categories of water pollution, water use, air pollution and land use as quantified in table 20. These location of these mid-point impacts (summed with impacts from operational and research supply chains) can be found in the appendix.

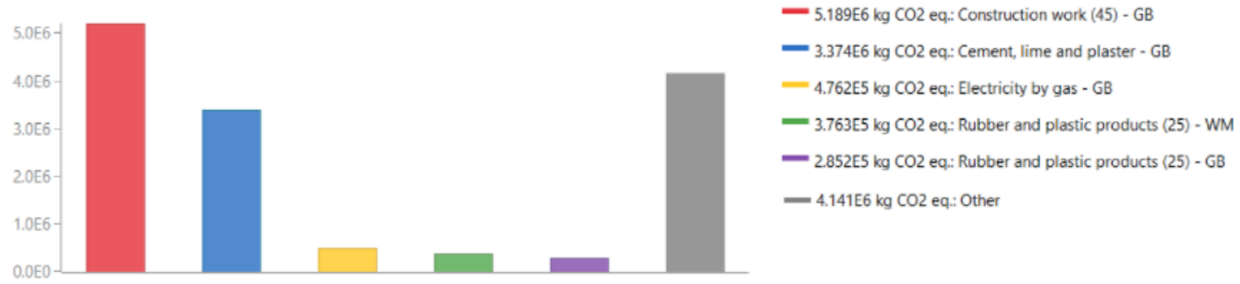
***Table 20:** available data on other mid-point impacts from the construction supply chain*

Impact	**Mid-to-end point pathway**	**Impact Value**	**Impact Metric**
Water Pollution	Eutrophication - Freshwater ecosystems	*7438.50966*	*kg PO4--- eq.*
Water Pollution	Toxicity - Freshwater ecosystems	*15952.26294*	*kg 1,4-dichlorobenzene eq.*
Water Pollution	Toxicity - Marine ecosystems	*71636755.17*	*kg 1,4-dichlorobenzene eq.*
Water Pollution	Toxicity - Terrestrial ecosystems	*148467.2273*	*kg 1,4-dichlorobenzene eq.*
Air Pollution	Acidification - Terrestrial ecosystems	*63500.05923*	*kg SO2 eq.*
Water Use	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	*134863.3758*	*m^3*
Land Use	Land Use - occupation	*740095.6014*	*m^2*

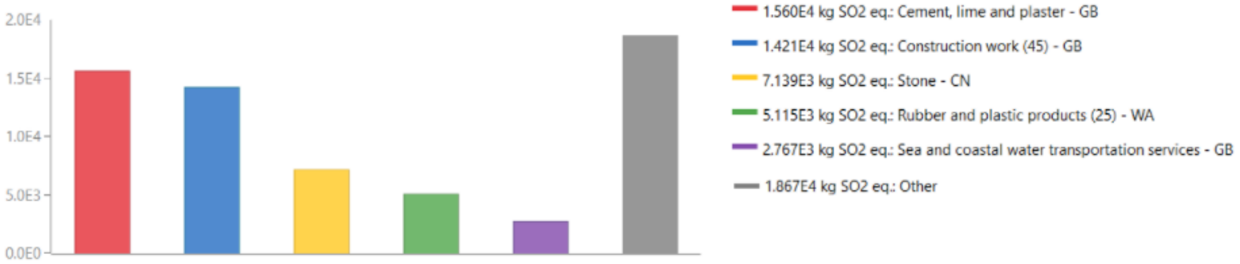
Top 5 contributions to impact category results

These mid-point impacts can be broken down into the top five downstream processes or inputs that contribute most to the final mid-point impact (Figure 21). From these graphs it is clear that the upstream process of other construction work within Great Britain produces substantial mid-point impacts. Aside from this, the consumption of cement, lime and plaster, stone, rubber and plastic products, metals and the use of transportation services significantly contribute to the overall mid-point impacts produced by the university spend on construction services.

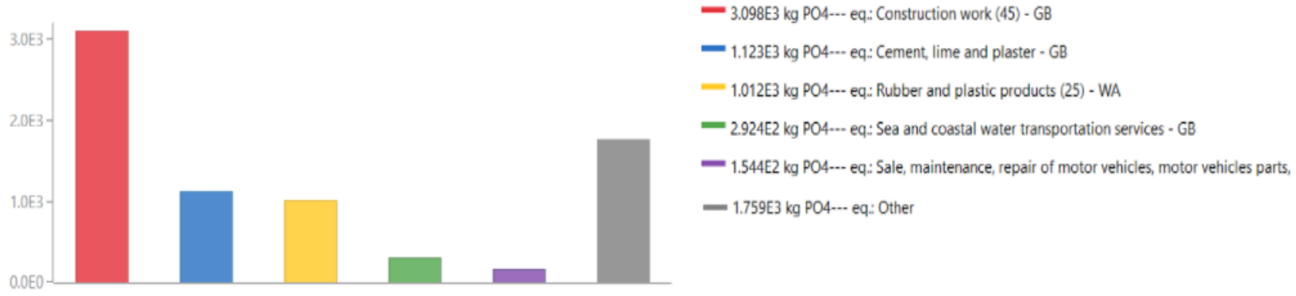
(A) GHG Emissions



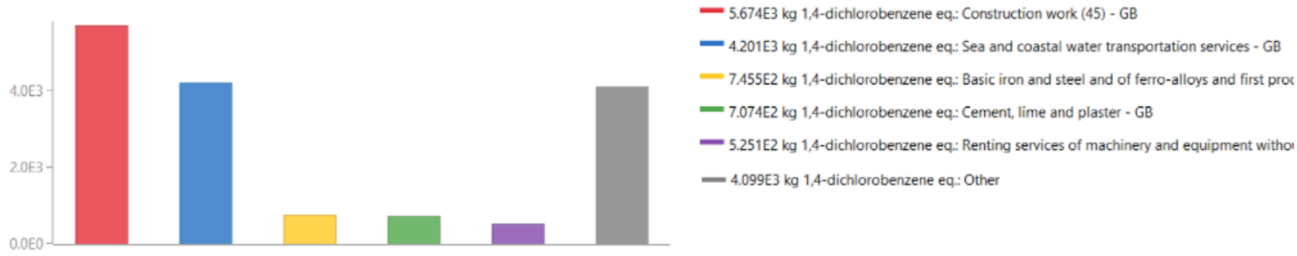
(B) Acidification



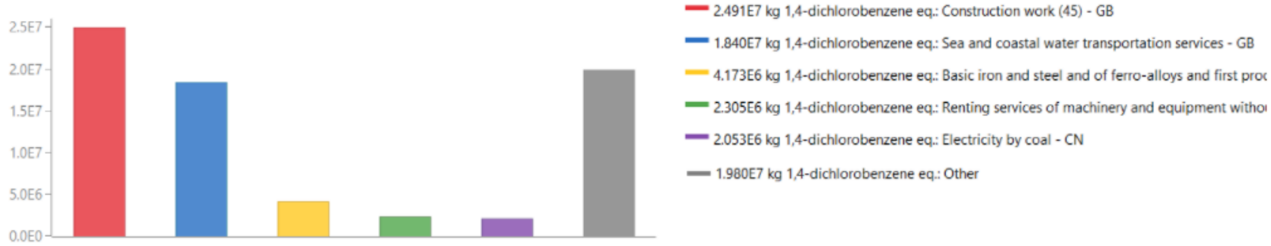
(C) Eutrophication



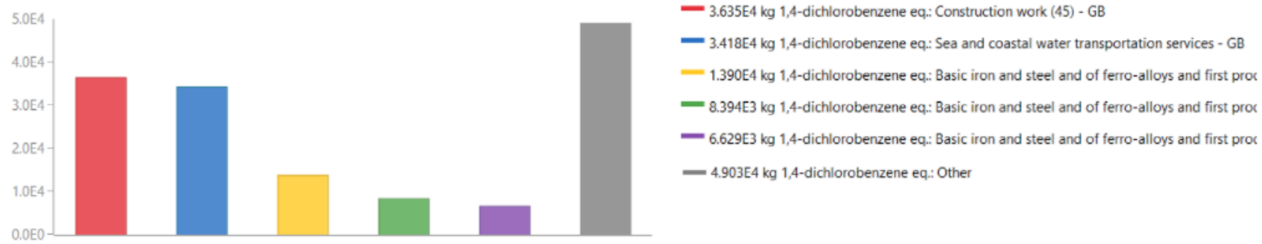
(D) Freshwater Ecotoxicity



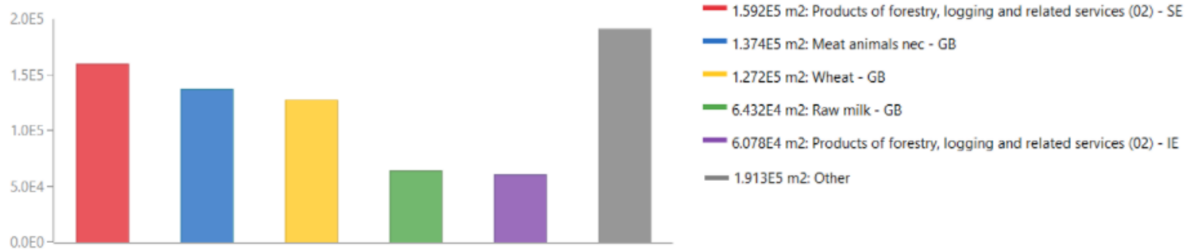
(E) Marine Ecotoxicity



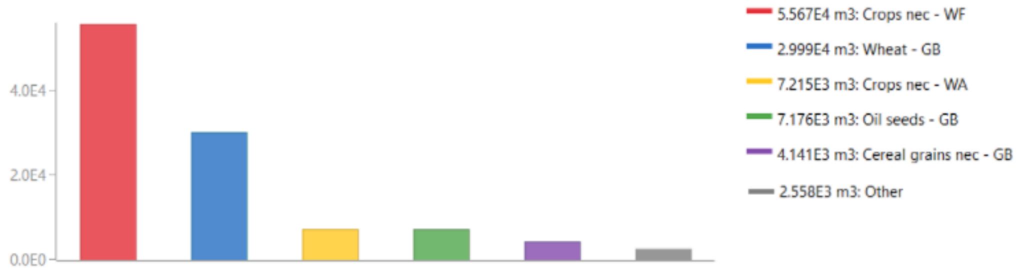
(F) Terrestrial Ecotoxicity



(G) Land Use



(H) Water Consumption - Green



(I) Water Consumption - Blue

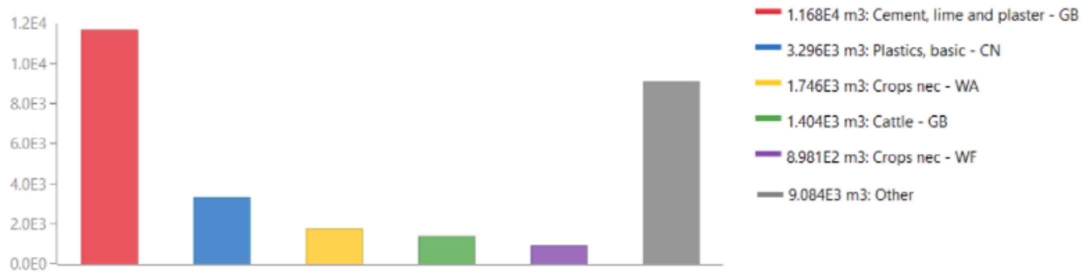


Figure 21: *graphs to show the top five contributing* ***upstream*** *processes or products that contribute to the overall mid-point impacts of total university spend on construction. (A) GHG emissions (B) Acidification (C) Eutrophication (D) Freshwater*

Ecotoxicity (E) Marine Ecotoxicity (F) Terrestrial Ecotoxicity (G) Land Use (H) Water Consumption – Green (I) Water Consumption - Blue

Land use

Areas of built environment that existed before the 2019-20 assessment period are not treated as being an 'impact' in terms of land use (i.e. historical clearance of natural habitats is excluded from this assessment). However, the current built environment footprint for University buildings in the Oxford area is included here for information, as provided by OUES. This footprint includes a total **5,083,657m²** of owned and leased sites that are part of the University's estate (group I) and a total **248,607m²** of sites that are owned by the University but leased to others for commercial/residential purposes (group II). Both of these land use types fall under sphere I, but under different management groupings (groups I and II).

3.3.4 End-point Impacts on Biodiversity

Following conversion of the mid-point impacts for this aspect, as specified in section 2.2 above, end-point biodiversity impacts summarised by sphere and impact, are provided in Figure 22. Note that estimates for impacts of water use on biodiversity are conservative, since it was not attempted to estimate how much water would be returned to the original water source, and how much would actually be 'consumed' (e.g. evaporated, incorporated into products, or returned to an alternative source) in the process of each activity.

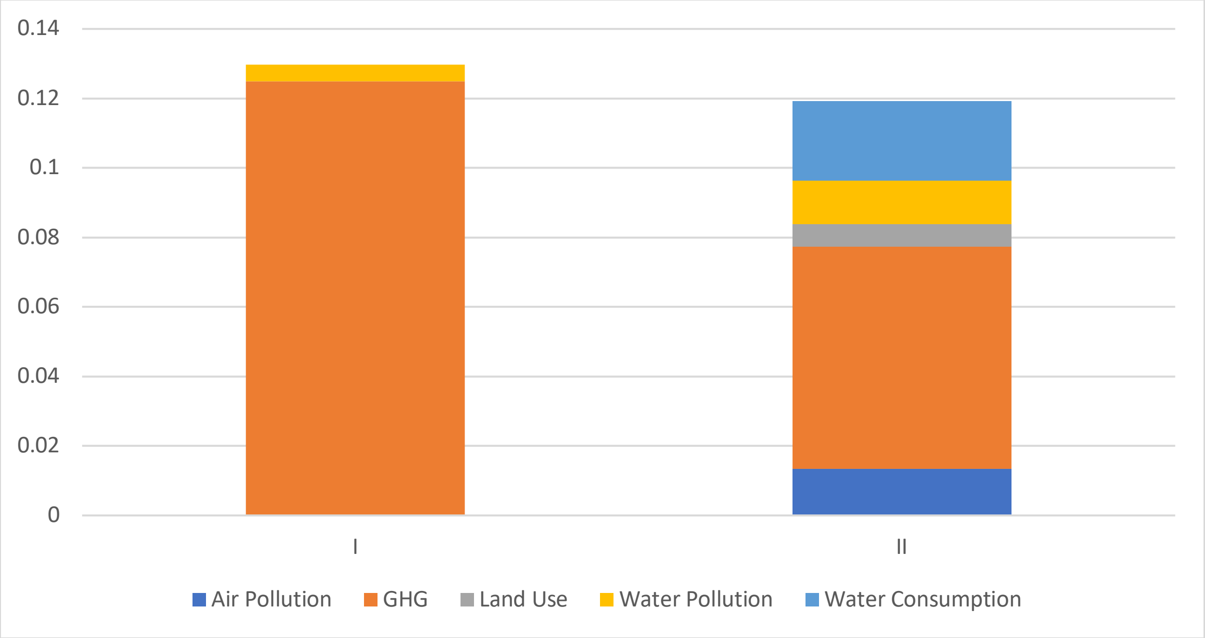


Figure 22: *Biodiversity impacts associated with Built Environment, categorised by mid-point impact and sphere.*

3.3.5 2018-19 vs 2019-20 Report Comparisons

The following section compares and explains the changes in mid-point impacts and subsequent end-point impacts on biodiversity from the previous preliminary assessment report. Suggested explanations for annual change can be found below each sub-heading, and quantification of these changes are illustrated in figures 23-25. It is important to note that the mid-point impact comparisons do not incorporate mid-point impact categories that were not included in the preliminary assessment for ease of comparison. However, in the end-point biodiversity impact comparisons, the new mid-points are included to wholly represent the construction supply chain impacts on biodiversity in Sphere II.

Mid-Point Impacts: GHG emissions

As mentioned in the EMR 2019-20, reductions in actual GHG emissions were suggested to be due to COVID-19 causing building closures across the University's Estate. This resulted in a 12% reduction in emissions from grid electricity consumption and a 1.98% decrease in natural gas consumption. These reductions in consumption resulted in a proportional decrease in GHG emissions from well-to-tank (WTT) supply chain emissions and transmission and distribution (T&D) emissions.

Finally, it is important to note that the large reduction in GHG emissions of construction supply chain is due to changes in accounting methodology between the preliminary and secondary impact assessment. Whilst the preliminary impact assessment gathered data from the HESCET Report 2018-19, which used another EEIO methodology[65], this report used the EE MRIO methodology that is explained under the 'General Methods' of this report. Thus, the data points for the construction supply chain, cannot be directly compared, but are left in for reference.

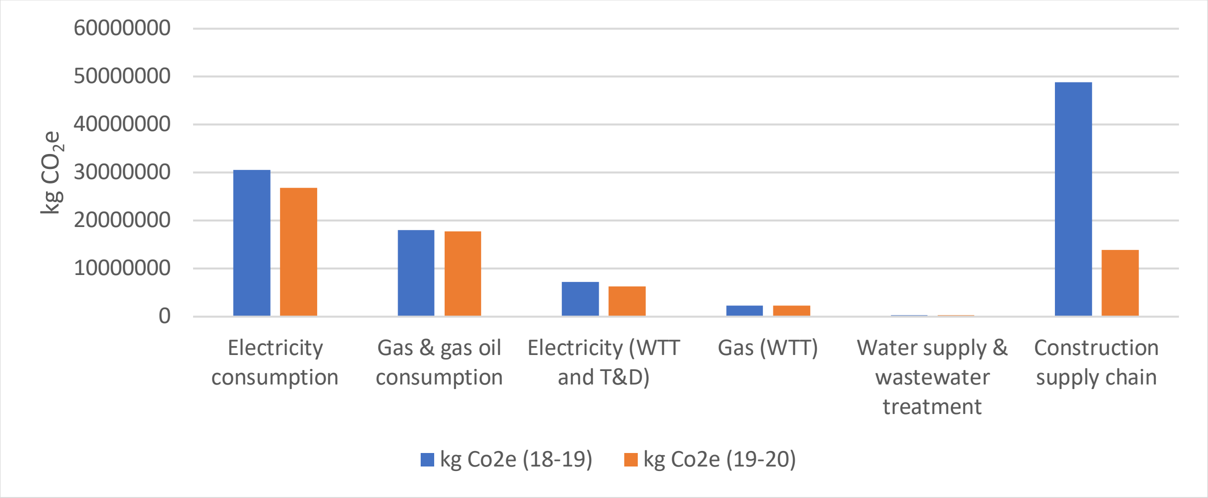


Figure 23: *Comparison of 2018-19 and 2019-20 GHG emissions from the Built Environment, summarised by sphere and activity (It must be noted that the construction supply chain calculations are non-comparable as each year calculation uses a different methodology).*

---

[65] See the Preliminary Report for further details

Mid-Point Impacts: Water Consumption

Like GHG emissions, water consumption decreased due to COVID-19 causing building closures across the Estate in Trinity Term. As with GHG emissions, construction supply chain calculations cannot be directly compared for the reasons mentioned above.

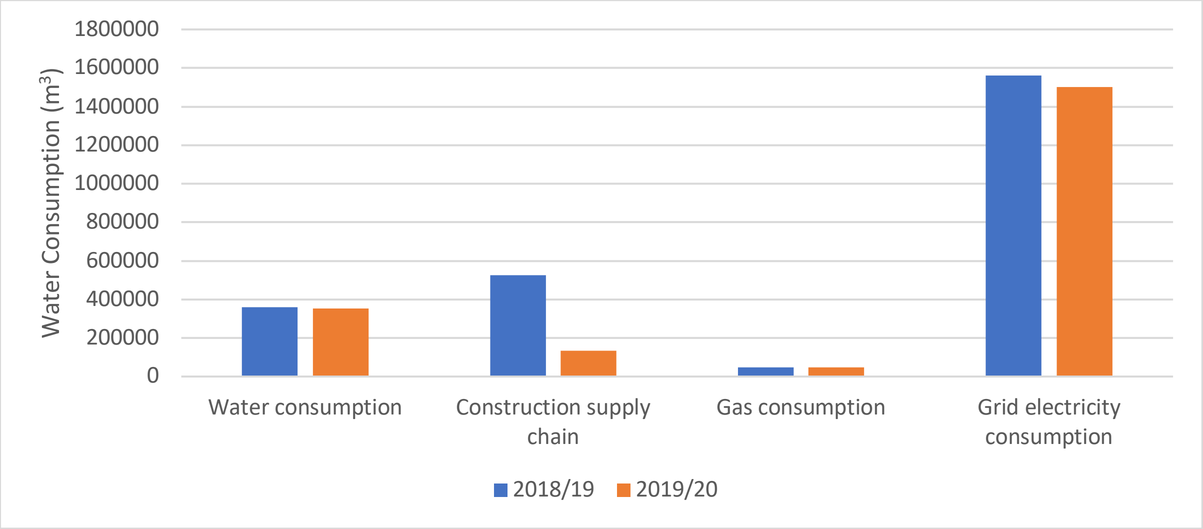


Figure 24: *Comparison of 2018-19 and 2019-20 Water Consumption from the Built Environment, summarised by sphere activity (It must be noted that the construction supply chain calculations are non-comparable as each year calculation uses a different methodology).*

End-Point impacts on Biodiversity

For spheres I and II, biodiversity impact reduced by ~8% and ~39% respectively. Whilst sphere I emissions are comparable due to consistent methodologies across the two years, sphere II emissions are not comparable due to two different methodologies being used.

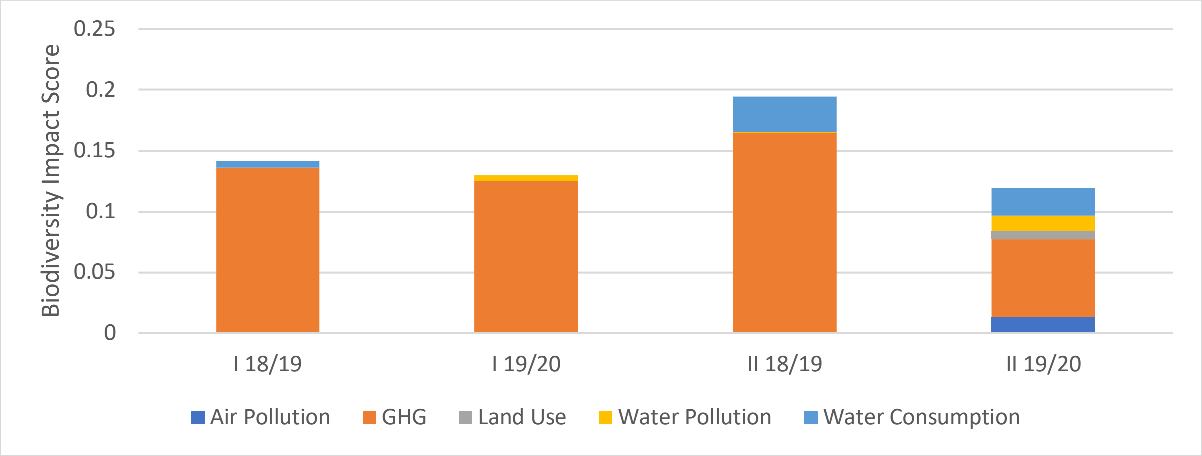


Figure 25: *Comparison of 2018-19 and 2019-20 end-point biodiversity impacts from the Built Environment, summarised by sphere and contributing mid-point impact.*

3.3.6 Data Gaps

Construction impacts: More in-depth work would be necessary in order to understand the detailed impacts of land use change for each new build projects, as well as the life cycle impacts of building materials used. Some buildings may already have had specific LCAs performed (e.g. as part of BREEAM or PassivHaus certification). The University's Environmental Sustainability Policy requires lifecycle impacts to be considered in all purchasing decisions, and the University Sustainability Design Guide requires certain materials used in construction to be A/A+ rated in the BRE Green Guide[66], so these data may be available.

Fugitive GHG (F-gas) emissions: no data were available on F-gas emissions from cooling/refrigeration units. This is an important data gap, as this would prevent the University from reporting Scope 1 emissions to the standard required by the GHG protocol. More detail on the impact of F-gases, and the importance of their reporting, is available in the Emissions Accounting Report 2019/20 that is being carried out in parallel with this project.

NO_x and other air pollutant emissions: no data were available on emissions of this type from gas boilers, although the assessment team understand that it is a work in progress.

Urban greenspace: pockets of greenspace contained within built environment sites are not currently distinguishable using the urban site area data available via OUES, which means some whole sites are treated as built environment when in fact they are built/natural environment hybrids. The Asset & Space Management team are shifting to a GIS-based system which should bridge this gap.

Water Pollution midpoint impacts: this aspect calculated all midpoint impacts associated with construction, but did not consider supply chain water pollution midpoint impacts associated with electricity production, natural gas and gas oil consumption and water consumption. By assessing the impacts associated with Exiobase 3 flows such as 'Electricity by wind – GB', 'Electricity by solar photovoltaic – GB', 'Transmission services of electricity – GB', 'Collected and purified water, distribution services of water (41) – GB' and 'Gas/Diesel Oil – GB', it becomes clear that each activity results in acidification, eutrophication, and aquatic & terrestrial ecotoxicity impacts. These midpoints are not included in this report, but should be included in future assessments to holistically calculate endpoint biodiversity impacts.

---

[66] Available at https://sustainability.admin.ox.ac.uk/files/estatesservicessustainabilitydesignguidepdf

3.3.7 Recommendations

The key data gap identified here relates to University construction projects, as the impacts estimated here were limited by a lack of granularity in the activity dataset. However, as indicated by the estimates made based on the Procurement Data Report 2019-20, GHG and biodiversity impacts from construction activities and material supply chains are likely to be very large. An important additional data gap from a GHG estimation, accounting and reporting perspective is the lack of information on F-gas emissions associated with refrigerator/cooling units. Further, it would be useful to understand what existing areas of greenspace are situated on urban sites owned by the University, as this will give an indication of what opportunities for biodiversity *gain* exist from developing new green infrastructure on University-owned sites. Although work by Emily Warner[67] has highlighted the opportunities for biodiversity gain on the University Estate, the review omitted land parcels smaller than 10 hectares. This meant that urban functional sites falling under this 'Built Environment' aspect were not reviewed, and thus no opportunities for biodiversity enhancement within urban greenspaces were recommended. Therefore, it is suggested that the University considers net gain within urban greenspaces, to serve the dual purpose of engaging students and staff, as well as increasing urban biodiversity.

Though electricity (and to a lesser extent gas) consumption through the built environment are clearly substantial sources of environmental impact, it is striking (in terms of both GHG and biodiversity impacts) how large the potential impacts embodied in construction projects are. Consequently, though reductions in energy consumption and initiatives around development of new renewable technologies will clearly be an important component of University impacts reduction (as suggested in the Strategy), attention must also be paid to means for better quantifying and then reducing the environmental impacts of construction projects.

---

[67] (Warner, 2020)

3.4 NATURAL ENVIRONMENT

3.4.1 Aspect Overview

Oxford University is a major UK landowner, and this extends to land uses which cannot be categorised under the 'built environment' (see previous aspect). Such land uses, which include anything that is not primarily hardstanding and grey infrastructure (areas of natural habitat, agricultural land, parks, recreational greenspace, etc.) can be important to local and regional biodiversity. Consequently, in this section, such land uses are collectively termed as 'natural environments' for simplicity and are explored as a standalone aspect.

Crucially (and in keeping with the rest of the assessment), the *current status* of areas of natural environment owned by the University is used as a baseline. That is, historical clearances of natural habitat on University land are not considered as 'impacts' here. Consequently, natural environments owned or managed by the University would be associated with negative biodiversity impacts were they to be cleared in the future (e.g. converted to hardstanding), but could also be associated with positive biodiversity impacts were they to be restored to more natural habitat types.

As such, the main impacts associated with this aspect relate to embodied GHG emissions and biodiversity impacts associated with procured goods and services necessary for land management. However, important consideration is also given to the *potential for biodiversity gain* on University-owned land.

Natural environment in the current Environmental Sustainability Strategy

There is no single section in the current draft Strategy that deals exclusively with the natural environment in the sense meant here – most directly relevant is section 4 ('biodiversity'), although this relates to biodiversity losses and gains more generally.

Data Gaps Addressed

<u>Detail of habitat data:</u> a more comprehensive picture of land owned by the University was outlined in the report '*Opportunities for biodiversity enhancement on the University of Oxford's Estate*'[68], which provided an assessment of habitat types within the university estate. This report could be used to influence the biodiversity net gain strategy that the University might employ. However, this report did not assess habitats that persist within land parcels owned by the university smaller than 10 hectares. Therefore, data from the OUES was used to categorise and sort university owned land holdings into land use types, and subsequently ReCiPe land use categories as detailed in table 21. Overall, the data provided in the OUES land holdings report provided more detailed land use data than in the preliminary report, aiding the categorisation process.

---

[68] (Warner, 2020)

3.4.2 Data Sources

Table 21 provides a summary of data sources, organisational scope, and sphere for each activity associated with the aspect of natural environment aspect. Assumptions made in collating and processing the activity data are listed after the table.

***Table 21**: available data on natural environments owned and/or managed by the University by source, categorised by sphere and scope*

Sphere	'Activity' description	Scope	Activity data source(s)	Data description
I	Land occupation of University-owned and managed greenspaces (e.g. University parks, Wytham Woods)	Operations	OUES (Asset & Space Management records)	Area and type of land
I	Land occupation of the commercial (agricultural) estate	Operations	OUES (Asset & Space Management records)	Area and type of land
II	Procured goods and services used in management and maintenance of University land	Operations	HESCET Scope 3 Carbon Report 2018-19	*Defra 311 sectors:* - *9.3.4.2 Plants, flowers, seeds, fertilisers, insecticides* - *5.5.2 Garden tools, equipment and accessories*

Data notes and assumptions

<u>Land holdings:</u> All areas of land are categorised as one of the following land use types: arable land, pasture, woodland, or parks and sports fields. Differences in management approaches (e.g. organic vs. intensive farmland) could not be considered as those details were not available. All areas falling within each different category are assumed to have the same impact.

<u>Defra 311 sectors:</u> Only sectors 9.3.4.2 and 5.5.2 were attributed to the aspect 'natural environment', as detailed in table 21. This contrasts the Defra 75 sectors 'Agricultural products', 'Forestry planting' and 'Fertilisers' that were attributable to this aspect in the preliminary assessment.

3.4.3 Mid-point Impacts

GHG emissions

The primary sources of GHG emissions estimated here originate from the supply chain impacts of procured goods relevant to the management and maintenance of University-owned land (sphere II). The relevant Defra 311 categories and associated GHG emissions were identified from the HESCET Report as 'Plants, flowers, seeds, fertilisers, insecticides' and 'Garden tools, equipment and accessories'. Whilst other procured goods and services might also fall under this aspect, such as gardening services, they are unaccounted for in the HESCET Report, so cannot be included in these end-point calculations.

As no relevant Exiobase 3 product or industry category matched the Defra 311 categories mentioned above, GHG emissions were taken directly from the HESCET Report, and no other supply chain mid-point impacts could be calculated.

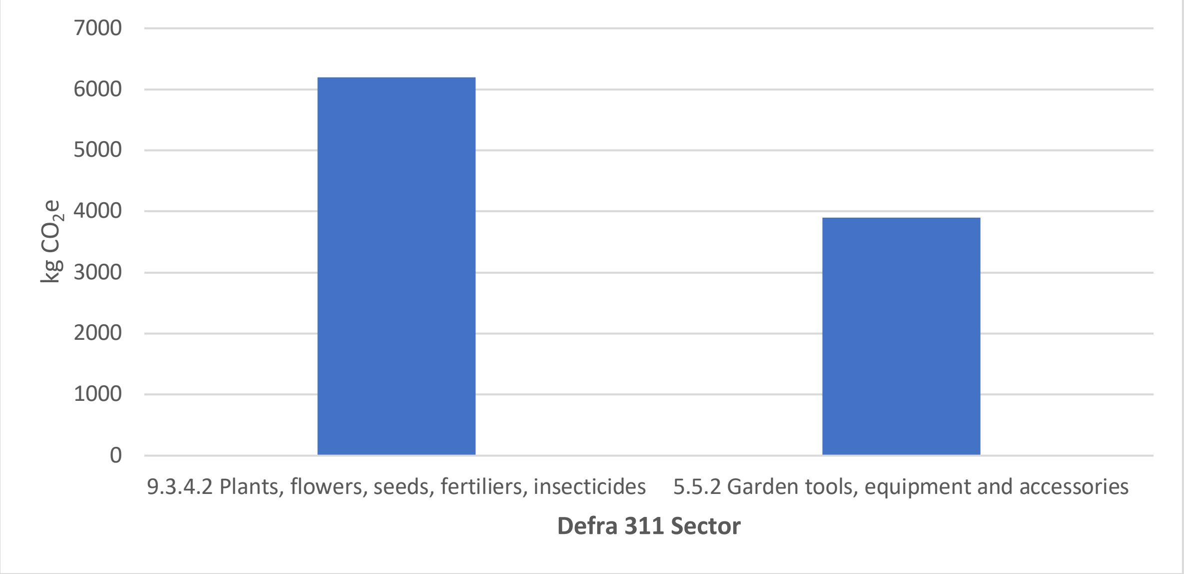


***Figure 26**: embodied GHG emissions in procured goods associated with management of sites in the natural environment category*

Land use

Information on the area and type of land use on University holdings within and surrounding Oxford was provided by OUES Rural Land Holdings Report 2021. This data is more detailed than what was provided for the preliminary report, including a breakdown of the land type by area found in each land holding following government land use codes[69]. For example, the land holding 'Wytham Wood' was further broken down into different land use types as outlined in table 22.

---

[69] Code details available here: Rural_Payments_service_-_land_use_codes_v2.0_Sep_2017.pdf (publishing.service.gov.uk)

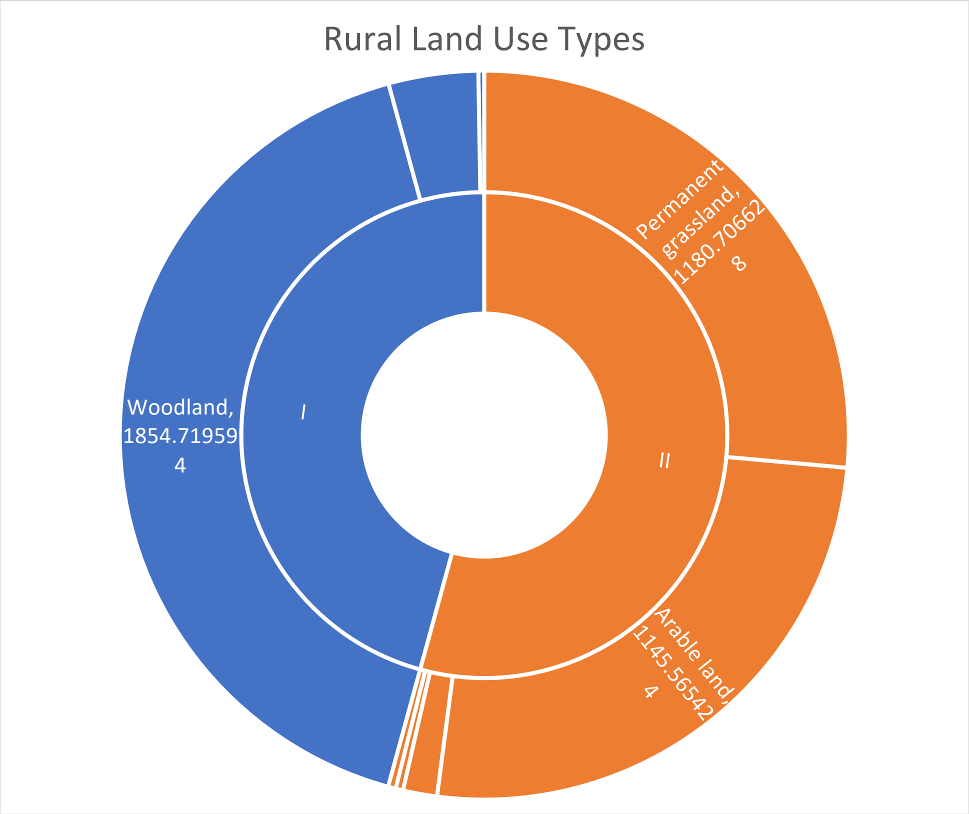
***Table 22**: Breakdown of Wytham Wood Land use types*

Land Use Category	**Acres**
Woodland	777.8781
Permanent grassland	549.6845
Arable land	464.1344
Scrub - Ungrazeable	6.18663
Inland Water	0.907771
Track - natural surface	0.681035
Pond	0.657141
Orchard	0.639476
Hard Standings	0.533375
Roads	0.465941
Watercourse	0.362771
Farmyards	0.261636
Rivers and Streams type 2	0.233287
Farm building	0.223336
Notional - Scrub	0.146994
Rivers and Streams type 3	0.050494

Moreover, this land holding report captured land that had newly come under University management since writing of the last report, including Godstow Nunnery, Tubney and additional land at Begbroke Hill Farm. As there is no information available as to whether these land holdings have been transformed since being managed by the University, these additional land holdings will become part of the baseline measurement of the land that the university occupies. Thus, this new land is not included as an impact as such, but is included to help consider possible opportunities for biodiversity interventions.

The total area (in acres) for each of the land use types relevant to the natural environment aspect is shown in Figure 27.

All land holdings fall under sphere I, but can be separated into two groups according to the management control the university has on the land. Group I incorporates all land that is owned and managed by the university (2043 acres), whilst Group II relates to all land that leased out to other land managers (2423 acres). For example, most land under Group II falls under a Farm Business Tenancy agreement, including the additional land that was purchased at Tubney and Begbroke Hill Farm.



Land Use type	Group I (acres)	Group II (acres)
Allotment Gardens	0	3.298303
Arable land	1.333856	1145.565
Drain/ditch/dyke	0	0.392111
Farm building	0.219628	0.332246
Farmyards	0.646516	0
Hard Standings	0.041554	1.276441
Inland Water	2.243149	0
Metalled track	0.038303	2.57864
Notional - Scrub	0.289202	0.074027
Orchard	1.580176	0
Pasture reversion	0	4.217088
Permanent grassland	177.5912	1180.707
Pond	1.278616	0.345213
Rivers and Streams type 2	0.014238	0.562227
Rivers and Streams type 3	0.120405	0.004368
Roads	1.151364	0
Scrub - Ungrazeable	0.665479	14.62199
Slurry Lagoon	0	1.597655
Track - natural surface	1.146086	0.536785
Watercourse	0.896424	0
Woodland	1854.72	67.45614

Figure 27: *Area of University holdings (acres) categorised into each land use type included in the natural environment aspect, and by management group (I or II).*

3.4.4 End-point Impacts on Biodiversity

Land Use

The ReCiPe methodology for estimating the impact of land-use on biodiversity uses a distinct set of anthropogenic land use types as input data, which are then converted to an equivalent area of annual cropland ('m2 annual crops eq.') in order to estimate relative impacts on biodiversity. The land-use types for University land holdings therefore had to be matched with a relevant ReCiPe category, using table 6[70] from the supplementary material of de Baan et al (2012) to match each of the land use types to the ReCiPe land use types. These matches are described in table 23.

***Table 23**: comparison between land use category as captured in University activity data and the corresponding ReCiPe land use category (with associated conversion factors to 'cropland equivalent')*

University land use category	**Corresponding ReCiPe land use category**	**Conversion factor (m^2 annual crops eq. per m^2 University land)**
Arable Land	Annual Crops	1
Orchard	Permanent Crops	0.7
Pasture reversion; Permanent grassland; Allotment Gardens; Farmyards	Pasture & Meadow	0.55
Parks & Sports fields; Farm Building; Hard Standings; Metalled Track; Drain/Ditch/Dyke; Slurry Lagoon; Roads; and Track – natural surface	Artificial Areas	0.73
Woodland; Scrub – ungrazeable; Notional - Scrub	(semi)-natural reference	0

The ReCiPe characterisation factors for land occupation are based on global meta-analyses by de Baan *et al*. (2013) and Elshout *et al*., (2014). These studies calculated the average relative species loss from various types of land occupation by comparing them with (semi)-natural reference sites. This method therefore calculates impacts on biodiversity relative to a baseline of current late-succession habitats. For this reason, any area designated as 'woodland' is assumed to be equivalent to the baseline state and therefore is assigned a biodiversity impact value of zero.

However, given the baseline year for assessment, these values are instead interpreted as the potential for biodiversity gain on University land, with the 'semi-natural' reference state representing the maximum biodiversity potential of an area of land. Areas with currently low levels of biodiversity would therefore be assumed to have the highest potential for net biodiversity gain through conservation interventions.

---

[70] Available here: Global_LCIA_LU_APPENDIX_Revised_Final (springer.com)

Conceptualising such areas in this way suggests that there is an opportunity for a biodiversity impact score **gain of 0.069** on University land; but most of this (a potential gain of 0.064) falls into management group II (i.e. University land that has been leased out). This is obviously marginal (by several orders of magnitude) compared to the negative biodiversity impacts caused through University activities under other aspects of this assessment.

3.4.5 2018-19 vs 2019-20 Report Comparisons

For this aspect, there is little value in comparing the mid-point impact of GHG emissions, as the Defra Sectors used in the HESCET 2018-19 and 2019-20 Report are distinct, and thus non-comparable. For example, the Defra 75 sectors included in the Natural Environment Aspect included Agricultural products, Forestry planting and Fertilisers. These are distinct to the Defra 311 sectors used in this report, as noted in table 21. Similarly, it is not appropriate to compare the end-point biodiversity impact of university owned land as, this year's report acts as an 'update' on the land use baseline of the University's rural land holdings.

3.4.6 Data Gaps

Overseas holdings: the data included here include UK holdings only. The assessment team did not find information on any overseas holdings.

Management impacts: there are likely to be multiple mid-point impacts associated with the management techniques of rural land holdings, for example the use of fertilisers on arable land. This report has not been able to quantify these management techniques, thus the impacts of management remain a data gap to be addressed in future reports. This could be done by quantifying the amount of fertiliser purchased by the UPD, or by carrying out quantitative surveys with land management teams.

3.4.7 Recommendations

Within the context of this aspect, there are opportunities to reduce the GHG emissions impact associated with the supply of agricultural products, but the GHG emissions here are far less than those for other aspects (e.g. built environment, travel).

The assessment team understands that work by Emily Warner has established where opportunities exist for biodiversity enhancement on University-owned land[71]. In Warner's report, interventions are recommended in line with the Conservation Hierarchy, whereby refraining from the most biodiversity-harmful actions is prioritised, followed by reducing these harmful actions. For example, the intervention 'Ensuring tree stock is optimised and maintained' falls under the 'Refrain' step, whilst 'Reducing pesticide and nutrient inputs on urban estate' falls under the 'Reduce' step.

Implementation of these interventions are to be encouraged – but it should be noted that biodiversity enhancement on the existing portfolio would fall far short of mitigating total University biodiversity impacts and realising the overall net gain objective. Consequently, biodiversity enhancements on University land could perhaps be seen more as an opportunity for communication and raising staff/student awareness about

---

[71] (Warner, 2020)

nature conservation, rather than a means for actually achieving the net gain objective for the University as a whole. Furthermore, enhancing biodiversity on the University's estate has a multitude of other benefits which are not measured in this report. This includes enhancing physical and mental wellbeing, as well as contributing to wider biodiversity benefits by improving connectivity at the landscape scale.

Having said this, on the scale of specific development projects, biodiversity impacts could and should be framed in terms of the new Defra biodiversity metric v.2.0 – as part of ensuring that new developments achieve biodiversity net gain at the site level. One component of this might involve engagement with the Oxfordshire Nature Recovery Network (NRN)[72], which identifies a core zone that represents the best areas for wildlife, and a recovery zone that represents landscapes where habitats can be restored to better support wildlife and to recover the range of economic and social benefits that nature provides. By working with partner environmental organisations and landowners, the University could contribute to local initiatives within the NRN, which would support nature's recovery, and could be used to generate additional biodiversity uplift; contributing towards achieving the net gain objective for the University as a whole.

---

[72] See for information: http://www.tverc.org/cms/news/proposed-nature-recovery-network-oxfordshire

3.5 RESOURCE USE & WASTE

3.5.1 Aspect Overview

The University procures an incredible diversity of goods and services in the course of its activities, many of which are associated with substantial environmental impacts through various stages of the supply chain. This is not unusual – Kering S.A. for example, in their development of a corporate EP&L approach, found that the majority of their impacts were at the root of global supply chains; and Bull et al. explain how a similar result is found for specific environmental aspects at other universities globally[73]. So far in this report impacts of certain goods and services have been assessed as part of other aspects (agricultural/forestry, construction, fuel/cars, utilities, and food). In this section impacts are assessed from the remaining components of the supply chain. This aspect also deals with waste production and disposal since waste can be considered the inefficient use of resource.

Both of these activities are considered under sphere II in this assessment, as the impacts created fall outside of direct or contractual control but can still be influenced by the University through choice of supply chains and disposal routes, as well through engagement with third party suppliers and waste management companies.

Further areas that could be assessed in relation to this aspect would be those associated with the physical use of resources (e.g. environmentally harmful cleaning chemicals; sphere I), as well as transport impacts associated with freight delivery and servicing (sphere II); however, these have not been included in the assessment. The former is likely to be insignificant in comparison to other activities considered in this report. The latter may be a significant source of carbon emissions and other air pollutants and is being addressed to some degree by the University through freight consolidation, however no useable data source could be identified for this assessment. Global supply chains are incredibly broad and diverse in scope. Therefore, all impact categories (GHGs, Land Use, Water Use, Water Pollution, and Air Pollution) are considered relevant and therefore assessed in relation to Resource Use & Waste.

Data Gaps Addressed

Consistent LCIA method used: One methodology was used to calculate all mid-point impacts (except GHG emissions) of the supply use chain of procured goods and services. Whilst the previous report used inconsistent conversion factors from different LCA literature for different procured materials, this report uses Exiobase 3 (an EE MRIO) to calculate mid-point impacts.

Resource Use & Waste in the Environmental Sustainability Strategy

Section 7.6 directly relates to this aspect of the report, with a broad commitment to avoid and reduce the biodiversity and climate impacts of the University's supply chain (7.6.1). More specific commitments focus on information technology procurement and operations (7.6.3, 7.6.4 and 7.6.5).

---

[73] Bull et al. (in review) A roadmap to biodiversity net gain for organisations

Commitment 7.6.2 aims to increase the recycling rates of the university, potentially through social competition interventions, such as a building recycling league table. This commitment links to the Waste section of this aspect.

3.5.2 Data Sources

Table 24 provides a summary of activity data sources, organisational scope and sphere for each activity considered within the resources and waste aspect. Assumptions made in collating and processing the activity data are listed after the table.

To calculate GHG emissions, the HESCET Report 2019-20 was used, whilst Procurement data taken directly from the UPD was used to calculate all other mid-point impacts. How both of these data sources were used to calculate mid-point impacts is detailed in the 'General Methods' section. Whilst both the HESCET Report and the Procurement data analysis produced GHG emission estimates, values for GHG emissions are taken directly from the HESCET report, to provide the best comparison between the preliminary and secondary assessment. To provide this comparisons, Defra 311 sectors that had spend data assigned were placed into a resource category used in the preliminary report, such as Paper, as described in table 24. Only 92/311 Defra sectors were assigned spend in the HESCET Report 2019-20.

***Table 24**: available data on resource use and associated waste streams by source, categorised by sphere, scope and mid-point impact calculated from the data*

Sphere	Mid-point impact calculated	Activity Description	Scope	Activity data source(s)	Data description
II	GHG	Resource disposal/ waste management	Operations	EMR 2019-20	Tonnes of waste, separated into disposal type (Waste-to-energy, hazardous, recycled, composted, anaerobic digestion)
II	GHG	Resource supply chain (Paper)	Operations	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	GHG	Resource supply chain (Laboratory equipment and resources)	Research	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	GHG	Resource supply chain (IT)	Operations	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	GHG	Resource supply chain (Business services)	Operations	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	GHG	Resource supply chain (Educational services)	Education	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	GHG	Resource supply chain (Other goods & services)	Operations	HESCET Scope 3 Carbon Report 2019-20	Aggregated spend (£) under the Defra 311 categories detailed in the supplementary material.
II	Air Pollution; Water Pollution; Water Use; and Land Use	Procurement Data Analysis	Operations	Procurement Data 2019-20 provided by the UPD	All University Spend data (£) 2019-20, aggregated by invoice and location of supplier into purchasing categories, which are then aggregated into Scopes (Research or Operations). The purchasing categories assigned to the operations scope, and that could be matched to an Exiobase 3 category include: - Desktop, Laptop and Tablet Computers / PC - Computer Accessories & Peripherals - Other Disposable Items (incl. Paperware) - Insurance (non-buildings/contents) - Hotel, College or Similar Overnight Accommodation - Workshop & Machining Equipment - Animals (Not Used as Food in the UK) - Office, Classroom, Library & Outdoor Furniture - Printing of Books and Leaflets (Print Productions) - Insurance - Stationery & Office Supplies - Lease and Maintenance of Photocopiers (incl. Stand-Alone MFD) - Books - Purchase of Audio Visual Equipment - Student Hotel or Similar Accommodation

					- Newspapers Magazines Journals and Periodicals (Hard Copy) - Electronic Components (incl. Batteries) - Protective Clothing & Safety Apparel (PPE) - Animal Feed - Mobile Phone Services (Rental, Call & Data Charges) - Office Equipment - Purchase of Mobile Phones - Metals - Mechanical Components - Purchase of Video Equipment - Telecoms Equipment (exc. Mobile Phones) - Photocopier Purchase (incl. Stand-Alone MFD) - Water Coolers - Plastics, Rubber, Glass & Ceramics - Animals (Can be Used as Food or Produce Food for Human Consumption in the UK) - Printer Purchase (incl. Networked MFD) - Mail Order Packaging - Wood - Sheet Music - Vending Machine purchase - Pre-Packaged Pet Food
II	Air Pollution; Water Pollution; Water Use; and Land Use	Procurement Data Analysis	Research	Procurement Data 2019-20 provided by the UPD	All University Spend data (£) 2019-20, aggregated by invoice and location of supplier into purchasing categories, which are then aggregated into Scopes (Research or Operations). The purchasing categories assigned to the research scope, and that could be matched to an Exiobase 3 category include: - Hand Held / Bench Top / Capital Laboratory/ Scientific/ Medical/ Refrigeration Equipment - Chemicals, Chemical Elements & Chemical Reagents (including Substances, Oligos & Antibodies) - Research Project - Clinical Trial Services (incl. Drug Manufacture & Packaging) - Research - Laboratory Plasticware - Laboratory Furniture - Laboratory Glassware

Data notes and assumptions

<u>Resource Supply Chain (GHG emissions):</u> Spend and GHG emissions data for each of the Defra 311 categories (excluding those incorporated into the 'built environment', 'natural environment' and 'food' aspects) were allocated to one of six groups for comparison: Laboratory equipment & resources; Paper; IT; Business services; Educational services; and, Other goods & services. These allocations were made based on the major sources of spend for each Defra 311 sector, using the Proc-HE codes assigned to each sector as a guide. Sectors allocated to the 'other goods and

services' category generally have lower carbon emissions compared with other sectors in the HESCET report and often have multiple sources of spend, making them difficult to allocate directly to a single group.

Resource Supply Chain Scope (all other mid-point impacts): To assign the scope to a purchasing category in the Procurement Report, the description of the purchasing category was used. However, some of these descriptions did not provide enough detail to be able to differentiate whether a category would fall under the operational, research or educational scope of this report. For example, the purchasing category 'Stationary and Office Supplies' could potentially fall under all three scopes. Therefore, where there is ambiguity, the purchasing category was assigned the scope 'Operations', as set out in table 24. The exception to this rule is stated below.

Research resources: Here it is assumed that the majority of procured laboratory and medical resources are used primarily for research purposes (rather than teaching, for example), and so they have been included under the research scope.

Procurement Data Analysis: For a full list of data notes and assumptions made in the analysis of the Procurement Data, refer to the 'General Methods' section.

3.5.3 Mid-point Impacts

GHG emissions: Waste disposal

GHG emissions from waste management and disposal were calculated by combining the waste mass by disposal method (Figure 28a) with the appropriate Scope 3 GHG emissions factor from Defra/DBEIS (2020) (Figure 28b). Defra/DBEIS do not supply a general emissions factor for hazardous waste and no further breakdown of waste types (e.g. batteries, waste electrical and electronic equipment, biohazardous waste etc) is included in the EMR dataset. Therefore, the emissions factor available for batteries (open-loop recycling) was applied to all hazardous waste. This is justified on the basis that, of the categories of hazardous waste conversion factors available from Defra/DBEIS, 'batteries' had the largest proportion of allocated University spend according to the HESCET report. All specific conversion factors used are listed in the supplementary material.

In line with GHG Protocol Scope 3 recommendations[74], Defra/DBEIS conversion factors for both recycled and incinerated waste (i.e. waste-to-energy) incorporate emissions from the processing and transport of waste only. In the latter case of waste-to-energy, GHG emissions associated with the consumption of that energy are accounted for by the end-users rather than the producer of the waste itself. However, it is worth noting that if these emissions were instead considered attributable to the producer of the waste (i.e. the University in this case), they would be the single highest source of GHG emissions associated with University activities (on the order ~ 627,000 – 1,522,000 t CO_2e per annum.[75]

---

[74] https://ghgprotocol.org/standards/scope-3-standard

[75] This figure is based on government emissions factors for waste incineration activities (700-1700 t CO_2e per t waste incinerated) (Defra, 2020)

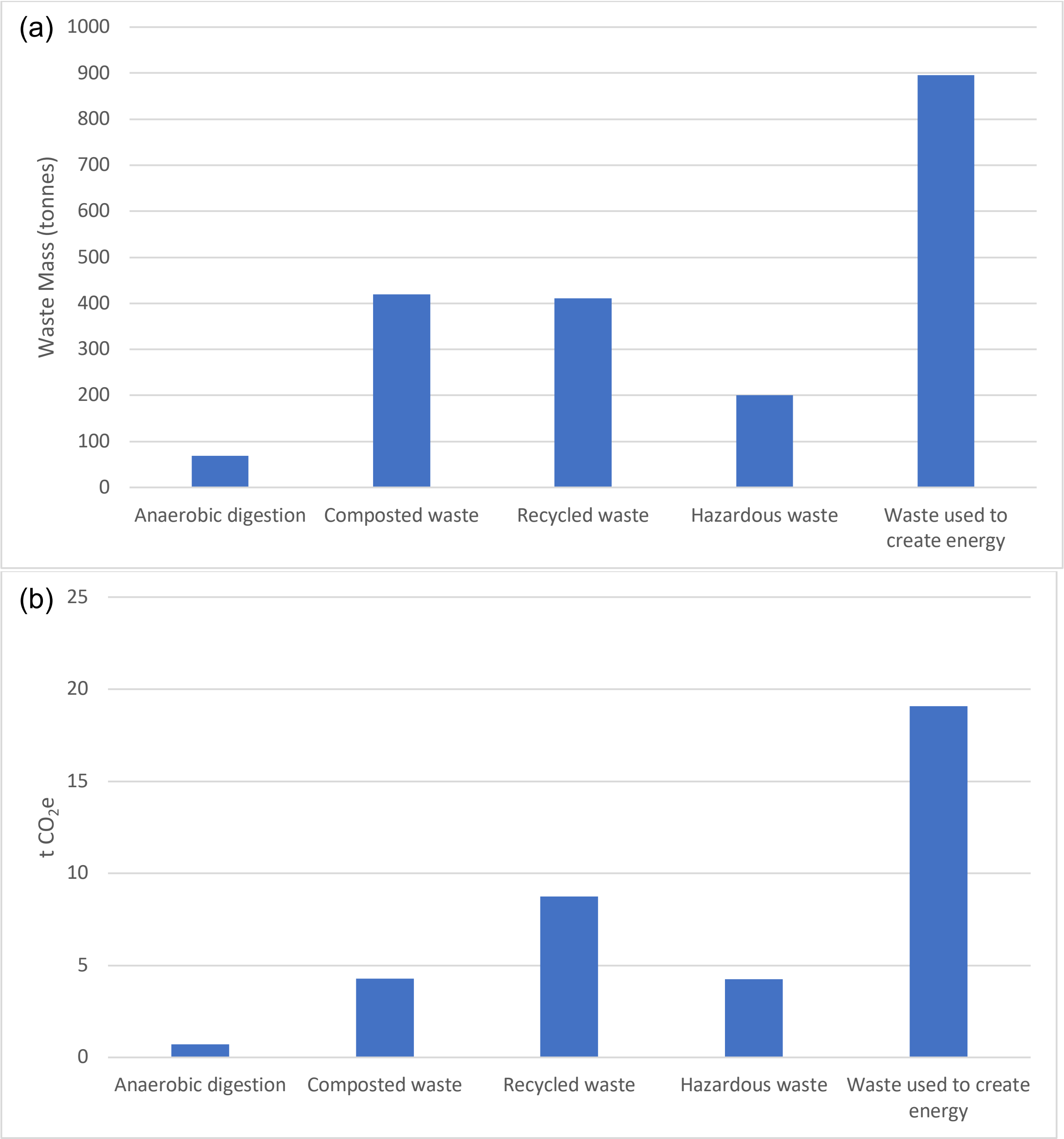


***Figure 28**: University waste production. (a) mass of waste (tonnes) produced in 2019/20 categorised by waste disposal method. (b) GHG emissions (tCO_2e) from the University's waste production, categorised by waste disposal method. No waste was sent to landfill.*

GHG emissions: Resource use

Upstream GHG emissions from the supply chains of procured goods and services were taken directly from the HESCET report. These are estimated using environmentally-extended input output (EEIO) analysis, as described in detail in in section 2.2.

Figure 29 gives the total GHG emissions (tCO_2e) for each procurement group, with total emissions from waste included for comparison. The largest quantity of emissions are clearly attributable to the laboratory resources supply chain, with 'Other Goods and Services' also producing significant GHG emissions.

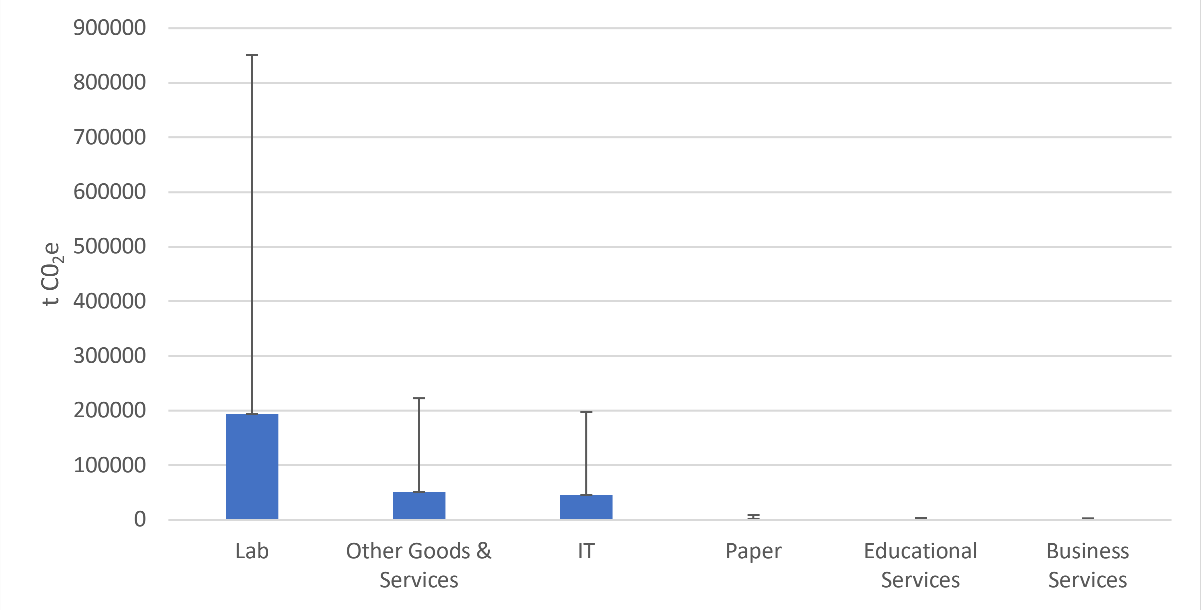
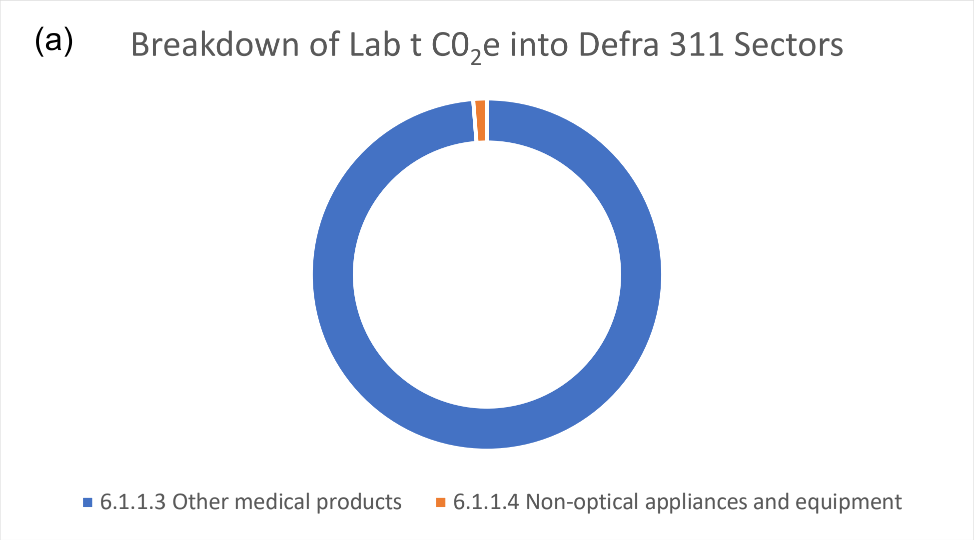


***Figure 29**: total GHG emissions (t CO$_2$e) for each procurement group (sphere II). Error bars estimates the emissions that would occur if all procurement spend data was accounted for in the HESCET report – whereby all unclassified spend is proportionally distributed amongst classified spend.*

Given that 'laboratory equipment and resources' is an extremely broad category, a further breakdown is provided here: first by Defra 311 sector (Figure 30a) and second by original source of spend based on the original spend categories (Proc-He codes) from the HESCET report (Figure 30b). A large proportion (99%) of the GHG emissions from this category originate from spend on '6.1.1.3 Other medical products', which, on its own, represents 30% (£74,295,050.34) of the total annual spend recorded in the HESCET report.



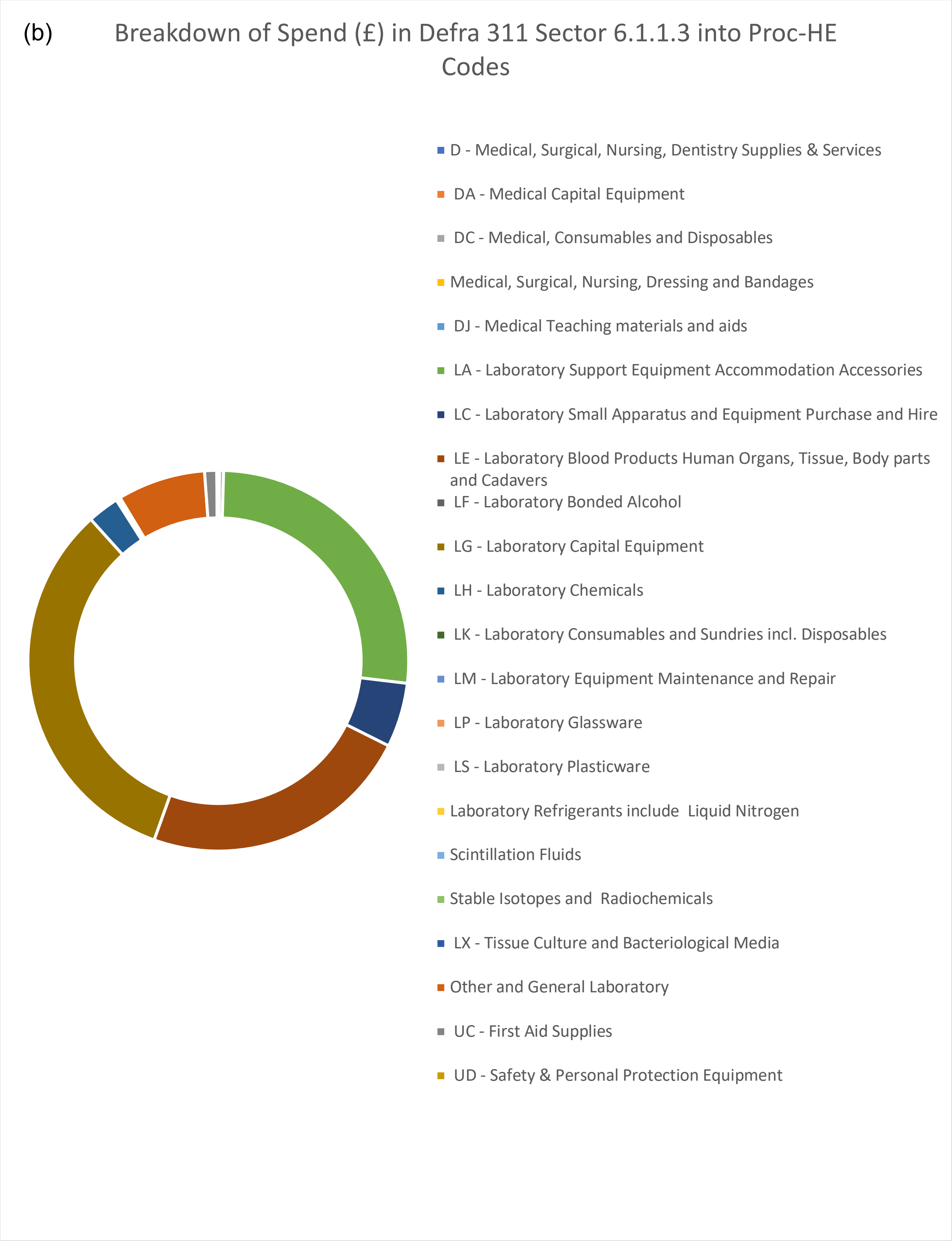


Figure 30: *(a) Proportional CO_2e emissions from laboratory resources & equipment (%) Broken down by Defra 311 sectors; (b) Breakdown of Defra Sector 6.1.1.3 by spend category (Proc-HE code).*

Other mid-point Impacts: Resource Use

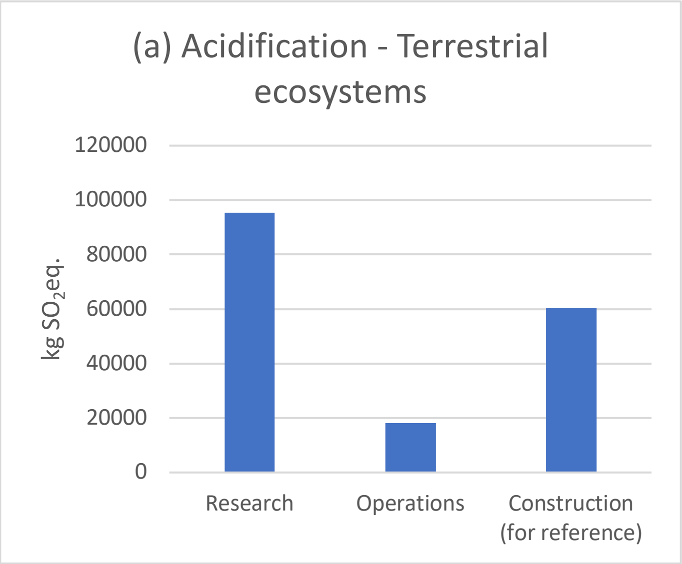
In order to calculate other mid-point impacts of University Spend, the Procurement Data 2019-20 from the UPD was analysed as detailed in the 'General Methods' section of this report. To summarise this method, spend in procurement categories in the procurement data 2019-20 was aggregated by scope and supplier location, and then matched to an Exiobase 3 industry/product flow and country, using the EU's NACE 1 categorisation system as a matching guide. This spend data was then inputted into an IOT in OpenLCA to carry out an LCIA, which then quantified and located the mid-point impacts detailed in table 25. The location of mid-point impacts from resource use (research and operations) and construction supply chains are summed, mapped and quantified by country in the appendices.

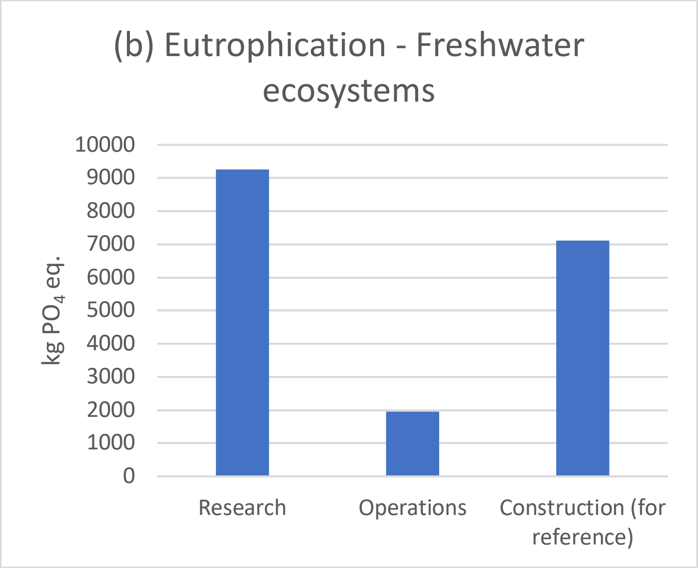
***Table 25**: Relevant mid-point impacts and associated mid-to-end point pathway used in this report, categorised by the Life cycle impact assessment (LCIA) method embedded in Exiobase 3 used to calculate the mid-point impacts.*

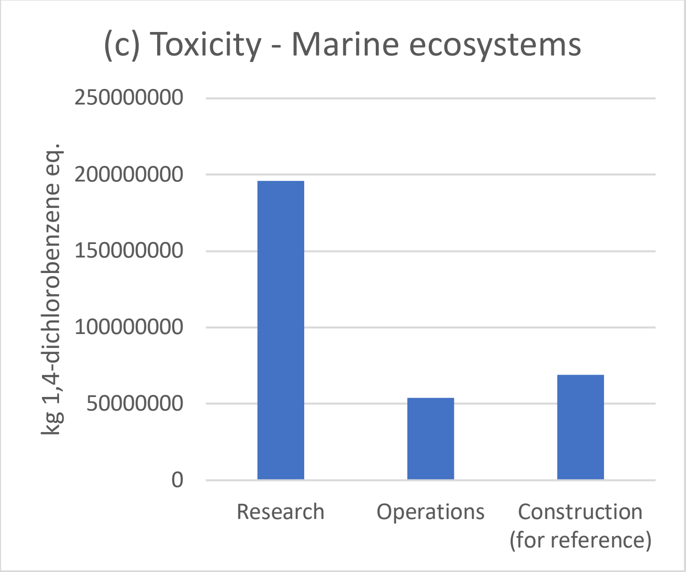
LCIA Method	**Mid-point impact**	**ReCiPe mid-to-end point pathway**
CML, 2001	Acidification	Acidification - Terrestrial ecosystems
CML, 2001	Eutrophication	Eutrophication - Freshwater ecosystems
CML, 2001	Freshwater aquatic ecotoxicity	Toxicity - Freshwater ecosystems
CML, 2001	Marine aquatic ecotoxicity	Toxicity - Marine ecosystems
CML, 2001	Terrestrial ecotoxicity	Toxicity - Terrestrial ecosystems
Exiobase – Other Impacts	Land use	Land Use - occupation
Exiobase – Other Impacts	Water Consumption (sum of Water Consumption Blue – Total and Water Consumption Green – Agriculture)	Water Consumption – Terrestrial Ecosystems

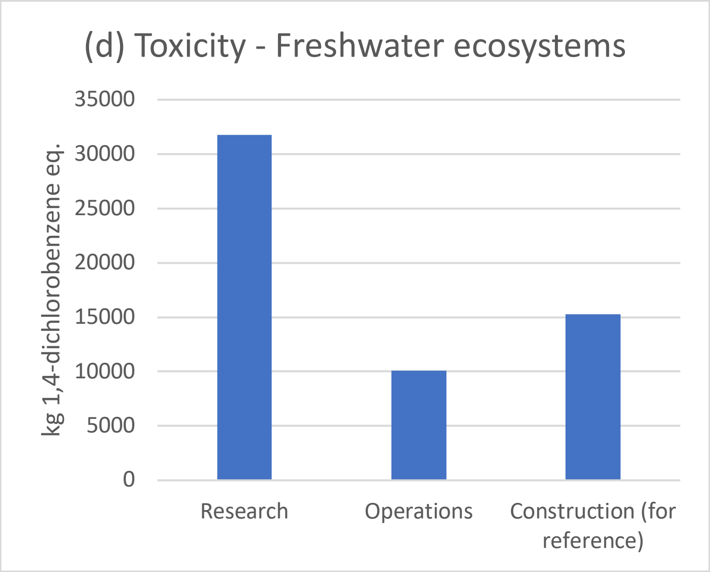
Results

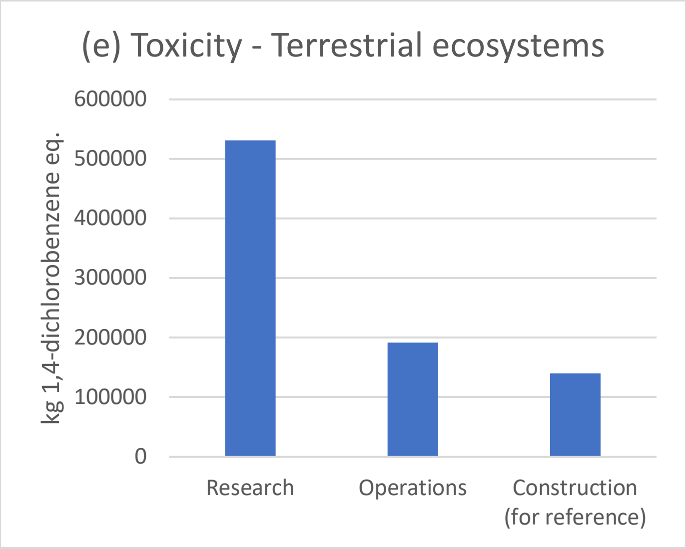
The following graphs illustrate each mid-point impact, broken down by scope (either Research or Operational), with the 'Construction' Supply Chain impact used as a reference point. Further details about Construction Supply Chain impacts can be found in the Built Environment aspect of this report.

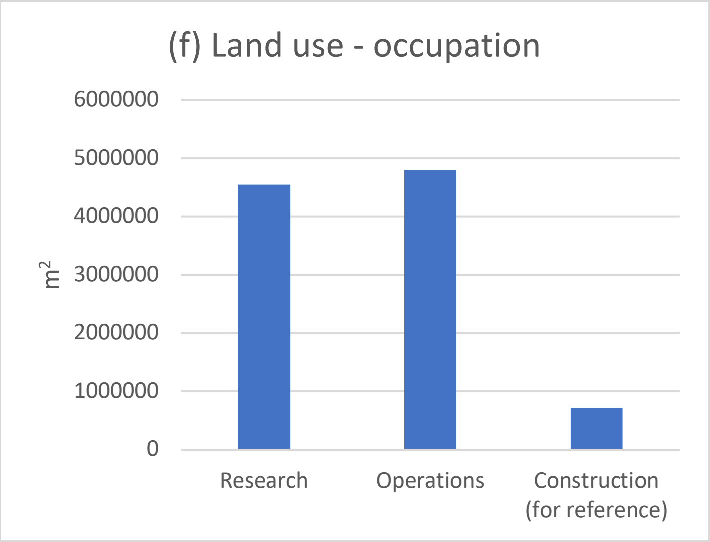

(a) Acidification - Terrestrial ecosystems
kg SO2eq.
120000
100000
80000
60000
40000
20000
0
Research
Operations
Construction (for reference)


(b) Eutrophication - Freshwater ecosystems
kg PO4 eq.
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Research
Operations
Construction (for reference)


(c) Toxicity - Marine ecosystems
kg 1,4-dichlorobenzene eq.
250000000
200000000
150000000
100000000
50000000
0
Research
Operations
Construction (for reference)


(d) Toxicity - Freshwater ecosystems
kg 1,4-dichlorobenzene eq.
35000
30000
25000
20000
15000
10000
5000
0
Research
Operations
Construction (for reference)


(e) Toxicity - Terrestrial ecosystems
kg 1,4-dichlorobenzene eq.
600000
500000
400000
300000
200000
100000
0
Research
Operations
Construction (for reference)


(f) Land use - occupation
m2
6000000
5000000
4000000
3000000
2000000
1000000
0
Research
Operations
Construction (for reference)

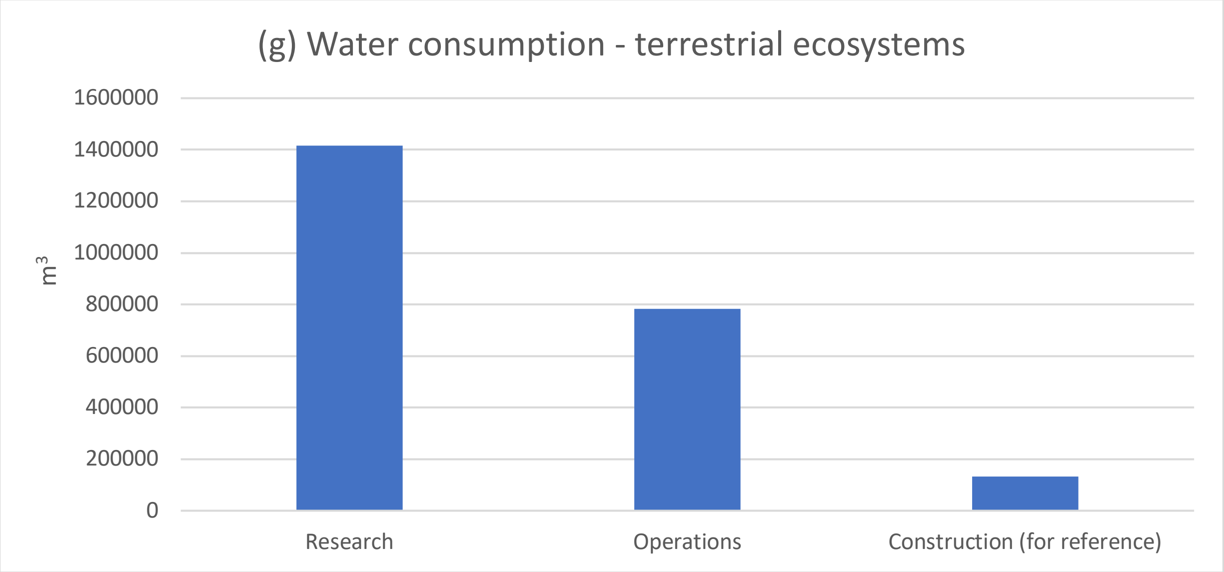


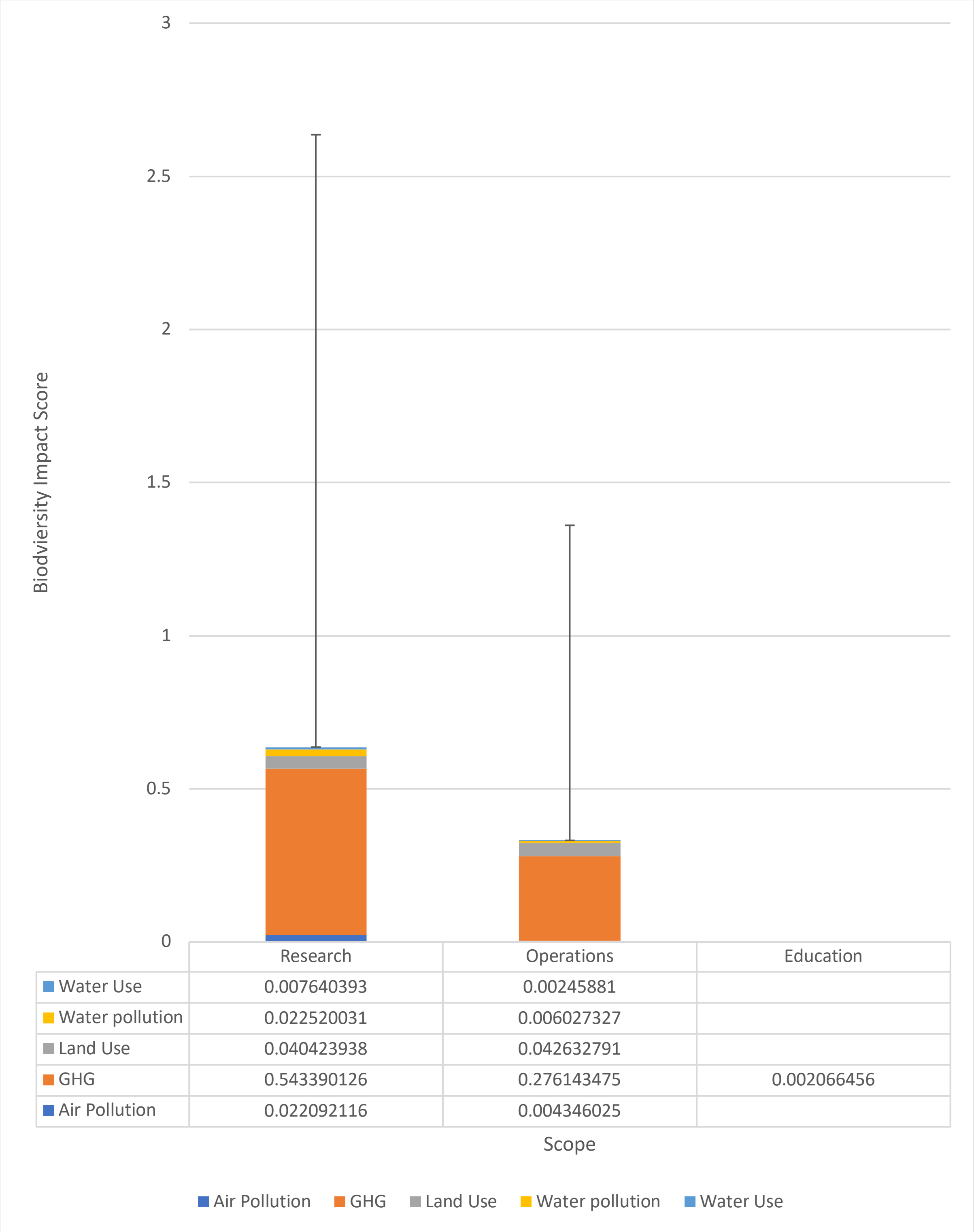
Figure 31a-g: *Mid-point impacts of the supply chain of resources that fall under either scope of Research or Operations, with Construction supply chain impacts used as a reference point.*

3.5.4 End-point Impacts on Biodiversity

Here, as for previous aspects, impacts on biodiversity are summarised from each of the analysed mid-point impacts by combining average values with ReCiPe conversion factors.

These results are summarised in figure 32, with this aspect contributing to a total end-point biodiversity impact score of **0.97**. It is worth noting that the activity data available (the HESCET Report 2019-20 and the Procurement Report 2019-20) was most easily categorised into either the Operational or Research Scope, rather than the Education Scope. However, there is expected to be significant overlap between the Research and Education scope in terms of resources used. The only resource that was clearly associated with education was the Defra 311 sector 10.1 'Education' found in the HESCET report, hence there is a single end-point value from GHG impacts within the Education Aspect in figure 32.

It is important to understand that GHG mid-point impacts have a high proportional contribution to the overall end-point biodiversity impact of Operations due to the information available to quantify the impacts of waste activity data, and the lack of information available to quantify the other mid-point impacts for these same data. Moreover, two different methods were used to calculate the mid-point impacts, as detailed in the previous section.



	Research	Operations	Education
Water Use	0.007640393	0.00245881	
Water pollution	0.022520031	0.006027327	
Land Use	0.040423938	0.042632791	
GHG	0.543390126	0.276143475	0.002066456
Air Pollution	0.022092116	0.004346025	

***Figure 32:** End-point Biodiversity impact of all activities falling under each scope, categorised by mid-point impact. The error bars indicate the potential biodiversity impacts that would occur if all procurement spend data was accounted for in the HESCET report and classified in the Procurement Report – whereby all unclassified spend is proportionally distributed amongst classified spend*[76].

---

[76] In this case, GHG emissions were multiplied to represent £1,042,711,437 of spend that is reported in the Procurement Report, of which 58% is unclassified in the Procurement report, and 77% is unclassified in the HESCET report.

3.5.5 2018-19 vs 2019-20 Report Comparisons

The following section compares and explains the changes in GHG mid-point impacts and all end-point impacts on biodiversity from the previous preliminary assessment report.

Mid-Point impact: GHG Emissions

Only GHG emissions can be compared as both assessments used similar data sources (HESCET Report and EMR) and methodologies to calculate mid-point impacts. However, comparisons of GHG impacts of resource use (Figure 34) must be made with caution as different categorisation methods within the HESCET Report were used across 2018/19 and 2019/20. Figures 33 and 34 describe how GHG impacts differed between assessments, for waste and resource use respectively, with figure 34 being taken straight from the HESCET 2019-20 Report.

Contrastingly, the methods used to quantify the other mid-point impacts from resource supply chains differ too much between reports to make comparisons appropriate. Whilst the preliminary report used inconsistent life cycle impact assessment methods across different types of materials purchased, this report uses a single impact database in the form of a set of EE MRIOTs (Exiobase 3). For more detail, refer to the 'General Methods' section of this report.

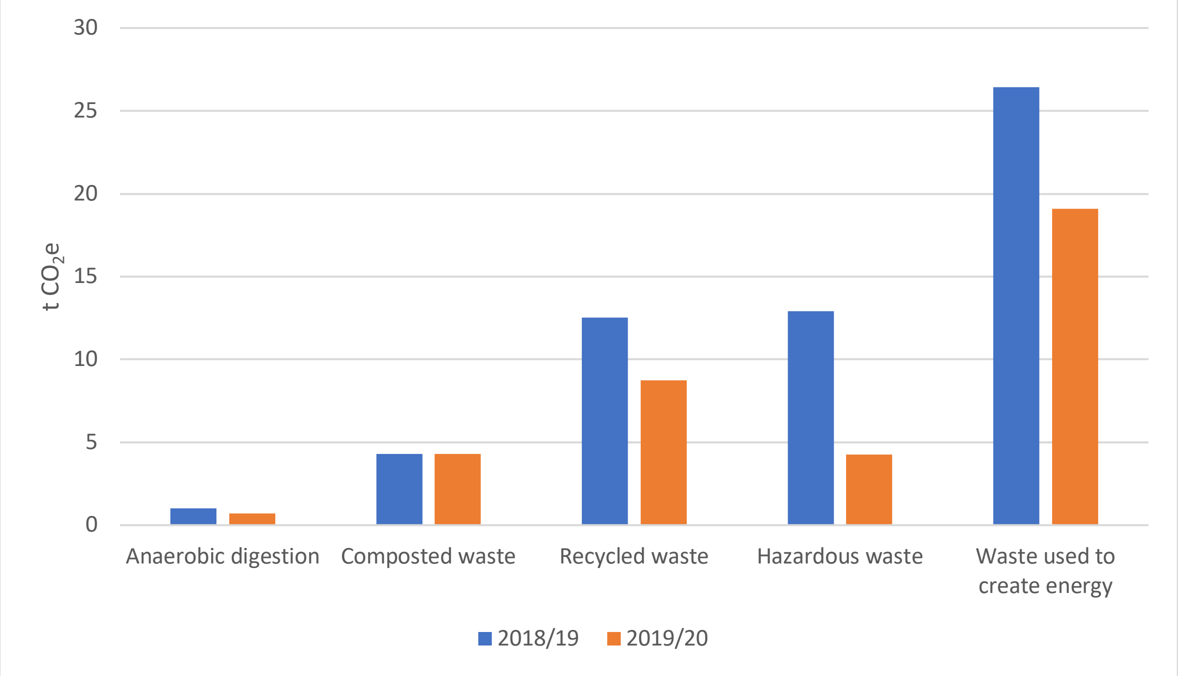


***Figure 33**: GHG Impact Comparisons for different types of waste disposal between the academic years 2018/19 and 2019/20.*

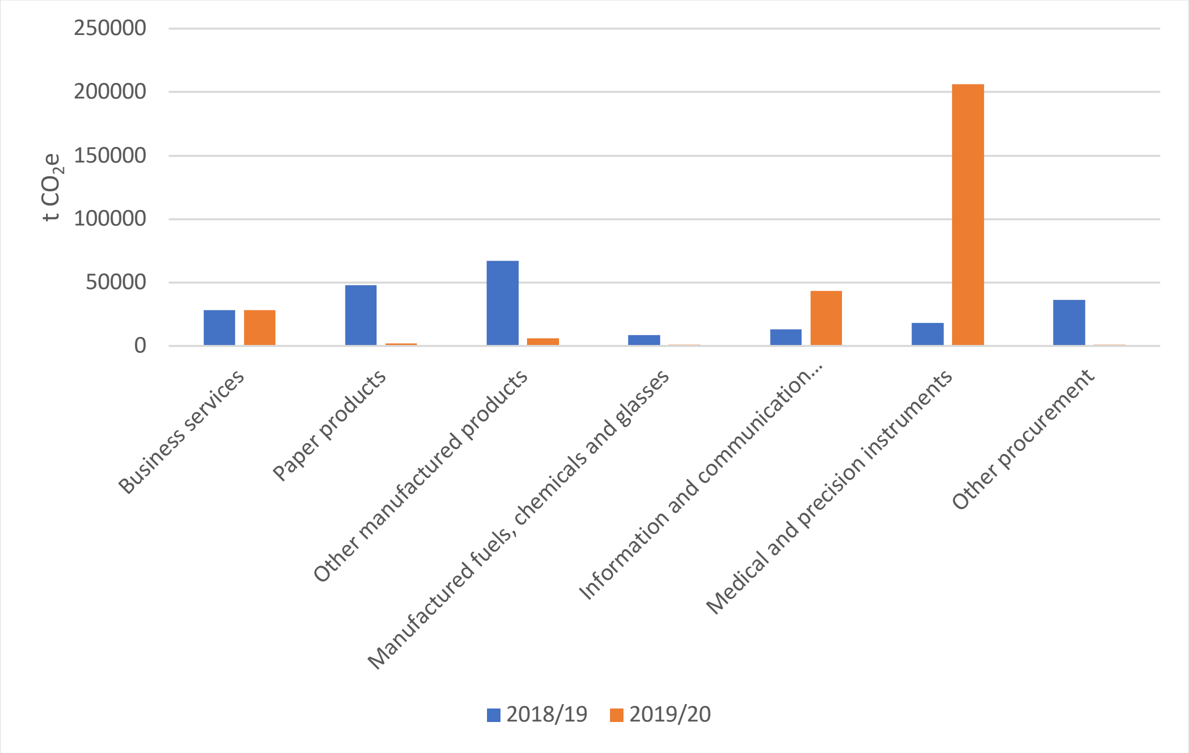


Figure 34: *GHG Impact Comparisons for different types of resource uses between the academic years 2018/19 and 2019/20.*

Table 26: *change in GHG emissions between the 2018/19 and 2019/20, according to the HESCET report. This table reports spend data from both 2018/19 and 2019/20 against the new Defra 311 categories, so that both reporting years are comparable.*

Year			
	Tonnes CO_2e 19/20	**Tonnes CO_2e 18/19**	**Change**
Business services	28212.23	28267.00	-54.77
Paper products	2103.34	47678.00	-45574.66
Other manufactured products	6247.55	67098.00	-60850.45
Manufactured fuels, chemicals and glasses	987.63	8753.00	-7765.37
Food and catering	1381.01	22072.00	-20690.99
Construction	2241.64	57622.00	-55380.36
Information and communication technologies	43363.73	13232.00	30131.73
Waste and water	579.69	760.00	-180.31
Medical and precision instruments	206447.12	18046.00	188401.12
Other procurement	822.77	36090.00	-35267.23
Unclassified	414.44	0.00	414.44
Total	**292801.15**	**299617.00**	

End-Point impact: Biodiversity

As methods for calculating the mid-point impacts involved in the Resource use and Waste Section (except for GHG waste impacts) differed between each assessment, the end-point biodiversity impact comparisons (figure 35) should be approached with caution. All impacts within this aspect fall under Sphere II. Note that the potential biodiversity impact score for both assessments could be higher if all spend data was classified within the HESCET and Procurement Report (as indicated in the error bars of figure 32).

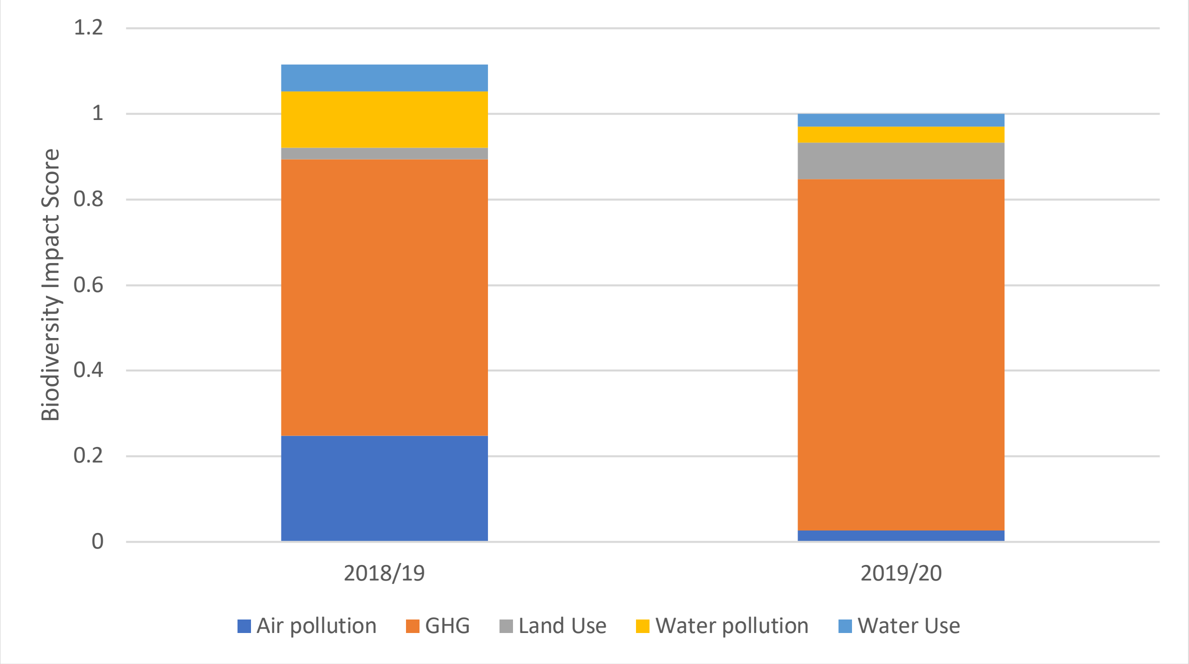


***Figure 35**: End-point Biodiversity impact comparison for the years 2018/19 and 2019/20*

3.5.6 Data Gaps

<u>Resource retention:</u> all activity data above are based on purchased goods, so it is not clear what proportion of these resources are used and what proportion is retained as stock on campuses (e.g. laboratory products, cleaning products, etc.) – although since the majority of resources are presumably used eventually, the implications of resource retention may be small.

<u>Transportation associated with resource use:</u> impacts associated with the transportation of resources from the point of manufacture to the University itself are not included here, as estimates are yet to be made by the University. However, it is understood that work is being carried out in order to improve local impacts through, for example, freight consolidation.

<u>Procurement Data:</u> To see a full set of limitations and data gaps for the Procurement data, refer to the 'General Methods' Section of the Report.

<u>HESCET Report:</u> To see a full set of limitations and data gaps for the HESCET Report, refer to the 'General Methods' Section of the Report.

Paper breakdown: No information could be obtained regarding the breakdown of recycled and virgin paper purchased by the University.

Waste breakdown: Here, there is a lack of certainty about which materials are and are not being recycled. Further, the impacts of hazardous waste will vary depending on the precise type of hazardous waste, and this is not captured here.

3.5.7 Recommendations

Though there are a number of important data gaps above, the recommended focus for improvement would be ensuring the accuracy and completeness of procurement coding on the part of staff across the University. Potential gains in accuracy of any future assessments will be more substantial if this issue is solved than those relating to the other data gaps (simply due to the magnitude of the relative impacts of resource use over those from other aspects assessed in this report).

It is abundantly clear from this assessment that the largest sphere II environmental impacts assessed here are those impacts associated with the upstream supply chain, specifically for research resources. In turn, this suggests that introducing more sustainable procurement measures (alongside existing proposals around reducing consumption) should be a priority.

In terms of research resources, though initiatives in this area are clearly vital given the relative size of the associated environmental impacts, it is difficult to say where the main impacts come from, given that purchasing categories in the procurement datasets are often vague. For example, the procurement category '*Hand Held / Bench Top/ Capital Laboratory/ Scientific/ Medical/ Refrigeration Equipment*' and '*Chemicals, Chemical Elements & Chemical Reagents (including Substances, Oligos & Antibodies)*' are both broad, so it is difficult to understand which exact purchases/items are producing the largest impact. Currently these purchasing categories are assigned a homogenous industry/product in the Exiobase 3 database, thus are assigned an industry/product average impact, dependent on the supplier location. Whilst this provides an insight to the relative impacts of these procurement data sets, it will not differentiate between low-impact and high-impact companies that the university may be supplying it's resources from. To shift procurement towards suppliers with low-impact supply chains, it is recommended that future assessments reach out to individual high-spend suppliers, such as Dell Corporation Ltd and Life Technologies Ltd to attain any impact accounting reports that each supply chain has carried out. Similar work was started by Maria Marinari within the OUES Sustainability Team relating to Carbon accounting. However, it is unlikely that suppliers will provide a full list of mid-point impacts as used in this report, so there is great benefit in using the current mid-point impact calculation methodology for supply chains, alongside reaching out to individual suppliers.

Though potentially small in terms of relative impacts (or not, depending on where the accounting boundaries for GHG emissions are drawn), decreasing waste whilst increasing the proportion of waste recycled – and particularly the proportion diverted from waste-to-energy – could make a meaningful contribution towards reducing impacts.

4. Summary and Conclusions

All headline results should be taken in the context of the numerous assumptions and caveats outlined throughout this report. One of the most important outputs here is the overview of remaining data gaps (included in Table 27 below, that also captures key recommendations).

However, with that in mind, the quantitative results can be summarised as follows. Firstly, in Figure 36 relative impact results are shown for both GHG emissions and biodiversity loss separately. In total, the end-point impacts are **417,000 tonnes CO_2e** and a biodiversity impact score (BIS) of **1.6**. The variation is considerable, but it is abundantly clear that the vast majority of impacts for both are found in sphere II resource use and waste.

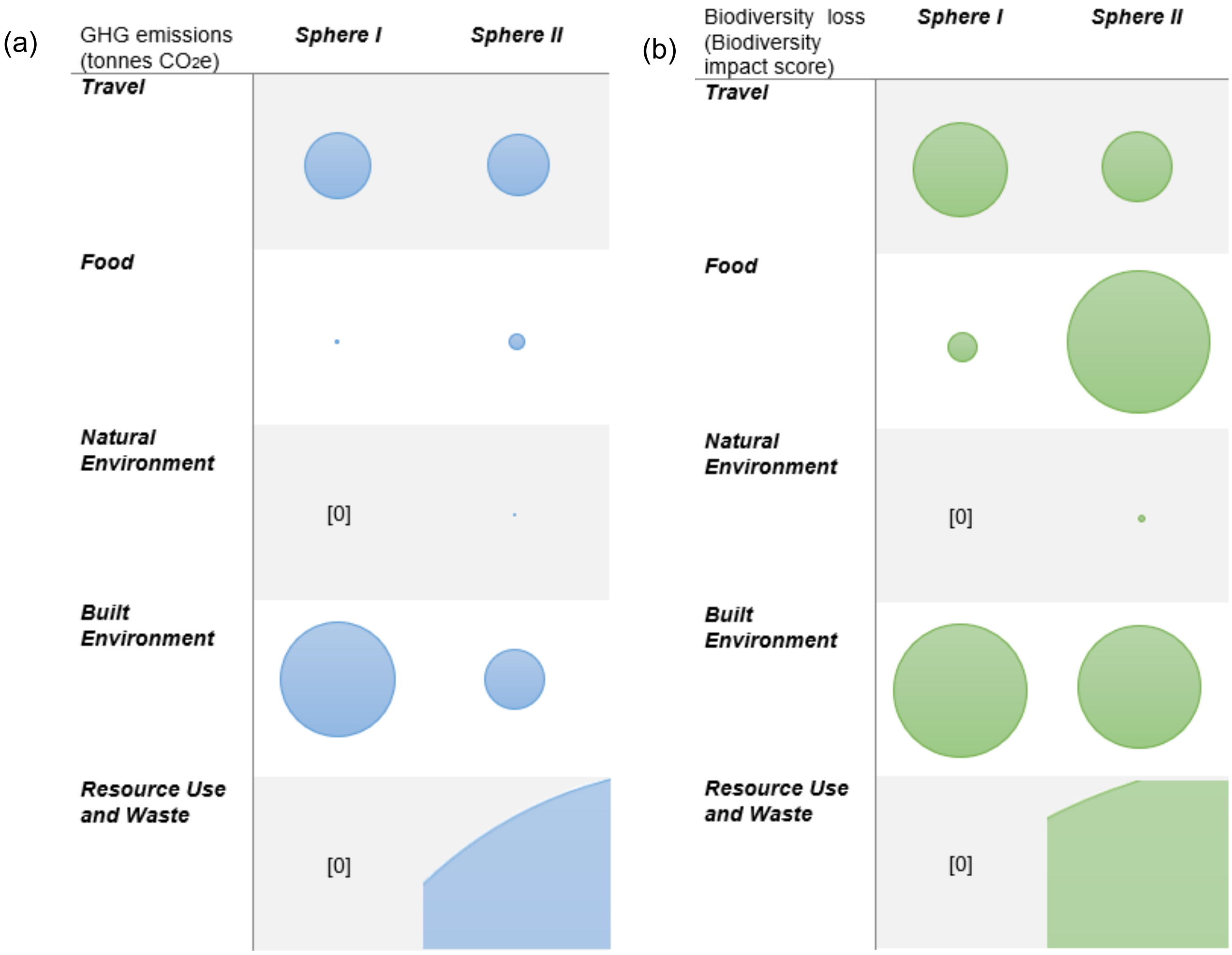
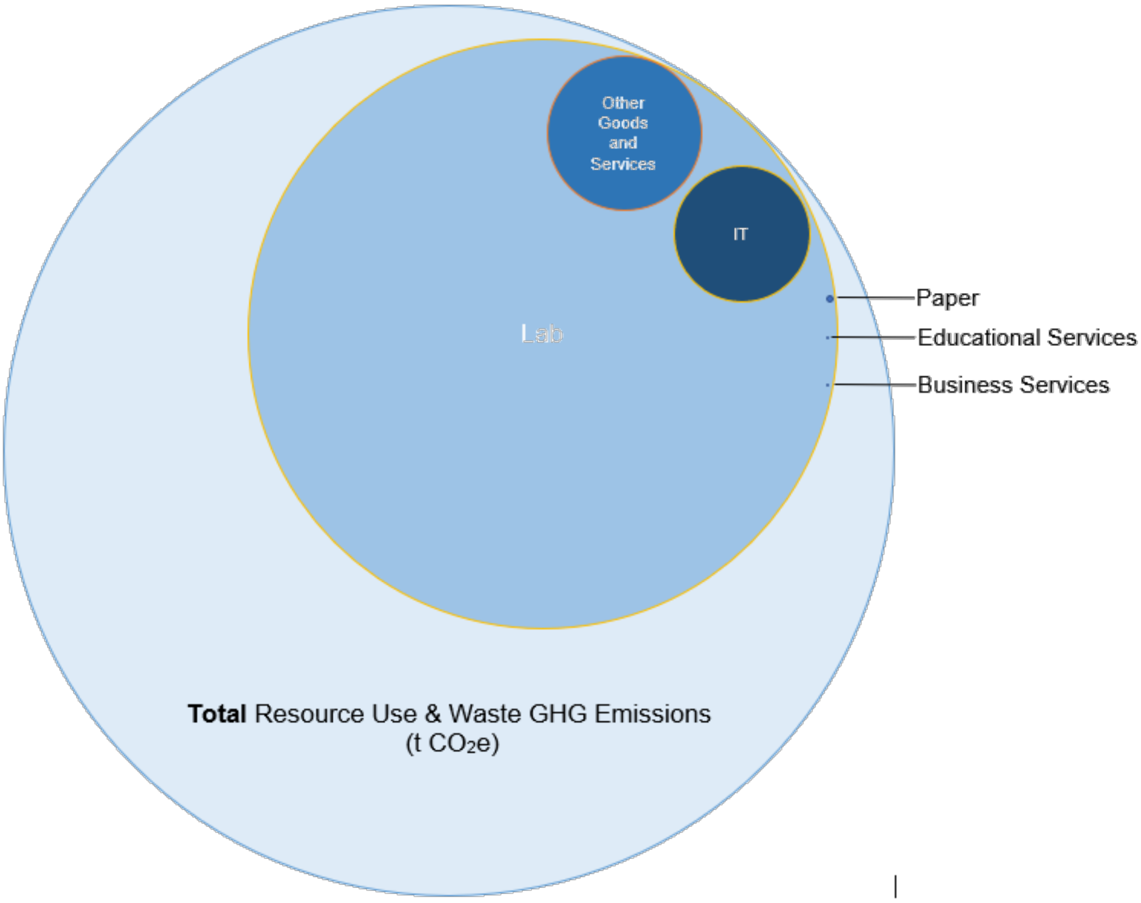


Figure 36: *summary of end-point impacts for (a) GHG emissions, (b) biodiversity loss and (c) GHG emissions for Resource Use & Waste (below). The diameter of each circle gives the relative size of the impact, although GHG emissions and biodiversity loss are not directly comparable. Sphere II (resource use & waste) in both cases gives a small section of a larger circle, with (c) breaking GHG emissions down. If squares appear blank it is due to extremely small relative impacts. Squares with [0] indicate impacts that were not assessed in this report, either due to those impacts being negligible (sphere I resource use & waste and sphere I natural environment), impacts*

not being included within the baseline of this assessment (sphere I natural environment).

(c)



The relative impacts of each sphere and aspect remain the same across the preliminary and secondary assessment. The only exception to this trend is within the built environment aspect, whereby sphere II impacts were larger than sphere I impacts in the preliminary report. However, this difference is likely to result from a change in methodologies used to calculate the sphere II impacts within the built environment aspect. Overall, the end-point impacts between the two reporting years decreased by 2,571 tonnes CO_2e and 0.4 BIS, representing a decrease of GHG emissions by 0.6% and biodiversity impact score of 20% respectively. However, interpreting these differences should be approached with caution as different methodologies and datasets were used across both assessments. In addition, data gaps still remain, as detailed in table 27.

Sphere I impacts are likely more readily influenced by University policy; consequently, efforts to reduce impacts could be usefully directed at minimising (a) impacts from international flights and staff commuting, and (b) impacts associated with utilities consumption in the built environment. However, it is clear that the University will not meet the overarching 2050 sustainability objectives without substantial efforts to reduce environmental impacts through the supply chain: particularly embodied environmental impacts of research related supplies. Further, since reductions in the environmental impacts of procured goods will leave residual impacts in terms of both GHG emissions and biodiversity loss, meeting the University's overarching 2050 sustainability objectives will require carbon offsetting and biodiversity offsetting (respectively) to some extent.

Table 27*: qualitative summary of key data gaps, primary impact sources, recommendations and headline annual comparisons (by aspect). [] = relevant stage of the Conservation Hierarchy (where A=avoid, M=minimise, R=restore, O=offset, and PCA=proactive conservation action)*

Aspect	Key impact areas	Data gaps	Main impact sources	Recommendations	Headline comparisons between 2018-19 and 2019-20
Travel	GHG emissions; Air pollution	Frequency of international student flights; Frequency of educational flights (year abroad and graduate fieldtrips); Impacts of delegate travel to Oxford-hosted conferences; Accuracy of business flight estimates; Midpoint impacts for water pollution	Flights (business and international students); Staff commuting	Focus on reducing flights taken by staff and students [M]; Liaise with Faculties that coordinate fieldtrips or year abroad programmes to reduce flights taken by students for educational purposes [M]; Encourage more sustainable commuting options [M]; Carbon offsetting [O]	The activities with the largest impact remain the same. COVID-19 is likely to have stopped travel from 23rd March 2020 until the end of the academic year, resulting in 38% less GHG emissions from flights and 40% less GHG emissions from student and staff commuting. 5 less cars were purchased in 2019-20, resulting in less vehicle supply chain emissions than 2018-19.
Food	Land use; GHG; Water use; Water Pollution and air Pollution	Food sourced externally but consumed on campus; Ingredients, portion size and source for food sold on campus	Food sourced off campus; Embodied land use in all food consumed	Awareness/nudge campaigns aiming to shift staff and student consumption away from animal-based food products [M]; Active encouragement to switch away from animal products in departmental purchasing [A/M]	Departmental food purchasing end point biodiversity impacts decreased by 56%, likely due to all events being cancelled after 23rd March 2020. Biodiversity impacts from university cafeterias only reduced by 8%. Staff and student meal biodiversity impacts similarly reduced by 42% as staff and students did not consume food on campus after 23rd March 2020.
Built environment	Land use; GHG; Water use; Water Pollution and air Pollution	Detailed construction impacts by supply chain; Miscellaneous emissions sources (e.g. Fluorinated GHG gases); Information on pockets of urban greenspace; Midpoint impacts for water pollution	Energy consumption (utilities); Embodied impacts in construction supply chains	Reduce energy consumption [A/M]; Carbon offsetting [O]; Better understand and seek to reduce the embodied impacts of construction projects [A/M]; Biodiversity net gain on new construction projects [R/O] Biodiversity enhancement within	Electricity consumption decreased by 12% due to building closures. Construction supply chain mid-point (and thus end point) impacts were significantly lower, but this is likely due to a change in methodology rather than annual change in construction supply chain impacts.

				urban greenspaces [R/O].	
Natural environment	GHG; Land use	Non-UK land holdings; detailed information of natural environment related procurement and management	Embodied GHG emissions in Natural Environment related procurement	Seek on-site biodiversity conservation (primarily as a communication and awareness tool) [PCAs]; Seek partnerships with other landowners to restore habitats and create biodiversity gains [R/O]	The rural land holding footprint of the university has been updated, and GHG emissions are non-comparable between reports (see section 3.4.5 for more Detail..
Resource Use & Waste	GHG; Land use; Water use; Water pollution; Air pollution	Coding accuracy and completeness (staff data input); Waste destination; Transport (freight delivery) impacts	Research related procurement	Improving coding and completeness of procurement records [n/a]; Seek out impact assessments from individual suppliers [n/a]; Seek to reduce embodied impacts of procured laboratory equipment [A/M]; Increase proportion of waste recycled, diverting from waste-to-energy [M]	Waste GHG emission decreased in all waste categories. GHG emissions increased in research and IT related categories, but decreased in Paper product and other procurement categories.

The following figures break down impacts by organisational scope and by individual activity to provide greater detail on sources of impacts. In breaking down impacts by organisational scope (here shown for GHG emissions, although patterns are similar for biodiversity; Figure 37) it is clear that Operations and Research constitutes the majority of impacts. In considering individual activities, the largest impacts for both GHGs (Figure 38a) and biodiversity (Figure 38b) can be attributed to ten key activities, of which these ten activities account for **98%** and **96%** of all impacts on GHGs and biodiversity recorded in this assessment, respectively.

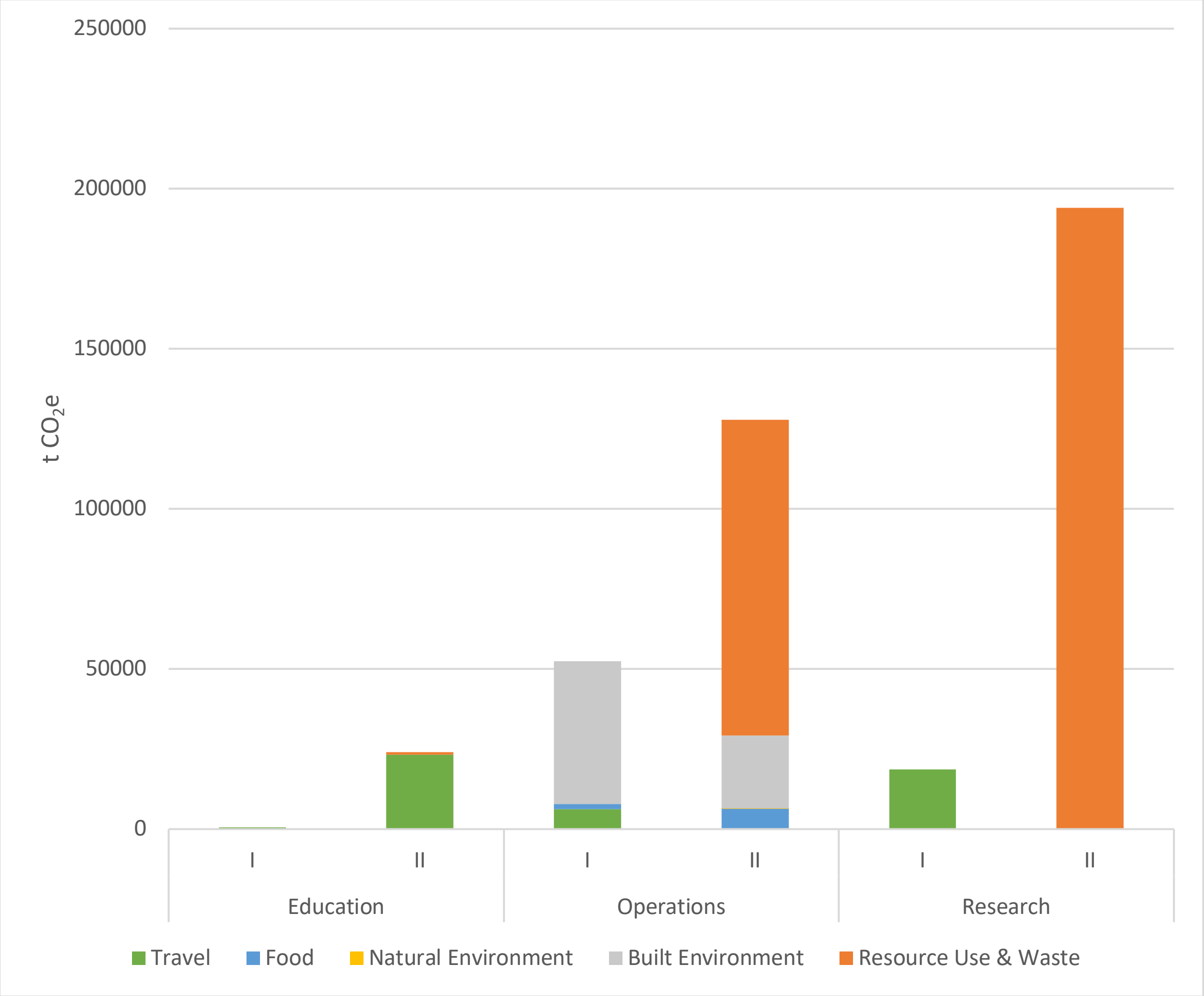


***Figure 37**: GHG emissions summarised by sphere, scope and aspect*

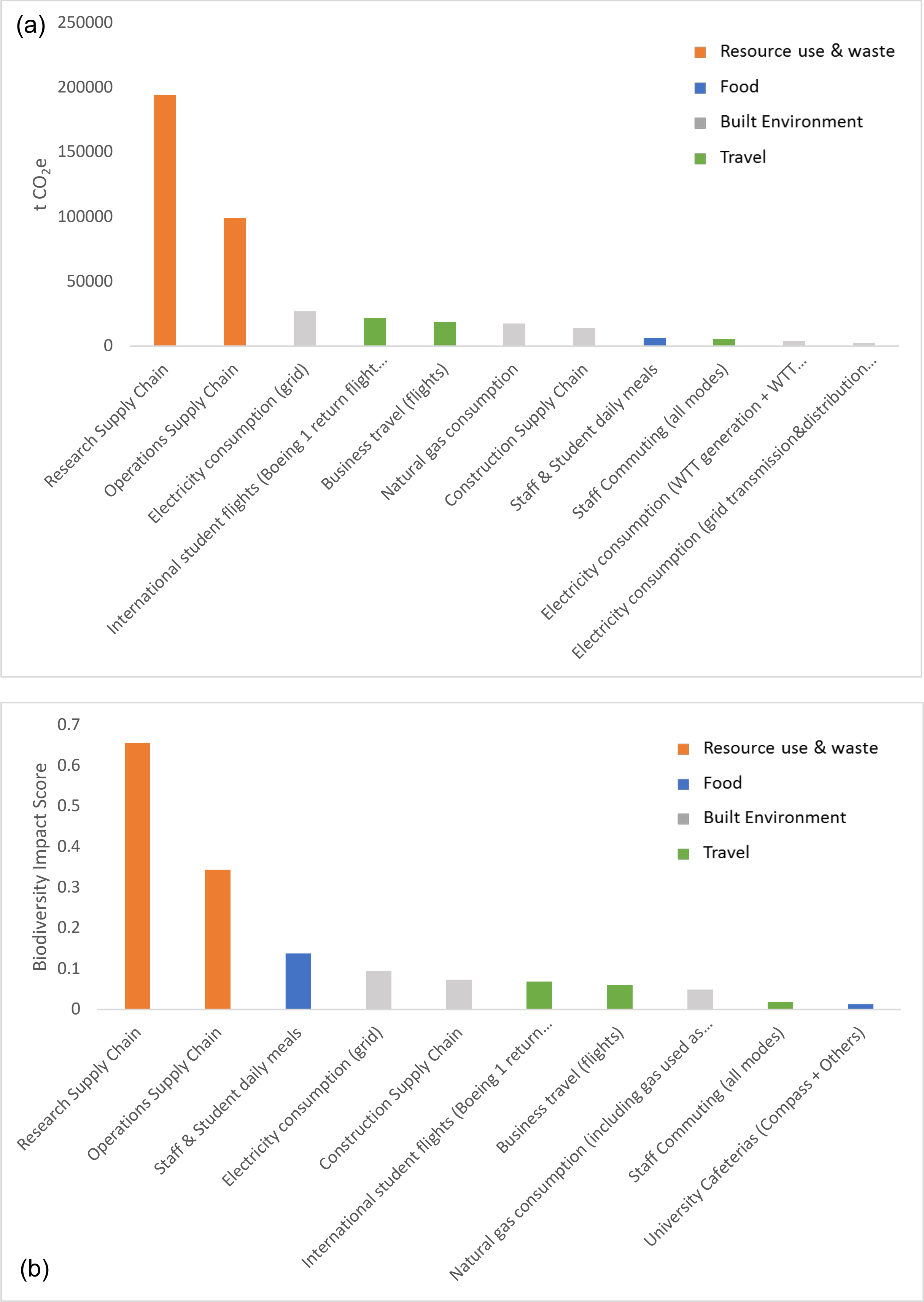


***Figure 38**: Summary of the top 10 most impactful activities assessed within this report for (a) GHG emissions and (b) biodiversity impacts.*

Though the University's land holdings potentially provide opportunities for achieving biodiversity gains through ecological restoration – which would probably also be associated with positive impacts on overall GHG emissions) – it is important to consider how small this gain would be balanced against biodiversity impacts (Figure 39). That is to say, it is unlikely biodiversity conservation measures on University landholdings in isolation would enable the University to make substantial progress towards the overarching biodiversity net gain objective. However, such initiatives are likely to be important nonetheless in terms of raising awareness about the University's sustainability efforts, communicating the importance of nature conservation, improving wellbeing and connecting with external biodiversity conservation initiatives.

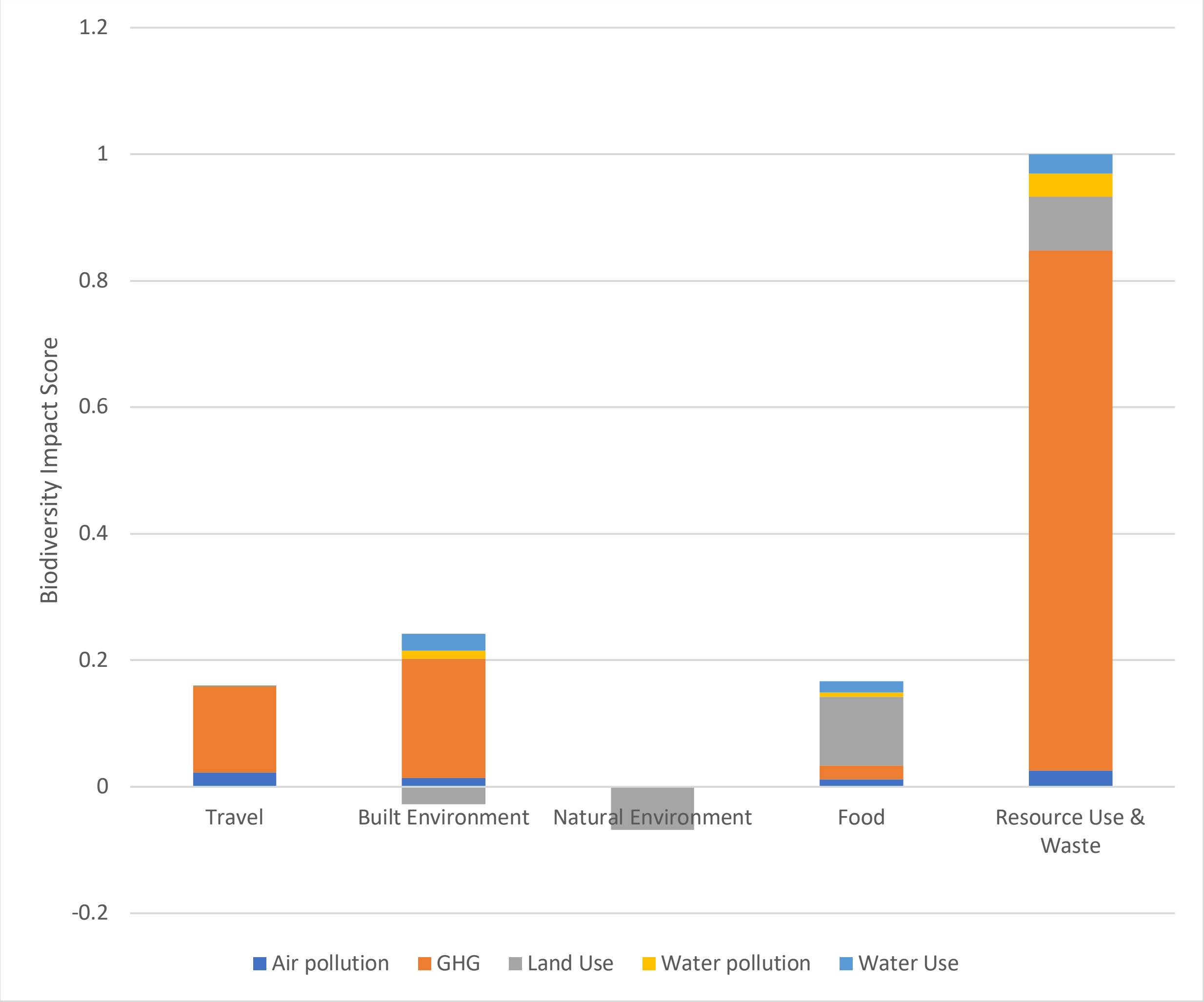


Figure 39: *Impacts on biodiversity summarised by aspect and by the midpoint impacts assessed in this report (note that not all midpoint impacts were assessed for each aspect and activity). Positive values = summary of end-point impacts on biodiversity (local species loss integrated over a year), summarised by aspect and the mid-point impacts driving that loss. Negative values (for built and natural environment) = estimate of potential positive impacts from ecological restoration on University land holdings.*

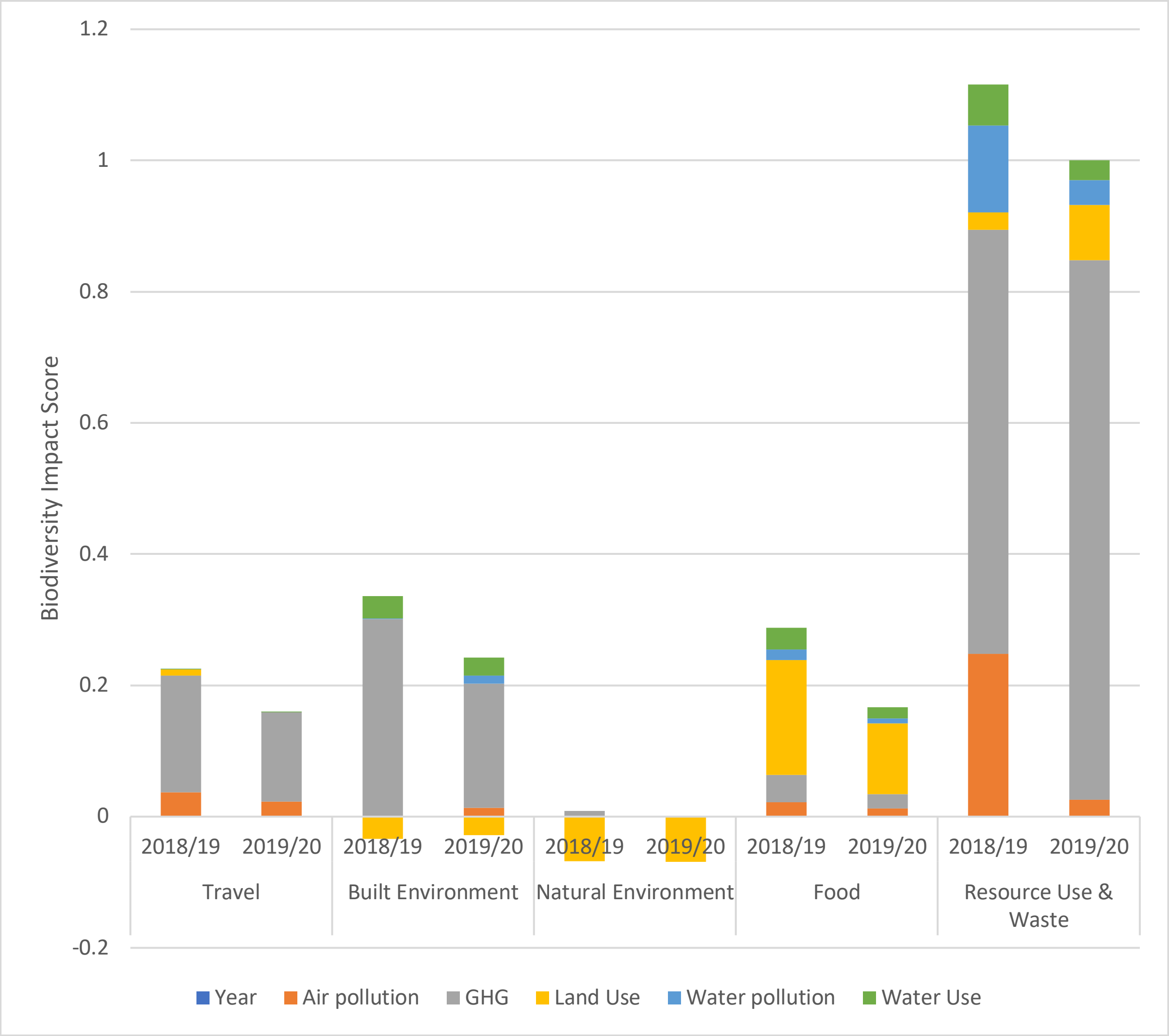


Figure 40: *Impacts on biodiversity summarised by aspect and by the midpoint impacts assessed in this report from 2018/19 and 2019/20.*

In order to make substantial progress towards the University's 2050 objectives on climate change and biodiversity, it is clear that there will need to be a carefully structured and coordinated programme of avoidance and minimisation measures applied to existing impacts across all spheres. However, it is not feasible that net zero (GHG emissions), or net gain (biodiversity) can be achieved without extensive compensatory measures (e.g. offsetting) for residual impacts. This is because many of the impact sources identified here are relatively inflexible and indeed mission critical: e.g., international students need to travel to campus, construction materials inevitably have some embodied impacts, people on campus need to eat, and research activities (including those that resulted in one of the COVID-19 vaccines) are integral to the existence of the University. Some impacts, therefore, cannot be avoided. Achieving biodiversity net gain across the University will require some degree of offsetting, and best practice (as well as financial feasibility) dictates that offsets should be as close as possible to the point of at which the biodiversity loss for which they compensate is caused. Consequently, having some understanding of the geographical location of residual impacts

Impacts of COVID-19

It is likely that the COVID-19 pandemic will have caused a reduction in the University's activities, thus decreasing the overall end-point impacts of GHG emissions and biodiversity loss for 2019-20. Figure 41 illustrates how undergraduate terms were impacted by the pandemic, with green boxes representing 'normal' terms, and orange boxes representing a term impacted by the COVID-19 pandemic. Table 28 provides quantitative examples of how disruption of normal university operations may have increased or decreased the end-point impacts of GHG emissions.

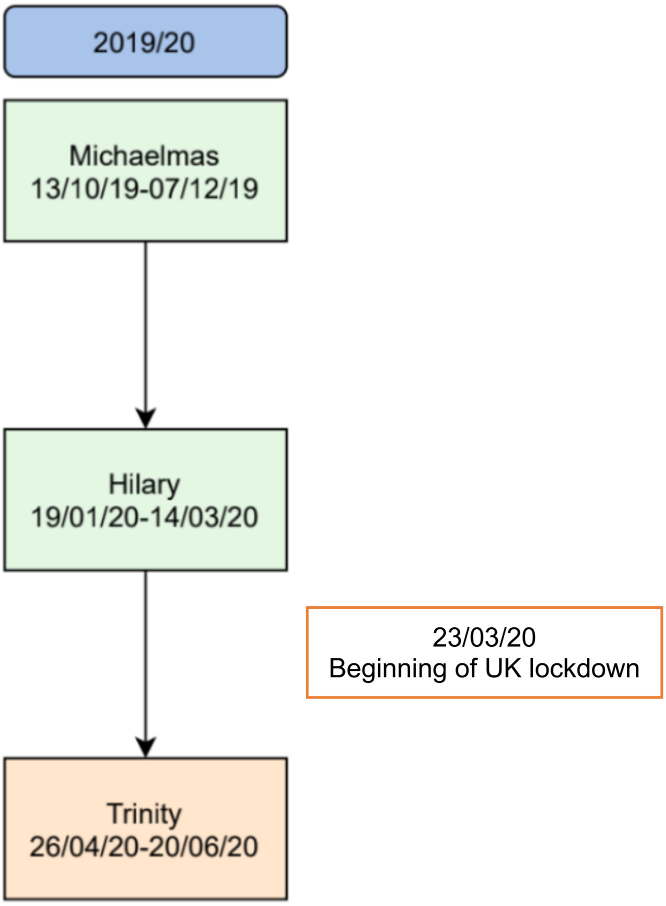


***Figure 41**: Flow diagram depicting the impacts of COVID-19 on the academic year of 2019-20*

***Table 28**: Quantified changes in GHG emissions due to COVID-19 impacts on university activities.*

Aspect	Sphere	Impact	Change in GHG emissions from 2018-19 (t CO_2e)
Travel	I	Reduction in business travel flights	-11,451.8
	I	Reduction in staff commuting	-3,752.5
	II	Reduction in student commuting	-663.0
Food	I	Compass and other cafeterias on campus closing from 23rd March 2020, resulting in a reduction of food purchased on campus	-1221.2
	II	Reduction in student and staff meals consumed on campus	-5,583.9
Resource Use and Waste	I	Reduction in waste produced	-20.1
	II	Increase in laboratory equipment procurement	+188,401
Online Learning	I	Increase in lecture streaming services (undergraduates) and online meetings (all students and staff)	+4.3

5. References

Arup, CenSA and De Montfort University. (2012) *Measuring scope 3 carbon emissions – supply chain (procurement)*: HEFCE. Available at: https://www.eauc.org.uk/measuring_scope_3_carbon_emissions (Accessed: 26 Jun 2020).

Berger, J., Goedkoop, M. J., Broer, W., Nozeman, R., Grosscurt, C. D., Bertram, M. and Cachia, F. (2018) *Common Ground in Biodiversity Footprint Methodologies for the Financial Sector*, Paris. Available at: http://www.mission-economie-biodiversite.com/publication/1833 (Accessed: 26 Jun 2020).

Bull, J. W., Milner-Gulland, E. J., Addison, P. F. E., Arlidge, W. N. S., Baker, J., Brooks, T. M., Burgass, M. J., Hinsley, A., Maron, M., Robinson, J. G., Sekhran, N., Sinclair, S. P., Stuart, S. N., zu Ermgassen, S. O. S. E. and Watson, J. E. M. (2020) 'Net positive outcomes for nature', *Nature Ecology & Evolution,* 4(1), pp. 4-7.

CML 2001. CML2 Baseline Method 2000.

European Commission. (2013) 'Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations, Annex II (Product Environmental Footprint (PEF) Guide)', *Official Journal of the European Union*. Available at: https://op.europa.eu/en/publication-detail/-/publication/93cb8358-b80d-11e2-ab01-01aa75ed71a1

Crenna, E., Sinkko, T. and Sala, S. (2019) 'Biodiversity impacts due to food consumption in Europe', *Journal of Cleaner Production,* 227, pp. 378-391.

Cruz, P. (2014) *GCU Carbon Footprint Report: 2012 - 2013*: Glasgow Caledonian University. Available at: https://www.gcu.ac.uk/media/gcalwebv2/theUniversity/centresprojects/sustainability/GCU-CFP-Report.pdf (Accessed: 26 Jun 2020).

de Baan, L., Alkemade, R. and Koellner, T. (2013) 'Land use impacts on biodiversity in LCA: a global approach', *The International Journal of Life Cycle Assessment,* 18(6), pp. 1216-1230.

Döll, P., Hoffmann-Dobrev, H., Portmann, F. T., Siebert, S., Eicker, A., Rodell, M., Strassberg, G. and Scanlon, B. R. (2012) 'Impact of water withdrawals from groundwater and surface water on continental water storage variations', Journal of Geodynamics, 59-60, pp. 143-156.

EASA, EEA and EUROCONTROL (2019) *European Aviation Environmental Report*: European Union Aviation Safety Agency. Available at: https://www.easa.europa.eu/eaer/ (Accessed: 26 Jun 2020).

Ellingsen, L. A.-W., Singh, B. and Strømman, A. H. (2016) 'The size and range effect: lifecycle greenhouse gas emissions of electric vehicles', *Environmental Research Letters,* 11(5), pp. 054010.

Elshout, P. M. F., van Zelm, R., Karuppiah, R., Laurenzi, I. J. and Huijbregts, M. A. J. (2014) 'A spatially explicit data-driven approach to assess the effect of agricultural land occupation on species groups', *The International Journal of Life Cycle Assessment,* 19(4), pp. 758-769.

Emara, Y., Siegert, M.-W., Lehmann, A. and Finkbeiner, M. (2018) 'Life Cycle Management in the Pharmaceutical Industry Using an Applicable and Robust LCA-Based Environmental Sustainability Assessment Approach', in Benetto, E., Gericke, K. and Guiton, M. (eds.) *Designing Sustainable Technologies, Products and Policies: From Science to Innovation*. Cham: Springer International Publishing, pp. 79-88.

Environment Agency. (2020) *Pollution inventory reporting – incineration activities guidance note*. Department for Environment, Food and Rural affairs. Available at:

https://www.gov.uk/government/publications/pollution-inventory-reporting-guidance-notes (Accessed 26 Jun 2020)

European Environment Agency (2018) *TERM 2018: Electric vehicles from life cycle and circular economy perspectives.* Luxembourg: Publications Office of the European Union.

Harrington, R. A., Adhikari, V., Rayner, M. and Scarborough, P. (2019) 'Nutrient composition databases in the age of big data: foodDB, a comprehensive, real-time database infrastructure', *BMJ Open,* 9(6), pp. e026652.

Hauschild M, Goedkoop M, Guinee J, Heijungs R, Huijbregts M, Jolliet O, Margni M, De Schryver A, Pennington D, Pant R, Sala S, Brandao M, Wolf M. (2011) *Recommendations for Life Cycle Impact Assessment in the European context - based on existing environmental impact assessment models and factors (International Reference Life Cycle Data System - ILCD handbook).* Luxembourg: Publications Office of the European Union. EUR 24571 EN.

Hawkins, T. R., Singh, B., Majeau-Bettez, G. and Strømman, A. H. (2013) 'Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles', *Journal of Industrial Ecology,* 17(1), pp. 53-64.

Hill, N., Karagianni, E., Jones, L., MacCarthy, J., Bonifazi, E., Hinton, S., Walker, C. and Harris, B. (2019) *2019 Government Greenhouse Gas Conversion Factors for Company Reporting - Methodology Paper for Emission Factors Final Report*: Department for Business Energy & Industrial Strategy (BEIS). Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019 (Accessed: July 2021).

Hill, N., Bramwell, R., Karagianni, E., Jones, L., MacCarthy, J., Hinton, S., Walker, C. and Harris, B. (2020) *2020 Government Greenhouse Gas Conversion Factors for Company Reporting - Methodology Paper for Emission Factors Final Report*: Department for Business Energy & Industrial Strategy (BEIS). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901692/conversion-factors-2020-methodology.pdf (Accessed: July 2021)

Hoekstra, A. Y. (2015) 'Chapter 7 - The water footprint of industry', in Klemeš, J.J. (ed.) *Assessing and Measuring Environmental Impact and Sustainability*. Oxford: Butterworth-Heinemann, pp. 221-254.

Hoekstra, A. Y., Chapagain, A. K., Mekonnen, M. M. and Aldaya, M. M. (2011) *The water footprint assessment manual: Setting the global standard.* Abingdon: Routledge.

Huijbregts, M. A. J., Steinmann, Z. J. N., Elshout, P. M. F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A. and van Zelm, R. (2017) 'ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level', *The International Journal of Life Cycle Assessment,* 22(2), pp. 138-147.

Kering, S. A. (2017) *Kering Environmental Profit & Loss (EP&L)*. Available at: https://www.kering.com/en/sustainability/environmental-profit-loss/ (Accessed: 22 Jun 2020).

Kitzes, J. (2013) 'An introduction to environmentally-extended input-output analysis', *Resources,* 2(4), pp. 489-503.

Lammerant, J. (2019) *Assessment of Biodiversity Measurement Approaches for Businesses and Financial Institutions*: European Commission. Available at: https://ec.europa.eu/environment/biodiversity/business/assets/pdf/European_B@B_platform_report_biodiversity_assessment_2019_FINAL_5Dec2019.pdf (Accessed: 26 Jun 2020).

Mayer, T. and Zignago, S. (2011) 'Notes on CEPII's distances measures: The GeoDist database'. *CEPII Working Paper 2011-25*

Mekonnen, M. M., Gerbens-Leenes, P. W. and Hoekstra, A. Y. (2015) 'The consumptive water footprint of electricity and heat: a global assessment', *Environmental Science: Water Research & Technology,* 1(3), pp. 285-297.

Milner-Gulland, E. J., Addison, P., Arlidge, W., Baker, J., Booth, H., Brooks, T., Bull, J., Burgass, M., Ekstrom, J. and zu Ermgassen, S. (2020) 'Four Steps for the Earth: mainstreaming the post-2020 Global Biodiversity Framework'.

Morelli, B., Hawkins, T. R., Niblick, B., Henderson, A. D., Golden, H. E., Compton, J. E., Cooter, E. J. and Bare, J. C. (2018) 'Critical Review of Eutrophication Models for Life Cycle Assessment', *Environmental science & technology,* 52(17), pp. 9562-9578.

Obringer, R. et al., 2021. The overlooked environmental footprint of increasing Internet Use. Resources, Conservation & Recycling, Volume 167

Poore, J. and Nemecek, T. (2018) 'Reducing food's environmental impacts through producers and consumers', *Science,* 360(6392), pp. 987.

Pulles, T., Bolscher, M. v. h., Brand, R. & Visschedijk., A., 2007. Assessment of global emissions from fuel combustion in the final decades of the 20th century. Application of the Emission Inventory Model TEAM, Apeldoorn, the Netherlands: TNO Bouw en Ondergrond.

Spang, E. S., Moomaw, W. R., Gallagher, K. S., Kirshen, P. H. and Marks, D. H. (2014) 'The water consumption of energy production: an international comparison', *Environmental Research Letters,* 9(10), pp. 105002

Stadler, K. et al., 2018. EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. *Journal of Industrial Ecology*, 22(3), pp. 502-515.

Stephan, A. and Crawford, R. H. (2016) 'Total water requirements of passenger transport modes', *Transportation Research Part D: Transport and Environment,* 49, pp. 94-109.

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P. M. (2013) 'Climate change 2013: The physical science basis'. *Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change (IPCC)*, 1535.

Taylor, I., Biggs, E., Gray, N., Clark, M., Stewart, C., Grub, H., Ashton, B., Bull., J. W., Milner-Gulland, E. J. (2021). 'Having their cake and eating it: Approaches for reducing the environmental impacts of food consumption at Lady Margaret Hall.' Wild Business Ltd for the University of Oxford (Oxford Partnership for the Operationalisation of the Conservation Hierarchy); London, UK.

Thomson, C. and Harrison, G. (2015) *Life Cycle Costs and Carbon Emissions of Onshore Wind Power* ClimateXchange. Available at: https://www.climatexchange.org.uk/research/projects/assessing-the-life-cycle-costs-and-carbon-emissions-of-wind-power/ (Accessed: 28 Jun 2020).

Vanham, D., Medarac, H., Schyns, J. F., Hogeboom, R. J. and Magagna, D. (2019) 'The consumptive water footprint of the European Union energy sector', *Environmental Research Letters,* 14(10), pp. 104016.

Warner, E., 2020. Opportunities for biodiversity enhancement on the University of Oxford's estate, s.l.: s.n.

6. Notes for Future Assessments

Data Accessibility

To carry out future reports, it is important to prioritise datasets that may be less accessible, and requires reaching out to a number of operational and teaching departments within the university. Table 29 gives an overview of all datasets used within this report, and an estimate of the accessibility of each dataset.

***Table 29**: Assessment of availability of datasets used for this report*

Data Source	Dataset Title	Availability of updated data	Reason
OUES	Estate Management Record (EMR) 2019-20	High availability	Record available annually.
OUES	Energy Savings Opportunity Scheme (ESOS) 2019	Low availability	The ESOS report is only returned every 4 years. This means grey fleet mileage and fuel consumption activity data has to be estimated based on the latest ESOS return.
OUES	University Fleet List 2020	High availability	Record available annually.
Key Travel	Key Travel Scope 3 Carbon Report 2019-20	High availability	Record available annually.
Student Data Management and Analysis Services	Student domicile and headcount statistics 2020	High availability	Record published online annually.
Student Data Management and Analysis Services	Domestic Student Postcode Data 2020	Medium availability	This data needs to be requested from the student data management and analysis services, with student data protection safeguards in place.
University HR Systems	Staffing figures 2020	High availability	Record published annually online.
OUES (Asset & Space Management)	Building footprint and urban site area data 2020	Medium availability	Record available annually, but requires liaison with A&SM.
OUES (Asset & Space Management)	Area of owned land (non-urban) 2020	Medium availability	Record available annually, but requires liaison with A&SM.
UPD / SUPC	Higher Education Supply-Chain Emissions Tool Scope 3 Carbon Report (HESCET) 2019-20	Medium availability	Record available annually, but requires liaison with UPD.
UPD / SUPC	Procurement Data 2019-20	Medium availability	Record available annually, but requires liaison with UPD.
Compass Group PLC	Compass Sales Data 2019-20	Medium availability	Record available annually, but requires liaison with Compass PLC.
University Departments	Departmental Fieldtrip and Year Abroad Dataset 2019-20	Low Availability	This dataset needs to be built by the assessment team, requiring liaison with all departments to provide information about undergraduate and postgraduate travel. In particular, departments do not have granular data on

			postgraduate student fieldtrips or travel.
IT Services	Online Lecture Delivery	Medium Availability	Record available annually, but requires liaison with the Educational Media Team in IT services.

Opportunities for future assessments

As resource use and waste produces the majority of biodiversity and GHG end-point impacts, it is suggested that future reports attempt to produce more in-depth assessments of supply chain impacts. This could be achieved in multiple ways, including:

- Running LCIAs on each Exiobase 3 spend category to pin-point high impact spend categories
- Running LCIAs on non-supply chain related activities. For example, using the Exiobase 3 industry 'GB transport' to assess whether there are other mid-point impacts of transport other than assessed in this report.
- Identifying high impact spend categories and reaching out to the main suppliers to these spend categories to investigate mid-point impacts embedded within their supply chains. This could help distinguish between high and low impact suppliers. This level of detail is not available through the current EE MRIO Exiobase methodology

Helpful resources: Businesses and Biodiversity

As businesses across the UK and beyond become increasingly aware of their carbon and biodiversity impacts, networks, platforms and forums have been established to tackle the complex task of impact mitigation. These networks may provide help to the University of Oxford in the context of implementing biodiversity net gain strategies[77], refining and continually updating biodiversity impact measurement methods[78] and knowledge sharing from other businesses trying to implement similar biodiversity strategies[79].

---

[77] For example: Science based targets network, who's initial guidance on measuring and setting targets for biodiversity has now been published. The executive summary is available here: 20210309-IG-executive-summary-ENGLISH-v28.pdf (sciencebasedtargetsnetwork.org)

[78] The EU Biodiversity Platform released an assessment of biodiversity Measurement approaches for Businesses and financial institutions, which provides a comprehensive guide to different biodiversity metrics that can be used to measure biodiversity impacts of business operations. This guide is available here: Critical assessment of biodiversity accounting approaches for businesses (europa.eu)

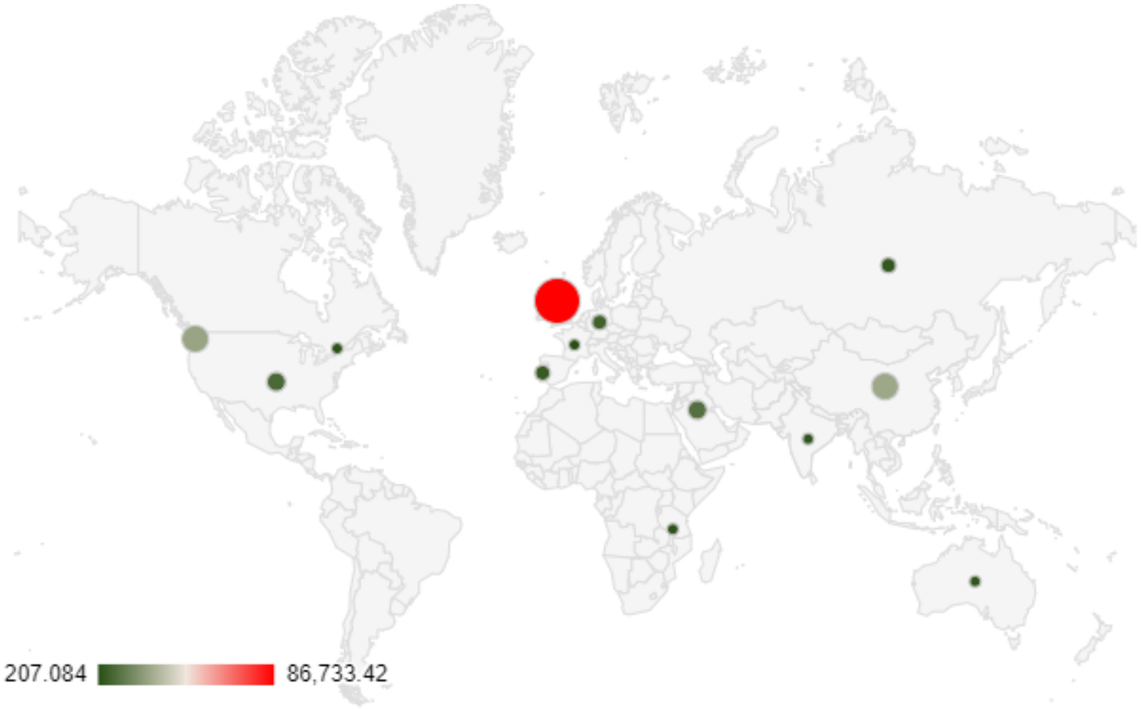
[79] For example, UK initiative such as the UK Business Biodiversity Forum (UKBBF): https://www.business-biodiversity.co.uk/services/

7. Appendix

Location of Supply Chain Impacts: Research, Operations and Construction

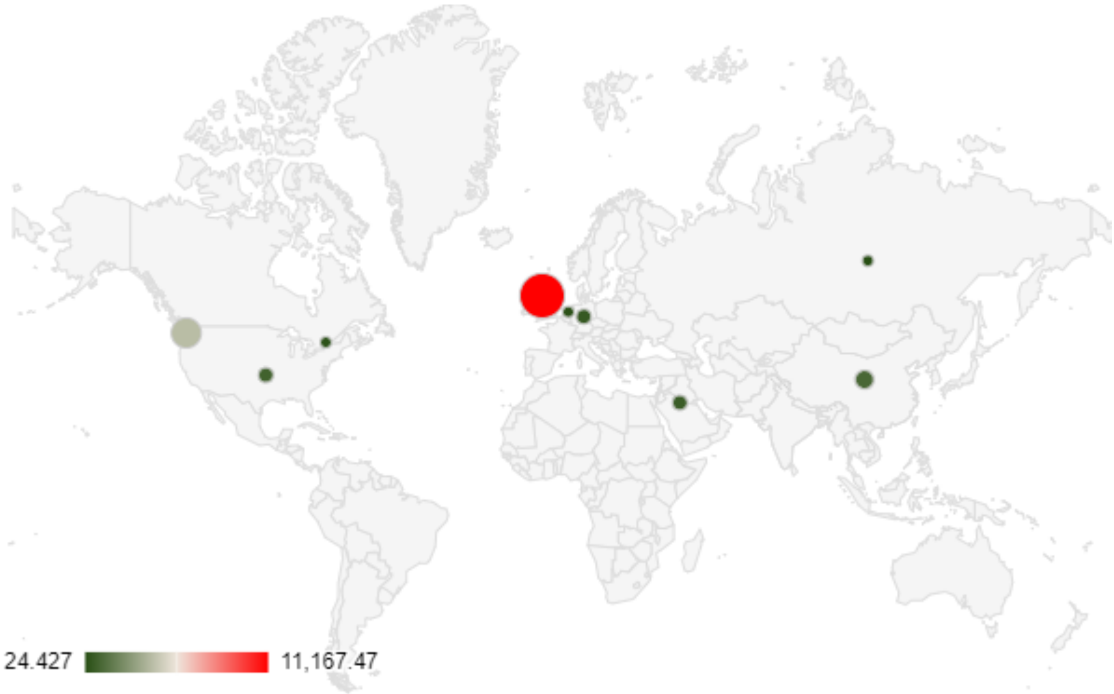
The following maps locate the **sum** of each mid-point impact from research, operation and construction supply chains, with tables numerically quantifying these impacts. The final map approximately calculates endpoint biodiversity impacts for each

Acidification



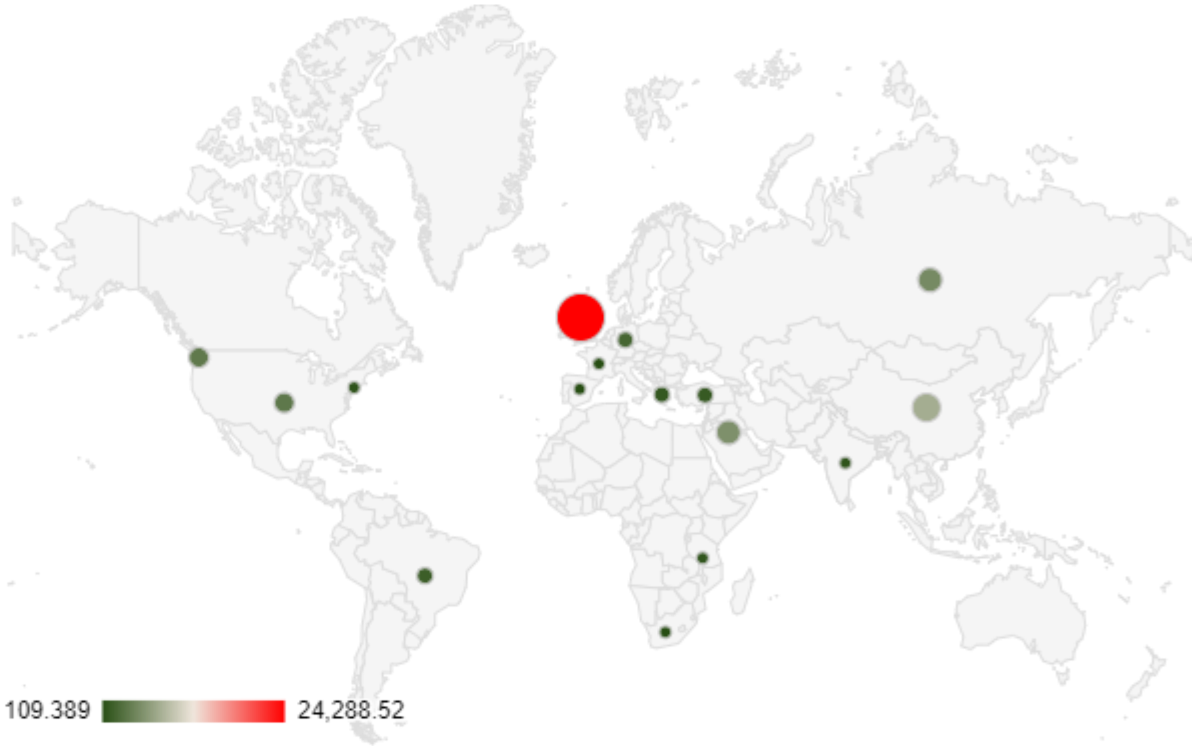
Location	kg SO2 eq.	% of supply chain midpoint
United Kingdom - GB	86733.42	49.92
China - CN	25700.63	14.79
Rest of World - Asia and Pacific - WA	24557.16	14.14
Rest of World - Middle East - WM	9970.726	5.74
India - IN	2192.489	1.26
Russian Federation - RU	2696.616	1.55
Germany - DE	5597.337	3.22
Australia - AU	1985.317	1.14
United States - US	7680.617	4.42
Rest of World - Africa - WF	1418.122	0.82
Rest of World - America - WL	209.2442	0.12
France - FR	207.0839	0.12
Portugal - PT	3609.874	2.08
Canada - CA	1170.724	0.67

Eutrophication



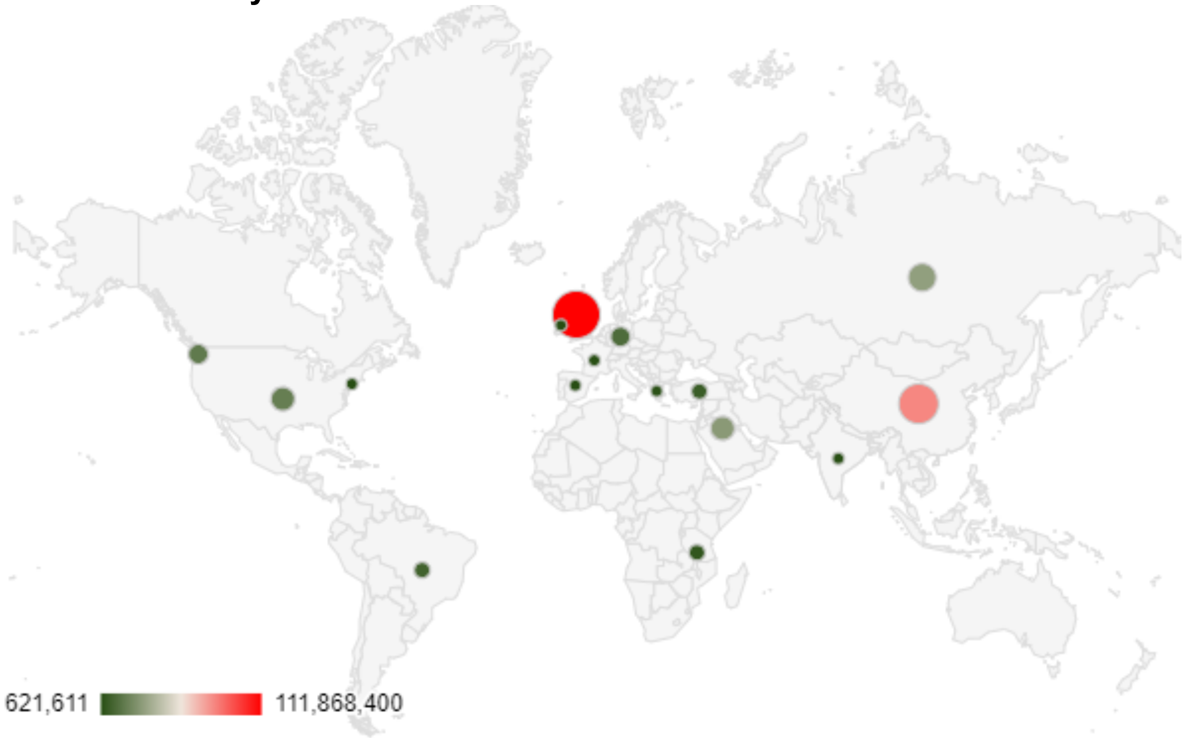
Location	kg PO4--- eq.	% of supply chain midpoint
United Kingdom - GB	11167.47	60.99
Rest of World - Asia and Pacific - WA	4080.894	22.29
China - CN	957.7403	5.23
Rest of World - Middle East - WM	592.2311	3.23
Germany - DE	430.1196	2.35
United States - US	751.6208	4.11
Russian Federation - RU	24.42651	0.13
Canada - CA	168.9487	0.92
Netherlands - NL	135.6918	0.74

Freshwater Ecotoxicity



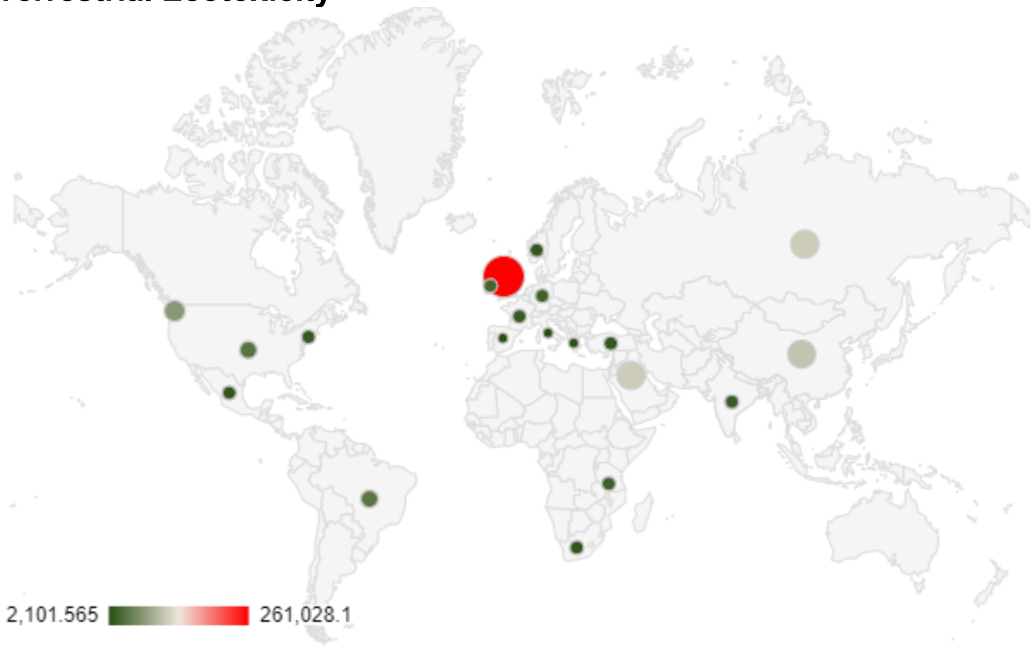
Location	kg 1,4-dichlorobenzene eq.	% of supply chain midpoint
United Kingdom - GB	24288.52	42.53
China - CN	7691.38	13.47
Rest of World - Asia and Pacific - WA	3547.777	6.21
Rest of World - Middle East - WM	5379.392	9.42
Russian Federation - RU	4911.219	8.60
Greece - GR	883.7563	1.55
Germany - DE	1979.883	3.47
Turkey - TR	1080.94	1.89
Brazil - BR	1378.612	2.41
Rest of World - Africa - WF	661.1708	1.16
India - IN	572.8372	1.00
Rest of World - Europe - WE	519.3481	0.91
United States - US	3449.309	6.04
Spain - ES	133.3741	0.23
France - FR	129.6258	0.23
South Africa - ZA	109.3894	0.19
Rest of World - America - WL	398.33	0.70

Marine Ecotoxicity



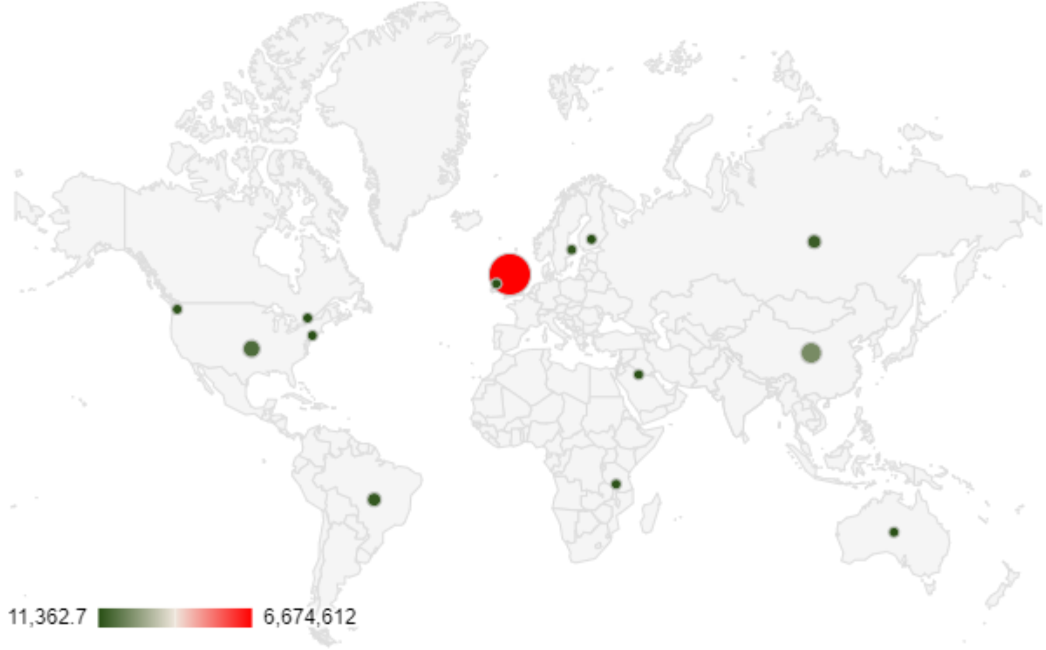
Location	kg 1,4-dichlorobenzene eq.	% of supply chain midpoint
United Kingdom - GB	111868400	35.11
China - CN	79199430	24.85
Rest of World - Asia and Pacific - WA	16576300	5.20
Rest of World - Middle East - WM	28017150	8.79
Russian Federation - RU	30187280	9.47
Greece - GR	1812210	0.57
Brazil - BR	7873868	2.47
Germany - DE	11564740	3.63
Turkey - TR	6027820	1.89
India - IN	984448	0.31
Rest of World - Africa - WF	3410980	1.07
France - FR	835953	0.26
Spain - ES	780681	0.24
United States - US	18165691	5.70
Rest of World - Europe - WE	723974	0.23
Ireland - IE	621611	0.20

Terrestrial Ecotoxicity



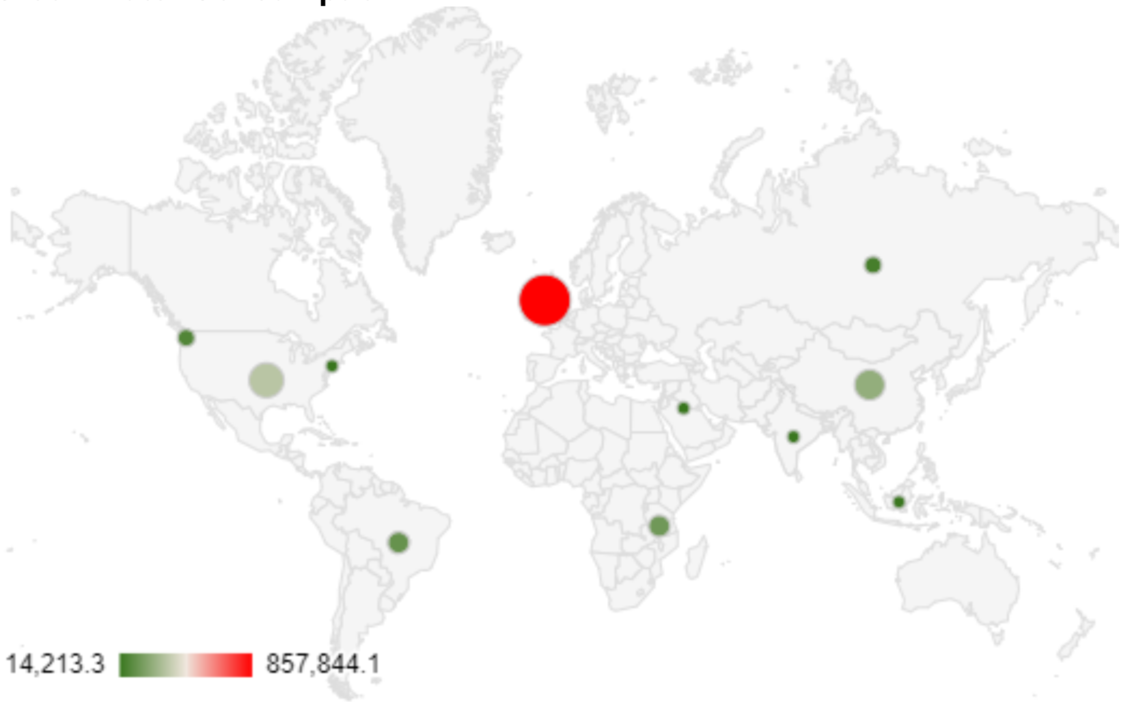
Location	kg 1,4-dichlorobenzene eq.	% of supply chain midpoint
United Kingdom - GB	261028.1	30.25
China - CN	102679	11.90
Rest of World - Asia and Pacific - WA	64946.2	7.53
Rest of World - Middle East - WM	109770	12.72
Russian Federation - RU	109298.4	12.66
Brazil - BR	35541.76	4.12
Rest of World - Africa - WF	16461.63	1.91
Ireland - IE	20450.01	2.37
Germany - DE	18004.6	2.09
France - FR	13396.21	1.55
India - IN	13978.05	1.62
Turkey - TR	9560.577	1.11
Rest of World - Europe - WE	11430.5	1.32
United States - US	33858.54	3.92
Norway - NO	9216.569	1.07
South Africa - ZA	8947.397	1.04
Mexico - MX	8903.71	1.03
Spain - ES	2169.391	0.25
Greece - GR	2125.513	0.25
Italy - IT	2101.565	0.24
Rest of World - America - WL	9138.032	1.06

Land Use



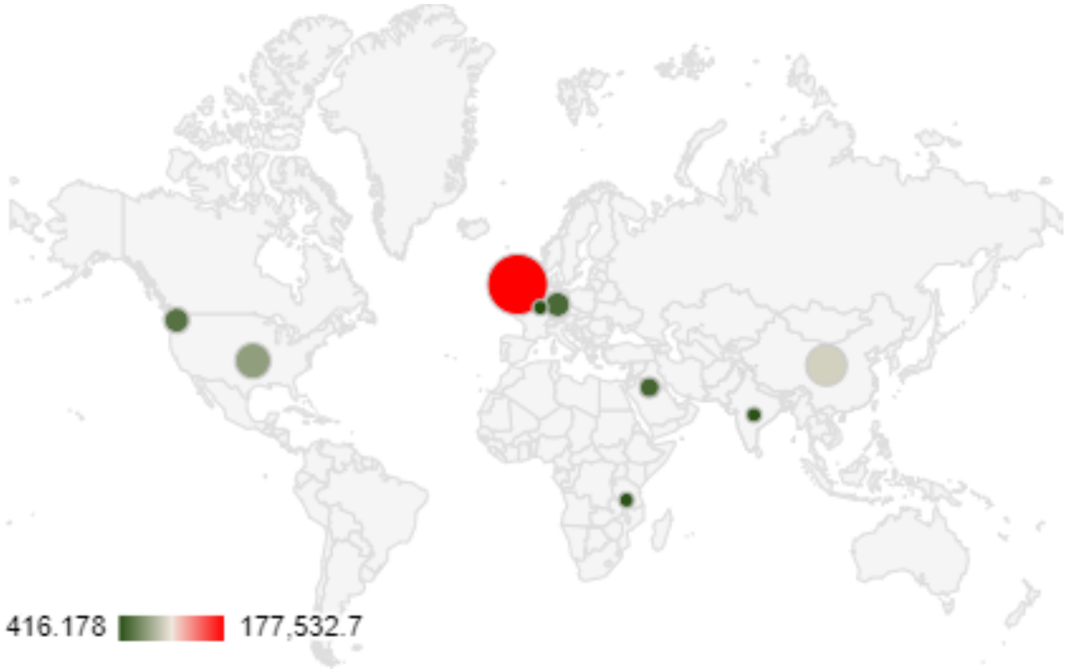
Location	M²	% of supply chain midpoint
United Kingdom - GB	6674612	66.23
Sweden - SE	159192	1.58
Ireland - IE	61053.9	0.61
Rest of World - Africa - WF	108599.9	1.08
Finland - FI	12356.6	0.12
Canada - CA	11362.7	0.11
China - CN	1353010	13.43
United States - US	669136	6.64
Russian Federation - RU	320741	3.18
Brazil - BR	233631	2.32
Rest of World - America - WL	204950	2.03
Rest of World - Asia and Pacific - WA	90300.4	0.90
Rest of World - Europe - WE	62442.5	0.62
Rest of World - Middle East - WM	60570.3	0.60
Australia - AU	55793.7	0.55

Green Water Consumption



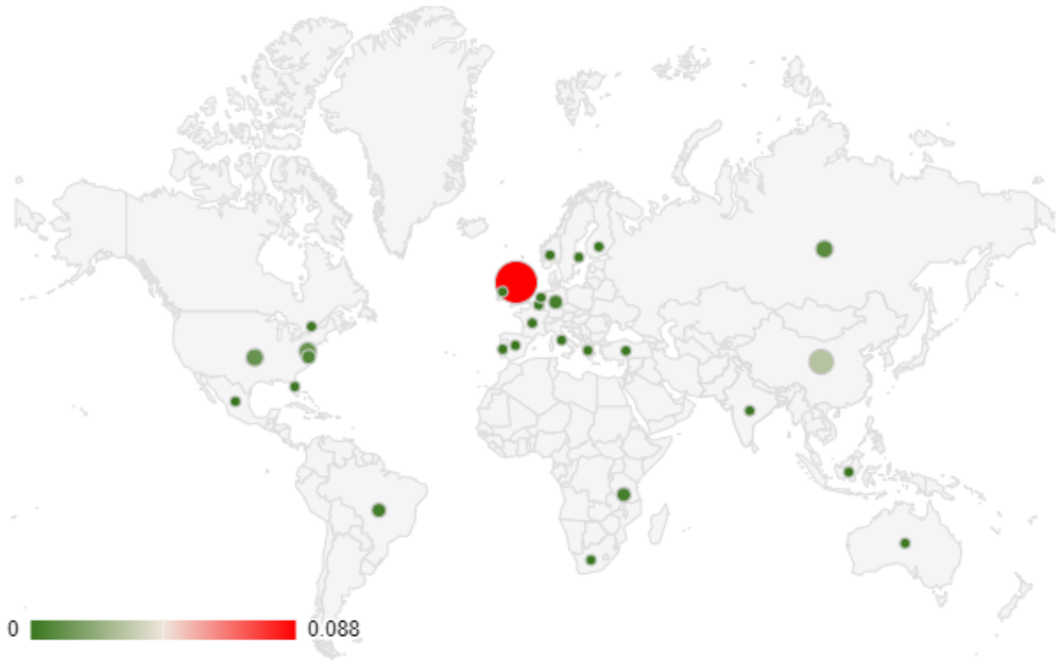
Location	M^3	% of supply chain midpoint
Rest of World - Africa - WF	143911.9	7.29
United Kingdom - GB	857844.1	43.47
Rest of World - Asia and Pacific - WA	71112.89	3.60
India - IN	17909.3	0.91
Rest of World - America - WL	131541.6	6.67
United States - US	312424	15.83
China - CN	224261	11.36
Brazil - BR	120753	6.12
Russian Federation - RU	46185.4	2.34
Indonesia - ID	18637.4	0.94
Rest of World - Europe - WE	14488.8	0.73
Rest of World - Middle East - WM	14213.3	0.72

Total Blue Water Consumption



Location	M³	% of supply chain midpoint
Belgium - BE	416.1778	0.12
China - CN	76039.21	21.33
Germany - DE	16126.57	4.52
India - IN	2748.531	0.77
Rest of World - Africa - WF	2194.644	0.62
Rest of World - Asia and Pacific - WA	21112.59	5.92
Rest of World - Middle East - WM	13083.57	3.67
United Kingdom - GB	177532.7	49.79
United States - US	47305.6	13.27

Endpoint Biodiversity Impacts



To calculate regionally specific endpoint biodiversity impact scores, country specific midpoint to endpoint conversion factors, where available, were used. Where not available (e.g. for land use and ecosystem toxicity), global average conversion factors were used. This provides a more accurate approximation of endpoint impact size at each location, which can be used to plan a biodiversity net gain strategy.

Location	Biodiversity Impact Score (BIS)	% of supply chain BIS
Australia - AU	7.28E-04	0.41
Belgium - BE	8.91E-07	0.00
Brazil - BR	3.15E-03	1.79
Canada - CA	5.13E-04	0.29
China - CN	3.02E-02	17.12
Finland - FI	1.10E-04	0.06
France - FR	1.51E-04	0.09
Germany - DE	3.55E-03	2.01
Greece - GR	1.91E-04	0.11
India - IN	5.63E-04	0.32
Indonesia - ID	1.82E-05	0.01
Ireland - IE	6.08E-04	0.34
Italy - IT	2.40E-08	0.00
Mexico - MX	1.02E-07	0.00
Netherlands - NL	7.52E-07	0.00
Norway - NO	1.05E-07	0.00
Portugal - PT	4.68E-04	0.27
Rest of World - Africa - WF	3.60E-03	2.04
Rest of World - America - WL	3.64E-03	2.06
Rest of World - Asia and Pacific - WA	1.17E-02	6.65
Rest of World - Europe - WE	8.27E-04	0.47
Rest of World - Middle East - WM	6.36E-03	3.61
Russian Federation - RU	8.16E-03	4.63
South Africa - ZA	1.78E-07	0.00
Spain - ES	8.21E-05	0.05
Sweden - SE	1.41E-03	0.80
Turkey - TR	6.34E-04	0.36
United Kingdom - GB	8.82E-02	49.96
United States - US	1.16E-02	6.56

A Brief Introduction to Exiobase 3

Exiobase 3 is a database of Environmentally Extended Multi-Regional input-output tables (EE MRIO), which comprehensively describe flows within the global economy and analyses their effects on the environment[80]. Exiobase 3 contains Supply-Use Tables as the main building blocks of the database, covering 163 industries and 200 product classifications. These Supply-Use tables are combined to form a set of country specific EE MRIOs that use data ranging from 1995-2011 for 44 countries and five 'rest of world' regions. Therefore, Exiobase considers industry and product output per country/region, associating different mid-point impacts within each industry and product by location. These mid-point impacts are calculated through a variety of methods, which are further detailed in the methodology paper by Standler et al, 2018[32].

For example, to provide industry-specific data on air pollutant emissions, Exiobase 3 combines activity data with consolidated emission factors retrieved from the TEAM model constructed by Pulles et al., 2007[81], which aggregates emissions factors from the IPCC (2006), European Environment agency (2009) and GAINs model (2009). This TEAM model calculates country-specific emission factors for each industry, considering the discrepancies in technology efficiencies between countries.

Using EE MRIOs such as Exiobase 3 has several benefits and limitations, which are outlined in table X.

	Benefits	**Limitations**
EE MRIOS	EE MRIOs provide a simple method for evaluating linkages between economic consumption activities and environmental impact[35]. EE MRIOs can be used to identify and compare different industry drivers and locations of environmental impacts. EE MRIOs take a consumption, rather than production orientated perspective on the causes of global environmental degradation and resource use[35]. This is suitable for this assessment which is based upon the University consumption of supply chains.	EE MRIOs assume homogeneity of products within a single industry or product within a single country or 'rest of world region'. This means the calculated impacts do not account for whether more sustainable, low-impact procurement took place within a single industry/product or the opposite. IOTs do not capture downstream impacts of spend in an industry or product. IOTs produce linear supply chain models that assumes constant, fixed proportions of inputs to create an industry's or sector's outputs. The accuracy of global IOTs are limited by disparities in the collection and standardisation of raw data in different countries, of which data may be collected over inconsistent time scales Assigning environmental impacts to industries and products is complex, and ultimately reflect a mixture of empirically measured data and modelled estimates, both of which introduce bias towards EEIOs analyses.[82]

---

[80] (Stadler, et al., 2018)
[81] (Pulles, et al., 2007)
[82] For more detail see (Kitzes, 2013)

EXIOBASE 3	Exiobase 3 is up to date, widely used and freely available. Exiobase is extensive, and is built upon supply use tables covering 163 industries and 200 product classifications Exiobase 3 is already used as a data input for existing biodiversity measurement methods (Including the Global Biodiversity Score, BFFI, BioScope). It is a recommended tool by those providing guidance on best practice in this field (e.g. in the SBTN Initial Guidance document[83]).	Due to the large size of the Exiobase 3 database, a cut-off point in the supply chain graph at $1e^{-5}$ had to be made, meaning that mid-point impacts calculated are likely to be an underestimate of actual mid-point impacts.

***Table X**: A list of benefits and limitations of using EE MRIOs and Exiobase 3.*

Nonetheless, Exiobase 3 provides a simple, consistent method for evaluating the linkages between University spend data on certain products and industries, and their associated mid-point impacts.

---

[83] Available here: SBTN-initial-guidance-for-business.pdf (sciencebasedtargetsnetwork.org)

Updated Scope 3 Emission Data & HESCET – Context Information

(Feb 2021 - UK)

Background

For many years, the HESCET tool (using embedded DEFRA conversion factors, until now using conversion factors based on data around a decade ago) has been used to calculate the Scope 3 (supply chain) emission across UK HE. This tool was originally developed with funding from HEFCE with the data processing managed by the 6 UK regional purchasing consortia. The tool was owned and controlled by HEFCE, it then passed to the recently established (UK Gov) Office for Students (OfS). The tool has not been refreshed with updated carbon equivalent data for many years (as it was owned by HEFCE, the sector itself did not have the power to update it). With the brief of OfS being different to HEFCE, the tool was therefore passed recently to the ownership of HEPA - the Higher Education Procurement Association (part of the British Universities Finance Directors Group).

Recent Activity

HESA had stated / states that the submissions for climate data for the 2019/20 AY (deadline April 2021) should be based on the 2020 DEFRA (published March 2020) conversion factors so a joint group was formed by HEPA and EAUC (with representatives from HEPA, EAUC, and from procurement and sustainability teams in the sector across the UK, as well as reps from purchasing consortia) to update the HESCET tool.

The group worked directly with the team in the University of Leeds that are contracted to calculate the carbon factors on behalf of DEFRA so that they would be able to both gain a good understanding of how they work and be able to access the data as soon as it was available. The team at Leeds advised that substantial changes to the calculation methodology had recent been put in place that would significantly change, significantly increasing in most cases, the carbon equivalent figures being reported due to various aspects including:

- Previously there were 75 DEFRA codes, now there are 311, this is to provide a better granularity of emission data across commodities.
- Much more (then when the old factors were calculated) is understood about the impact of other gases (beyond carbon) such as methane in the role they play in climate changes so these impacts have been included.
- Previously the data was based on two global regions of source, the UK and the rest-of-the-World, the new factors break the World into 16 regions so that different emissions caused by production in the different regions can be more accurately accounted for.
- Due to most of the largest emission goods that HE buy (ICT, Furniture, Lab equipment, Lab consumables, various single use products, as well as steel used in construction) now being purchased from China (and India often in the case of steel), where virtually all electricity is generated from coal (versus higher levels of renewable energy being factored into the old rest-of-the-World region figures in past years), we were advised to expect huge increases in the carbon equivalent figures (but which are

now much more accurate) for these commodities, versus the same spend calculated using previous versions of the HESCET tool / previous conversion factors, with some increases expected well in excess of 100%.

The HESCET tool can be a difficult tool to operate from a procurement perspective and challenging to examine more than one year of data at a time. APUC have an arrangement with the four English regional consortia to process their members annual spend data (LUPC and NWUPC from 18/19 data, SUPC and NEUPC from 19/20 data) where the institutions supply it. APUC working in partnership with HEPA & other UKUPC consortia, decided therefore to incorporate the DEFRA conversion factors (using exactly the same data as in the new HESCET tool) into their spend management system and make it available to institutions using the customer portal. This provides much more reportability of data, right down to supplier level, and will be a highly useful prioritisation tool.
For those institutions submitting 18/19 data to this tool (APUC, LUPC and NWUPC members), they will also have included in the reports the previous years' spend reported against the new factors on a single view / worksheet to enable them to put the changes into context, as if people simply looked at the previous year's HESCET data versus the recent year data, it would look like a huge increase in institutional emissions, whereas seeing the data in these new reports span a period that related to when reporting was under the old HESCET tool (but with the new conversion factors applied for the previous reporting period), allows year to year changes to be seen in the correct context, all using the new conversion factors. Institutions may then if they are reporting this data, can also refer back to their 18/19 HESCET data reports and explain the above and also explain that for example, x under the old HESCET tool is equal to Y in the latest report etc, but despite the higher figures does not necessarily mean there is an actual increase in institutional emissions.

Looking Forward

It is estimated that for HE/FE institutions, that out of their total climate emissions, depending on the institution's activities, between 65% and 80% of its climate emissions will be Scope 3 / caused in their supply chains. These new conversion factors are bringing that into sharp focus.

Global supply chains are unlikely in the short to medium term, to move away from these high-coal based economies, and while consortia and procurement colleagues in institutions, working in partnership with key stakeholder user groups will work to maximise reductions strategies where possible, the most optimal way for the sector to materially reduce its climate impacts therefore is to re-evaluate how it consumes high emission goods and services.

This will include reducing demand (so for example where a research grant provides for new equipment, making a decision not to buy it if existing equipment will suffice for the purpose in hand), making equipment last longer, large scale refurbishment of equipment to extend life, and moving away from purchasing anything for single use unless it is a critical need and there is no re-usable alternative.

Characterisation factors & assumptions

Table 32 below lists each calculation for each activity described in this report, arranged by aspect and tier. Each calculation is shown on a separate row, which gives the specific characterisation factors used, any additional data notes and assumptions made, and a qualitative estimate of the uncertainty of the calculation result.

Some common assumptions apply to a number of the activities described below – particularly for those that estimate impacts from the supply chains of purchased commodities. Two of these are described in detail here and, where applicable, are referred to using the letter in square brackets in table 32 below.

[A] Different mid-point characterisation methods used: In this analysis, estimates for mid-point impacts are taken from a broad range of sources (as described in section 2.2 of the main report). Each of these sources may calculate and characterise mid-point impacts using different methodologies. For instance, there are many different life cycle impact assessment (LCIA) methods (of which ReCiPe is one), which characterise mid-point impacts using different models. Some models are more standardised than others - for example, GHG emissions are usually characterised in terms of carbon dioxide equivalents (CO_2e), which are modelled in terms of global warming potential, as published by the IPCC (Stocker et al., 2013). Conversely, models used to estimate the eutrophication mid-point, for example, are more variable (see Morelli et al. (2018) for a useful discussion). For instance, the ReCiPe method characterises freshwater and marine eutrophication separately, considering only phosphorus-based emissions and nitrogen-based emissions when modelling each of these, respectively. Whereas the CML2 baseline method (CML, 2001; used by Poore & Nemecek (2018) in their food analysis) models freshwater and marine eutrophication together, combining N and P emissions into one measure of eutrophication potential.

The ReCiPe mid-to-endpoint characterisation factors (i.e. those that quantify endpoint impacts on biodiversity based on values for midpoint impacts, measured in species.year per kg CO_2e or per kg P-eq for example) assume that mid-points have been characterised using the ReCiPe mid-point methodology. This is not the case in this analysis, since mid-point values are taken from different sources that use different characterisation methodologies and no attempt is made to correct for differences between these methodologies. It is therefore assumed here that the range of sources used in this report would each make a prediction that is at least at a similar order of magnitude, however it is acknowledged that estimates made here are by no means precise. As mentioned in section 2.2 of the report, one way to overcome this issue would be for the University to carry out its own environmentally-extended input-output analysis (EEIO), which could estimate a broad range of emissions and consumption data across all areas of spend using a single, harmonised method (EEIO is employed by Kering, S. A. for example, in their Environmental Profit & Loss accounting methodology).

[B] Linearity of mid-point impacts: As explained in section 2.2 of the main report, LCA studies present their results based on a given functional unit (e.g. 1 tonne CO_2e per tonne of paper produced, or 0.006 m^3 water per km driven by car). In this assessment, these results are used directly as characterisation factors to estimate total impacts associated with a given activity (e.g. by multiplying the LCA result of 0.006 m^3 water per km by the total number of kilometres driven). This assumes a linear relationship between the magnitude of the activity and the magnitude of the impact – that is, it assumes that the impact *per functional unit* remains the same regardless of the number of functional units being produced/consumed/carried out. In turn, this also assumes, where an LCA study makes estimates for more than one category of impact (e.g. kg CO_2e, m^3 water consumed and kg SO_2e per tonne of paper), that the magnitude of one impact can be used to predict the magnitude of another impact. For example, where there is an existing estimate for GHG emissions based on spend on paper (from the HESCET report for example), but no estimate of the actual quantity of paper purchased, the magnitude of the known GHG estimate is used to predict the magnitude of other impacts, as described with an example in section 3.5.3 ('other impacts') (an alternative but similar approach to this example is to calculate the ratio between GHG emissions presented in an LCA study and GHG emissions from the HESCET report, and use this ratio to factor up other mid-point impacts measured in the same LCA study). However, for the reasons highlighted above and also given the numerous other caveats outlined in the table below, estimates made using this approach are only used to indicate an order of magnitude for midpoint impacts and should be treated with caution.

Table 32: *Characterisation factors, data notes/assumptions and uncertainty for each calculation, categorised by aspect and tier. Values for uncertainty are estimated on a qualitative basis, and categorised as low, medium, high or very high. These categories are based on 1) how the activity data has been estimated and 2) how impacts have been estimated (characterised). Categories are broadly defined as follows:*

- *Low = Calculation based on actual consumption/activity data and characterised using standard techniques (e.g. using government conversion factors)*
- *Medium = Calculation based on actual consumption/activity data and characterised using non-standard factors from the literature; OR calculation based on estimated consumption/activity data from university sources and characterised using standard techniques (e.g. using government conversion factors)*
- *High = Calculation based on estimated consumption/activity data and characterised using non-standard factors from the literature*

- *<u>Very High</u> = Calculation based on estimated consumption/activity data based on spend and characterised using non-standard factors from the literature*

NB: Regarding GHGs, factors for CO_2e are provided here. However, the sources identified in the table provide a breakdown of individual Kyoto Protocol GHGs. CF = Characterisation factor.

Travel								
Tier	*Activity*	*Impact*	*Activity data source*	*Mid-point CF source (s)*	*Mid-point CF value and metric (s)*	*ReCiPe2016 Mid-End-point CF (s)*	*Additional data notes & assumptions made in calculations*	*Uncertainty*
I	Business travel (University owned vehicles)	GHG	EMR 2019/20 Report	DEFRA GHG conversion factors (2020) - Fuels; Liquid Fuels; Diesel (average biofuel blend) and Petrol (average biofuel blend)	2.54603 kg CO_2e / litre diesel 2.16802 kg CO_2e / litre petrol	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No detailed fuel consumption data for university fleet was available this year as no ESOS report had been published, Therefore fuel consumption calculations from the ESOS 2018/19 report had to be used*, as reported in the EMR 2019/20 report. These fuel consumption calculations were factored up to correspond with the new vehicles added to the university fleet in 2020. This produced an estimated increase in petrol and diesel consumption for the year 2019/20. Updated DEFRA 2020 conversion factors were then applied to calculate the final GHG emissions. All calculations involving Business travel and grey fleet travel exclude OUP and subsidiary companies. A major assumption here is that the new fleet vehicles had the same fuel consumption and mpg profiles as the 2018/19 fleet. Another assumption is that COVID-19 did not disrupt, and thus reduce, the amount of university fleet travel due to their key operational roles. * These figures were calculated using a mixture of actual fuel consumption figures and estimated fuel consumption based on mileage or cost of fuel for 2018/19.	Medium

I	Business travel (University owned vehicles)	Air Pollution	EMR 2019/20 Report	National Atmospheric Emissions Inventory (NAEI): Fleet Weighted Road Transport Emission Factors **2019** - Factors used for lightweight goods vehicles	All specific factors (including PM broken down by tyre, brake, road ware and exhaust) are available on the NAEI website – https://naei.beis.gov.uk/data/ef-transport 0.0.075 g NOx / km (petrol) 1.13 g NOx / km (diesel) 0.001 g SO2 / km (petrol) 0.001 g SO2 / km (petrol)	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	No updated ESOS data was available, thus last year's breakdown of individual vehicle fuel consumption had to be used, as reported in the 2018/19 ESOS report. 1) Calculate the total fuel consumed in 2019/20 using EMR calculations, excluding OUP and Wholly owned subsidiaries. By excluding these two entities, the fuel consumed estimates are slightly lower than the EMR estimates. 2) Calculate the proportion change of fuel consumed from 2018/19 (excluding OUP and subsidiaries) to 2019/20 due to new university fleet additions (approximately and increase in 2.3% and 14.3% for petrol and diesel consumed respectively). 3) Using the updated conversion factors from the NAEI, multiply the previous car emissions data* (excluding OUP and subsidiary companies) by the new conversion factors to get an updated estimated air pollution emissions for 2018/19. 4) Multiply each of these air pollution emissions by the increase in diesel and petrol which was calculated above. 5) Sum these diesel and petrol emissions to get the final air pollution calculations. The major assumption here is that the new fleet vehicles had the same fuel consumption and mpg profiles as the 2018/19 fleet. Another assumption is that COVID-19 did not disrupt, and thus reduce, the amount of university fleet travel due to their key operational roles. *Which includes mpg breakdown for each vehicle owned by the university. See last year's report for more detailed methodology: *1) Mileage was calculated for the university-owned fleet (excluding OUP and University subsidiaries) using 'miles-per-gallon' figures from vehicle manufacturers where available in the ESOS dataset. Where not available, average UK mpg figures were used from the UK Department for Transport (values for diesel & petrol LWG vehicles)* *2) electric vehicles were not included in calculations*	Medium

							3) For particulate matter (PM), PM (total) gives the summed PM values for exhaust emissions, tyre wear, brake wear & road abrasion for both PM2.5 and PM10. *4) NOx and SO_2 were both characterised in terms of acidification potential using the ReCiPe midpoint CFs. NOx was also characterised in terms of photochemical ozone formation impacts.*	
I	Business travel (Grey fleet)	GHG	ESOS 2019	DEFRA / DBEIS GHG emissions factors (2020) - Passenger Vehicles; Cars (by size); Average car (diesel and petrol)	0.28052 kg CO_2e / mile (petrol) 0.27108 kg CO_2e / mile (diesel)	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	ESOS 2018/19 data was used to estimate this year's grey fleet travel. A major assumption includes that the **grey fleet mileage reduced by 37%** between 2018/19 to 2019/20, accounting for the fact that no business travel took place for 19 weeks between 23rd March – 31st July. This was estimated by the OUES, and meant that mileage from the ESOS dataset had to be used. The following method was used: (1) Mileage was reduced by 37%, and the proportion of diesel/petrol vehicles in the grey fleet had to be estimated using the proportion of petrol/diesel vehicle km on urban roads were taken as a proxy: for 2018 these were 54% petrol, 46% diesel, based on table 2a of the "Vehicle Fleet Compositions Projection (Base 2018)" in the NAEI at http://naei.defra.gov.uk/data/ef-transport. (2) Using updated conversion factors, mileage by fuel type was converted to CO_2e.	Medium
I	Business travel (Grey fleet)	Air Pollution	ESOS 2019	National Atmospheric Emissions Inventory (NAEI): Fleet Weighted Road Transport Emission Factors 2019 - Factors used for average car	All specific factors (including PM broken down by tyre, brake, road ware and exhaust) are available on the NAEI website – https://naei.beis.gov.uk/ data/ef-transport	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	1) Split between petrol/diesel mileage was estimated in the ESOS dataset as described above. 2) same assumptions made as for university-owned fleet air pollution calculations, except for the following assumption that the **grey fleet mileage reduced by 37%** between 2018/19 to 2019/20, accounting for the fact that no business travel took place for 19 weeks between 23rd March – 31st July. This was estimated as no ESOS data is available for the year 2019/20, considering COVID-19 lockdowns. 2018/19 ESOS data was processed with 2020 conversion factors, and OUP and subsidiary companies were removed.	Medium

I	Business travel (flights)	GHG	Key Travel Scope 3 Report 2019-20	DEFRA / DBEIS GHG emissions factors (2021) - Business travel – air; inclusive of radiative forcing	Specific factors used, taking into account flight haul and passenger class (in kg CO_2e / km). Full list of factors available on the Defra website.	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Based on surveys conducted by the University's sustainable transport team, approximately 40% of travel bookings are made through Key Travel (the University's preferred travel provider). CO_2e estimates provided in the Key Travel Scope 3 carbon report* are therefore factored up to 100% to estimate total emissions from business flights, which assumes that Key Travel bookings are representative of all university air travel. *This calculation accounts for cancelled flights due to COVID-19.	Medium
I	Business travel (flights)	Air Pollution	Key Travel Scope 3 Report 2019-20	European Aviation Emissions Report (2019); EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 - See part B section 1.A.3.a Aviation 1 Master emissions calculator 2019. Emissions factors (kg pollutant per kg of fuel burn) were calculated by selecting a reference aeroplane model and flight distance for each flight category, and dividing the total emissions per flight by the total fuel burn per flight. Reference aeroplane models were selected from those listed in the Defra/DBEIS 2019 UK Government GHG Conversion	Fuel burn per passenger kilometre travelled 0.027 kg fuel/pkm Flight category; reference aeroplane model; average distance travelled per flight category; and conversion factors for pollutants: Short Haul (<3700km) *Airbus A319* 1, 033 average flight length (km) 0.013719 kg NOx / kg fuel 0.00084 kg SOx / kg fuel 0.00011 kg PM volatile/ kg fuel Long Haul (>3700km) *BOEING 737-800* 4,203 km average flight length 0.0132 kg NOx / kg fuel 0.00084 kg SOx / kg fuel 0.00011 kg PM volatile / kg fuel Short Haul (<3700km) *BOEING 737-700*	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	1) an average value for fuel burned per pkm was used meaning that flight class is not considered here (e.g. this value would be higher for business class flights and lower for economy class) 2) NOx and SO_2 were both characterised in terms of acidification potential using the ReCiPe midpoint CFs. NOx was also characterised in terms of photochemical ozone formation impacts. PM was not included in biodiversity calculations. 3) figures for total air pollutant emissions were factored up from 40% to 100%, as described for CO_2e values above.	High

				Factors for Company Reporting Methodology Paper - https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019 All flight distances, model data and conversion factors were taken from 2019 for consistency, as only more up to date DEFRA flight distances were available.	990km average flight length 0.013603 kg NOx / kg fuel 0.00084 kg SOx / kg fuel 0.0001 kg PM volatile / kg fuel Long Haul (>3,700km) *Airbus-330-200 Prestige* 6,590km average flight length 0.014071 kg NOx / kg fuel 0.00084 kg SOx / kg fuel 0.0001 kg PM volatile / kg fuel			
I	Undergraduate educational flights (year abroad and fieldtrips)	GHG	Departmental Information	DEFRA / DBEIS GHG emissions factors (2020)	Short-haul, average passenger: 0.15553kg CO_2e/pkm Long haul average passenger: 0.19085 kg CO_2e/pkm	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Flights were estimated from the Year Abroad and Fieldwork data sets, provided by university departments. Due to COVID-19, there were no fieldwork flights, but some travel for year abroad students continued. No specific flight details for these students were recorded, but their individual placement locations were recorded and different flight scenarios could then be constructed to estimate pkms. Details of the different flight scenarios can be found in the travel aspect report (3.1).	Medium
I	Undergraduate educational flights (year abroad and fieldtrips)	Air Pollution	Departmental Information	European Aviation Emissions Report (2019); EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 - See part B section 1.A.3.a Aviation 1 Master emissions calculator 2019. Emissions factors (kg	Fuel burn per passenger kilometre travelled 0.027 kg fuel/pkm Flight category; reference aeroplane model; average distance travelled per flight category; and conversion factors for pollutants:	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	The same approach used to calculate air pollution impacts for other flight categories were used (see above).	High

				pollutant per kg of fuel burn) were calculated by selecting a reference aeroplane model and flight distance for each flight category, and dividing the total emissions per flight by the total fuel burn per flight. Reference aeroplane models were selected from those listed in the Defra/DBEIS 2019 UK Government GHG Conversion Factors for Company Reporting Methodology Paper - https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019 All flight distances, model data and conversion factors were taken from 2019 for consistency, as only more up to date DEFRA flight distances were available.	Models used for different flight scenarios (further detail in Air Pollution Calcs Spreadsheet): Short Haul (<3700km) Year Abroad Scenario 1: ERJ-170-100 Year Abroad Scenario 2: EMBRAER ERJ190 Long Haul (>3700km) Year Abroad Scenario 1: BOEING 737-800 Year Abroad Scenario 2: BOEING 777-300ER			

I	Business travel (rail)	GHG	Key Travel Scope 3 Report 2019-10	DEFRA / DBEIS GHG emissions factors (2018 and 2019) - Business travel – land; Rail	National rail (2018): 0.04678 kg CO_2 / passenger.km International rail (2018): 0.01225 kg CO_2e / passenger.km National rail (2019): 0.0411 kg CO_2e/ passenger.km International rail (2019): 0.00597 kg CO_2e/passenger.km Light rail and tram (2019): 0.03508 CO_2e/passenger.km London Underground (2019): 0.03084 CO_2e/passenger.km	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	CO_2e values taken directly from the Key Travel Scope 3 report, which used conversion factors from both 2018 and 2019. As with flights, it was assumed that rail journeys booked through Key Travel accounted for 40% of all rail journeys. Assuming Key Travel journeys were representative of all journeys, mid-point impact values were factored up to 100%	Medium
I	Business travel (rail)	Air Pollution	Key Travel Scope 3 Report 2019-20	Department for Transport - TSGB0308 (ENV0301): Air pollutant emissions by transport mode - Trains	0.37009 g NOx / pkm 0.003028 g SO_2 / pkm 0.01813 g PM / pkm	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	Air pollutants were factored up from 40% to 100%, as described above.	High
I	Staff Commuting (road & rail)	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Business travel – land: Cars (by size): Average car Bus (average local bus) Motorbike (average motorbike) Rail (national rail)	Average cars: 0.16844 kg CO_2e / km Average local Bus: 0.10312 kg CO_2e / passenger.km Average Motorbike: 0.11337 kg CO_2e / km National Rail: 0.03694 kg CO_2e / passenger.km	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	CO_2e values taken directly from EMR, which accounted for a reduction in travel by 37% due to COVID-19. Total passenger kilometre data was used that had been calculated previously for the University Estate Management Records in 2019 (EMR). These estimates are based on travel surveys undertaken at the university and use average distances travelled per mode of transport, taking into account differences in the number of working days for staff and different types of student (i.e. undergraduate vs. postgraduate). However, no travel survey was taken in 2020, and the impact of COVID had to be estimated. Assumption made that staff only travelled for 33 weeks of the academic year (63.5%).	Medium

I	Staff Commuting (road & rail)	Air pollution	EMR 2019-20	National Atmospheric Emissions Inventory (NAEI): Fleet Weighted Road Transport Emission Factors 2019 - Petrol cars - Diesel cars - Buses - Motorcycles Department for Transport - TSGB0308 (ENV0301): Air pollutant emissions by transport mode - Trains	<u>Petrol cars:</u> 0.071 g NOx / km 0.001 g SO_2 / km <u>Diesel cars</u> 0.568 g NOx / km 0.001 g SO_2 / km <u>Rail</u> 0.2302 g NOx / pkm 0.0028 g SO_2 / pkm <u>Buses</u> 2.242 g NOx / km 0.004 g SO_2 / km	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	CO_2e values taken directly from EMR, which accounted for a reduction in travel by 37% due to COVID-19. 1) Passenger kilometres for staff commuting calculated for EMR as described above. 2) NAEI emissions factors are provided per km, rather than per passenger km. Emissions from buses were therefore divided by the average passenger occupancy for local buses in England in 2019/20 as reported by the Department for Transport (= 12.8 passengers) (see Department for Transport - BUS0304: Average occupancy on local bus services by metropolitan area status and country 2019/20.	Medium
II	Domestic Student Transport	GHG	Domestic Student Postcode Data 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Business travel – land: Cars (by size): Average car	Average cars: 0.16844 kg CO_2e / km	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Multiple assumptions were used to calculate the total pkms, and thus mid-point impacts. These include: (1) Two return trips were made for the academic year of 2019-20. This assumes that students were dropped off once and picked up once, with the car making a round trip for each 'drop off' or 'pick up'. (2) Estimates of driving distances were used, rather than actual driving distances (3) Every trip was made by car, and not another mode of transport (4) Every domestic student travels from their home postcode, and not another location (5) The Postcode data is up-to-date	Medium
II	Domestic Student Transport	Air Pollution	Domestic Student Postcode Data 2019-20	National Atmospheric Emissions Inventory (NAEI): Fleet Weighted Road Transport Emission Factors 2019 - Petrol cars - Diesel cars	<u>Petrol cars:</u> 0.071 g NOx / km 0.001 g SO_2 / km <u>Diesel cars</u> 0.568 g NOx / km 0.001 g SO_2 / km	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	Same as above.	Medium

II	Student Commuting (road & rail)	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Business travel – land: Cars (by size): Average car Bus (average local bus) Motorbike (average motorbike) Rail (national rail)	Average cars: 0.16844 kg CO_2e / km Average local Bus: 0.10312 kg CO_2e / passenger.km Average Motorbike: 0.11337 kg CO_2e / km National Rail: 0.03694 kg CO_2e / passenger.km	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	CO_2e values taken directly from EMR. See staff commuting above.	Medium
II	Student Commuting (road & rail)	Air pollution	EMR 2019-20	Same as for staff commuting (see above)	Same as for staff commuting (see above)	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	Same as for staff commuting (see above)	Medium
II	International student flights	GHG	Student domicile and headcount statistics 2020	DEFRA / DBEIS GHG emissions factors (2020) - Business travel – air; inclusive of radiative forcing; average passenger	Specific factors used, taking into account flight haul (in kg CO_2e / km). Factors available on the Defra website.	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	A full description of assumptions made is provided in the main text of the report. [sections 3.1.2 and 3.1.3]. NB flight class not taken into account here, all passengers assumed to be 'average passengers' according to the Defra definitions.	Medium
II	International student flights	Air pollution	Student domicile and headcount statistics 2020	As above for business travel (flights)	As above for business travel (flights)	Photochemical ozone formation - Terrestrial ecosystems Acidification - Terrestrial ecosystems	A full description of assumptions made in calculating total passenger kilometres for international student flights is provided in the main text of the report. [sections 3.1.2 and 3.1.3]. NB flight class not taken into account here, all passengers assumed to be 'average passengers' according to the Defra definitions. Midpoint values for air pollutants are based on the assumptions described above for business travel (flights), although distance values are not taken from the Key Travel dataset and so are not factored up.	High

II	Purchased fuel (supply chain, or 'well-to-tank')	GHG	ESOS 2019 (university-owned fleet and grey fleet)	DEFRA / DBEIS GHG emissions factors (2020) - WTT - Fuels; liquid fuels; Petrol (average biofuel blend) & diesel (average biofuel blend)	0.59344 kg CO_2e / litre petrol 0.61015 kg CO_2e / litre diesel	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Fuel consumption data based on same assumptions described for business travel (university-owned fleet) and business travel (grey fleet). Defra WTT factors cover upstream emissions associated with extraction, refining and transportation of the raw fuel sources to an organisation's site (or asset), prior to combustion.	Medium
II	Purchased vehicles (supply chain)	GHG	University Fleet List 2020	Ellingsen et al. (2016)	t CO_2e per Vehicle, categorised by vehicle kerb weight: <1100 kg 7 (BEV); 3.5 (ICEV) >1100 kg 9.5 (BEV); 5.5 (ICEV) >1500 kg 12 (BEV); 8 (ICEV) >1750 kg 14.5 (BEV); 10 (ICEV)	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	A newly purchased vehicle was defined as a vehicle that was newly registered under the University fleet list of 2020 in comparison to 2019. This includes 9 new vehicles. The kerb weight and engine type (internal combustion vs electric) were obtained from the vehicle manufacturer website in order to combine with CFs from Ellingsen et al. (2016). CFs cover cradle-to-gate GHG emission values for vehicle and engine/battery production.	Medium
II	Fleet mileage (University-owned & grey) – fuel & vehicle supply chain	Air pollution	ESOS 2019 and University Fleet List 2020 (university-owned fleet and grey fleet)	Hawkins et al. (2013)	0.00089 kg SO2 eq/km (petrol); 0.00079 kg SO2 eq/km (diesel)	Acidification - Terrestrial ecosystems	As above, a major assumption includes that the **grey fleet mileage reduced by 37%** between 2018/19 to 2019/20, accounting for the fact that no business travel took place for 19 weeks between 23rd March – 31st July. This was estimated as no ESOS data is available for the year 2019/20, considering COVID-19 lockdowns. **A different assumption is made for university fleet mileage**, which accounts for an increase in fleet size, but assumes that per vehicle fuel consumption has remained constant between 2018/19 and 19/20, with the COVID-19 pandemic not inhibiting operational transport. 1) The mileage (i.e. total km driven) for the grey fleet was taken from the ESOS 2018/19 data source and reduced to account for COVID-19, which was estimated as described above for business travel (grey fleet). OUP and subsidiary transport were omitted. 2) Mileage for the university fleet was estimated as described above for business travel (university-owned fleet). 3) CFs are 'Cradle-to-grave', meaning they cover a broader scope of impacts than the factors used for GHGs, which	High

							don't include impacts from the end-of-life phase (i.e. vehicle disposal). However, impacts from the EoL phase are very marginal compared with other life-cycle stages (i.e. manufacture and use), so this was considered acceptable. 4) CFs include midpoint impacts from fuel combustion, fuel production and vehicle production - whereas for GHGs, these are considered separately using separate CFs, as described above. 5) **Different mid-point characterisation methods used** (see discussion provided above [A]).	
II	Fleet mileage (University-owned & grey) – fuel & vehicle supply chain	Water pollution	ESOS 2019 (university-owned fleet and grey fleet)	Hawkins et al. (2013)	kg P eq/km 0.00005 (petrol) 0.00005 (diesel) kg N eq/km 0.00008 (petrol) 0.00009 (diesel) kg 1,4-DCB eq/km (to freshwater) 0.00151 (petrol) 0.00146 (diesel) kg 1,4-DCB eq/km (to seawater) 0.00194 (petrol) 0.00188 (diesel)	Eutrophication - Freshwater ecosystems Toxicity - Freshwater ecosystems Toxicity - Marine ecosystems Eutrophication - Marine ecosystems	all assumptions as described above	High
II	Fleet mileage (University-owned & grey) – fuel & vehicle supply chain	Land use	ESOS 2019 (university-owned fleet and grey fleet)	Hawkins et al. (2013)	m^2 natural land transformation / km 0.00009 (petrol) 0.000073 (diesel) m^2 agricultural land transformation / km 0.001398 (petrol) 0.001346 (diesel)	Land use - occupation and transformation	all assumptions as described above	High
II	Fleet mileage (University-owned & grey) – fuel & vehicle supply chain	Water use	ESOS 2019 (university-owned fleet and grey fleet)	Stephan et al. (2016)	0.0059 m^3 water / km	Water consumption - terrestrial ecosystems Water consumption -	1) The mileage (i.e. total km driven) for the grey fleet was estimated from the ESOS 2018/19 calculations, accounting for COVID-19 which was estimated as described above for business travel (grey fleet). 2) Mileage for the university fleet was estimated as described above for business travel (university-owned fleet)	High

						aquatic ecosystems	3) CFs include water consumption from fuel combustion, fuel production and vehicle production - whereas for GHGs, these are considered separately using separate CFs, as described above. 4) it is conservatively assumed that all water use was consumptive (i.e. not returned to source) 5) CFs are for petrol cars, so this necessarily assumes that all university cars run on petrol	

Food

Tier	*Activity*	*Impact*	*Activity data source*	*Midpoint CF source (s)*	*Midpoint CF value and metric (s)*	*ReCiPe2016 Mid-End-point CF (s)*	*Additional data notes & assumptions made in calculations*	*Uncertainty*
I	Food purchased by university departments	GHG	HESCET Report (2020) - 'Contract Catering'	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg CO_2e per kg or L of product	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	1) The sum of spend in the Defra 311 sector "Contract Catering" was broken down into the Defra 75 food category sectors (as detailed in table 11), using the same proportions of spend in each category as the previous academic year (2018-19). This makes the very broad assumption that spend on each food category was proportionally the same between the academic years of 2018-19 and 2019-20. As results are based upon 2018-19 calculations, the assumptions from these calculations (italicised) must also be considered: 2) *Consumption data (i.e. kg or L of food consumed) for different categories of food product is based on spend values recorded in the 2018-19 HESCET report, using reference food products as detailed in table 11 of the main report. This makes the very broad assumption that reference products are representative of their entire category of spend, which in reality would consist of a broad range of products with differing environmental impacts. Reference products were selected based on a qualitative assessment of all purchasing invoices under the categories 'facilities: catering' and 'hospitality, food & drink' (provided by UPD). Further information on reference products (e.g. portion sizes) was obtained directly from supplier's websites or menus (e.g. Compass Occasions).*	Very high

							3) *It is assumed that the spend values recorded in the HESCET report are accurate, which may not be the case (see main report for further details)* 4) *GHG values are characterised in the FoodDB dataset using GWP100 (IPCC, 2013), which is consistent with the ReCiPe characterisation factors.*	
I	Food purchased by university departments	Land use	HESCET Report (2020) - 'Contract Catering'	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg m^2 cropland or m^2 pasture per kg or L of product	Land use - occupation and transformation	1) as above 2) as above 3) as above 4) *area values for pasture and cropland were characterised in terms of m^2 annual crop equivalents using the ReCiPe midpoint method, before pairing with mid-to-end point CFs for biodiversity impacts:* *1 m^2 cropland = 1 m^2 annual cropland eq.* *1 m^2 pasture = 0.55 m^2 annual cropland eq.*	Very high
I	Food purchased by university departments	Water use	HESCET Report (2020) - 'Contract Catering'	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in litres water consumed per kg or L of product	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	1) as above 2) as above 3) as above 3) *all values for water use (or 'freshwater withdrawals' as defined in Poore & Nemecek (2018)) were assumed to be consumptive (i.e. not returned to source). This will produce an overestimate, since some water will return to source (through percolation for example) – although this would depend on the type of crop and method of irrigation. Döll et al. (2012) estimate that approximately 40% of water used for irrigation is consumptive.*	Very high
I	Food purchased by university departments	Water pollution	HESCET Report (2020) - 'Contract Catering'	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg PO_4^{3-}eq. per kg or L of product	Eutrophication - Freshwater ecosystems	1) as above 2) as above 3) as above 3) *Values for eutrophication were multiplied by 0.33 to roughly convert from kg PO_4^{3-} eq. to kg P eq. due to the former containing a third of the quantity of phosphorus based on molecular weights (following the ReCiPe midpoint characterisation methodology. However, eutrophication impacts are still likely to be an overestimate, as a different midpoint characterisation method was used. See [A] for more details.*	Very high
I	Food purchased by university departments	Air pollution	HESCET Report (2020) - 'Contract Catering'	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on	Different values per food product. Expressed in kg SO_2e per kg or L of product	Acidification - Terrestrial ecosystems	1) as above 2) as above 3) as above 3) *A different midpoint characterisation method was used for acidification. See [A] for more details.*	Very high

				Poore & Nemecek (2018))				
I	Food sold in university cafeterias	GHG	Compass Cafeteria Sales Data 2019-20	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg CO_2e per kg or L of product	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	2) Assumed that Compass data was representative of other non-Compass cafeterias, for which data was not obtained (described in detail in the main report) 3) Assumed that ingredients of FoodDB products and estimated portion sizes were representative of Compass products (described in detail in the main report) 4) GHG values are characterised in the FoodDB dataset using GWP100 (IPCC, 2013), which is consistent with the ReCiPe characterisation factors.	High
I	Food sold in university cafeterias	Land use	Compass Cafeteria Sales Data 2019-20	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg m^2 cropland or m^2 pasture per kg or L of product	Land use - occupation and transformation	1) as above 2) as above 3) as above 4) area values for pasture and cropland were characterised in terms of m^2 annual crop equivalents using the ReCiPe midpoint method, before pairing with mid-to-end point CFs for biodiversity impacts: 1 m^2 cropland = 1 m^2 annual cropland eq. 1 m^2 pasture = 0.55 m^2 annual cropland eq.	High
I	Food sold in university cafeterias	Water use	Compass Cafeteria Sales Data 2019-20	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in litres water consumed per kg or L of product	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	1) as above 2) as above 3) as above 4) all values for water use (or 'freshwater withdrawals' as defined in Poore & Nemecek (2018)) were assumed to be consumptive (i.e. not returned to source). This will produce an overestimate, since some water will return to source (through percolation for example) – although this would depend on the type of crop and method of irrigation. Döll et al. (2012) estimate that approximately 40% of water used for irrigation is consumptive.	High

I	Food sold in university cafeterias	Water pollution	Compass Cafeteria Sales Data 2019-20	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg PO_4^{3-}eq. per kg or L of product	Eutrophication - Freshwater ecosystems	1) as above 2) as above 3) as above 4) Values for eutrophication were multiplied by 0.33 to roughly convert from kg PO_4^{3-} eq. to kg P eq. due to the former containing a third of the quantity of phosphorus based on molecular weights (following the ReCiPe midpoint characterisation methodology. However, eutrophication impacts are still likely to be an overestimate, as a different midpoint characterisation method was used. See [A] for more details.	High
I	Food sold in university cafeterias	Air pollution	Compass Cafeteria Sales Data 2019-20	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg SO_2e per kg or L of product	Acidification - Terrestrial ecosystems	1) as above 2) as above 3) as above 4) A different midpoint characterisation method was used for acidification. See [A] above for more details.	High
II	Staff & student meals	GHG	Compass Cafeteria Sales Data 2019-20; Student & Staff statistics 2020	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg CO_2e per kg or L of product	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	1) Assumptions are taken as above for food sold in university cafeterias 2) Assumed that main meals (under the categories "Hot Meals" and "Sandwiches and Wraps") sold in university cafeterias is representative of all main meals consumed during working hours by staff and students. This is a broad assumption, since Compass can only offer a certain range of products which won't necessarily capture the complexity of dietary variations among staff and student. 3) Environmental values for Main Meals purchased within Compass cafeterias were factored up to 100% based on Compass main meals accounting for approximately 5.9% of the total number of staff and student lunches consumed for 2019-20, before the 23rd of March 2020. These Compass environmental values are the sum of all mid-point impacts of Compass sales, not just "Hot Meal" and "Sandwiches and Wraps". Therefore, this calculation does assume that staff and students consume food items other than "Hot Meals" and "Sandwiches and Wraps" as part of their daily meal consumed on campus during a working day. Therefore, when factoring up the results based on meals alone, it is assumed that the sales of other Compass products represent a similar proportion of annual	Very high

							consumption. This may lead to some products being over/underrepresented in the factored up environmental values - e.g. if people more often choose to buy a coffee than to have a meal at a Compass café, a greater proportion of people's annual coffee purchases would be represented in the Compass data compared to the proportion of meal purchases. Coffee would therefore be overrepresented in the final factored up estimates for staff and student food consumption.	
II	Staff & student meals	Land use	Compass Cafeteria Sales Data; Student & Staff statistics	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg m^2 cropland or m^2 pasture per kg or L of product	Land use - occupation and transformation	As above	Very high
II	Staff & student meals	Water use	Compass Cafeteria Sales Data; Student & Staff statistics	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in litres water consumed per kg or L of product	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	As above	Very high
II	Staff & student meals	Water pollution	Compass Cafeteria Sales Data; Student & Staff statistics	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg PO_4^{3-}eq. per kg or L of product	Eutrophication - Freshwater ecosystems	As above	Very high
II	Staff & student meals	Air pollution	Compass Cafeteria Sales Data; Student & Staff statistics	FoodDB & LEAP database (developed by Harrington et al. and the LEAP project team, based on Poore & Nemecek (2018))	Different values per food product. Expressed in kg SO_2e per kg or L of product	Acidification - Terrestrial ecosystems	As above	Very high

Built Environment

Tier	*Activity*	*Impact*	*Activity data source*	*Midpoint CF source (s)*	*Midpoint CF value and metric (s)*	*ReCiPe2016 Mid-End-point CF (s)*	*Additional data notes & assumptions made in calculations*	*Uncertainty*
I	Natural gas consumption	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Fuels; Gaseous fuels; Natural gas (Gross CV)	0.18387 kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made, figures based on actual consumption data and were taken directly from the EMR dataset	Low
I	Gas oil consumption	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Fuels; liquid fuels; gas oil (gross CV)	0.25672 kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made, figures based on actual consumption data and were taken directly from the EMR dataset	Low
I	Electricity consumption	GHG	EMR 2018/19	Estimate based on 'market' method: Scottish Power Energy Retail Ltd REGO assurance statement (Provided by Deloitte LLP) Main estimate using location-based grid factors: DEFRA / DBEIS GHG emissions factors (2020) - UK electricity; electricity generated	Estimate based on 'market' method: 0 kg CO_2e / kWh Main estimate using location-based grid factors: 0.23314kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Activity value and carbon emissions taken directly from the EMR 2019/20 report (grid electricity consumption). The COVID 19 Pandemic caused building closures across the University's estate in 19/20. This resulted in a reduction of over 3,732 MWh (electricity) in 19/20; this directly affected the emissions from grid electricity	Low

I	Electricity Consumption for online education	GHG	IT Department	(Obringer et al., 2021)	Supplementary material UK based Estimates: Median Carbon footprint 17.245g of CO_2eq/GB	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	Actual streaming data gathered from the educational media department, so no assumptions made about the number of hours of lecture content streamed. However, it is assumed that all undergraduates and taught postgraduates had 2 hours of zoom classes/tutorials for each week of Trinity Term 2020. Conversion factors are based upon the UK electricity generation in 2019, which considers the average energy source mix of the UK in 2019. This assumes that all lectures were watched in the UK, ignoring the fact that international students may have watched lectures from their home countries during Trinity Term 2020.	High
I	Electricity Consumption for online education	Water use	IT Department	(Obringer et al., 2021)	Supplementary material UK based Estimates: Median Water footprint: 1.183L/GB	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	As above	High
I	Water consumption	Water use	EMR 2018/19	n/a	Figures taken directly from consumption data	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	Figures for water use were conservatively assumed to be consumptive (i.e. not returned to source). This is likely to overestimate the impact on biodiversity to some degree, since a large amount of domestic/industrial water use is usually returned to source.	Low
I	Urban land occupation (university-managed buildings)	Land use	OUES (Asset & Space Management records)	ReCiPe	Classed all urban area as 'artificial area' (0.73 m^2 annual crops equivalent)	Land use - occupation and transformation	Land occupation by university-owned built area is not included as an impact in this assessment (see section 3.3.3 'land use' for more details)	Low
I	Urban land occupation (commercial & residential buildings)	Land use	OUES (Asset & Space Management records)	ReCiPe	Classed all urban area as 'artificial area' (0.73 m^2 annual crops equivalent)	Land use - occupation and transformation	Land occupation by university-owned built area is not included as an impact in this assessment (see section 3.3.3 'land use' for more details).	Low

II	Gas consumption (gas supply chain, 'well-to-tank')	GHG	EMR 2018/19	DEFRA / DBEIS GHG emissions factors (2020) - WTT – fuels; gaseous fuels; natural gas (gross CV)	0.02391 kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made; figures based on actual consumption data.	Low
II	Gas consumption (gas supply chain)	Water	EMR 2018/19	Vanham et al. (2019)	136 m^3 water / TJ or 0.0004896 m^3 water consumed / kWh	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	CF based on average blue water footprint for energy produced from gas in Europe. Figures for water use were conservatively assumed to be consumptive (i.e. not returned to source).	Medium
II	Gas oil consumption (gas oil supply chain, 'well-to-tank')	GHG	EMR 2018/19	DEFRA / DBEIS GHG emissions factors (2020) - WTT – fuels; liquid fuels; gas oil (gross CV)	0.05888 kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made; figures based on actual consumption data.	Low
II	Electricity consumption (supply chain; well-to-tank)	GHG	EMR 2018/19	Main estimate using location-based grid factors: DEFRA / DBEIS GHG emissions factors (2020) - WTT – UK & overseas electricity; WTT- UK electricity (generation) Estimate based on 'market' method: Thomson & Harrison (2015)	Estimate based on 'market' method: 0.015 kg CO_2e / kWh Main estimate using location-based grid factors: 0.03217kg CO_2e / kWh	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made; figures based on actual consumption data.	Low

II	Electricity consumption (supply chain; transmission & distribution losses + WTT values for T&D losses)	GHG	EMR 2018/19	DEFRA / DBEIS GHG emissions factors (2020) - Transmission and Distribution; T&D – UK electricity - WTT – UK & overseas electricity; WTT- UK electricity (T&D)	0.02005 kg CO_2e / kWh 0.00277 kg CO_2e / kWh (WTT)	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made; figures based on actual consumption data.	Low
II	Electricity consumption (supply chain)	Water use	EMR 2018/19	Mekonnen et al. (2015)	3000-4240 m^3/ TJ Or 0.0130 m^3/kWh	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	CF is the estimated blue water footprint for UK electricity production. All water use is assumed to be consumptive (i.e. not returned to source)	Medium
II	Construction (supply chain)	GHG	Procurement Report 2019-20	Exiobase 3	Multiple CF values and metrics embedded within Exiobase 3	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	All spend data in the following Purchasing Categories were categorised under the Exiobase 3 flow “Construction Work (UK)”: - Construction Services - Repairs, Alterations and Decorating Services - Flooring All suppliers for the above procurement categories were from the UK. The flow “Construction Work” in Exiobase 3 is based upon the statistical classification of economic activities in the European Community (NACE). NACE is a four-digit classification system, with Exiobase 3 using NACE 1 to classify all industry and product flows. For the full list of activities included in the flow “Construction Work”, follow this link: https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=598503&StrLayoutCode=EN Therefore, when total spend of all construction related purchasing categories are inputted to the “Construction Work” flow, Exiobase 3 considers construction-related activities that may stretch beyond the original spend data	Very High

							scope in the Procurement Report. Conversely, some could argue that using the NACE category "Construction Work" will accurately cover all spend activities that are encompassed within the vague purchasing category of "Construction Services". A full set of limitations and assumptions for using Exiobase 3 to calculate mid-point impacts can be found in the 'General Methods' section of this report.	
II	Construction (supply chain)	Water use	Procurement Report 2019-20	Exiobase 3	Multiple CF values and metrics embedded within Exiobase 3	Water consumption - terrestrial ecosystems Water consumption - aquatic ecosystems	See Construction (supply chain) - GHG	Very High
II	Construction (supply chain)	Water Pollution	Procurement Report 2019-20	Exiobase 3	Multiple CF values and metrics embedded within Exiobase 3	Eutrophication - Freshwater ecosystems Toxicity - Freshwater ecosystems Toxicity - Marine ecosystems Toxicity - Terrestrial ecosystems	See Construction (supply chain) - GHG	Very High

II	Construction (supply chain)	Air Pollution	Procurement Report 2019-20	Exiobase 3	Multiple CF values and metrics embedded within Exiobase 3	Acidification - Terrestrial ecosystems	See Construction (supply chain) - GHG	Very High

Natural Environment

Tier	*Activity*	*Impact*	*Activity data source*	*Midpoint CF source (s)*	*Midpoint CF value and metric (s)*	*ReCiPe2016 Mid-End-point CF (s)*	*Additional data notes & assumptions made in calculations*	*Uncertainty*
I	University owned and managed land	Land Use	OUES (Asset & Space Management records)	*ReCiPe*	1 m^2 arable land = 1 m^2 annual cropland eq. 1 m^2 pasture = 0.55 m^2 annual cropland eq. 1 m^2 artificial areas = 0.73 m^2 annual cropland eq. 1 m^2 woodland = 0 m^2 annual cropland eq.	Land use - occupation and transformation	Differences in land use categories as reported by the university could not be distinguished between in the different ReCiPe conversion factor categories. All areas falling within each different category are assumed to have the same value for biodiversity. University land occupation is not included as an impact in this assessment (see section 3.4.3 for more details).	Medium
I	University owned commercial & residential land	Land use	OUES (Asset & Space Management records)	*ReCiPe*	As above	Land use - occupation and transformation	As above	Medium

II	Agricultural products, fertilisers & forestry products (supply chain)	GHG	HESCET Report 2019-20: - 9.3.4.2 Plants, flowers, seeds, fertilisers, insecticides - 5.5.2 Garden tools, equipment and accessories	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	*Kg CO_2e / £*	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	1) Figures for CO_2e taken directly from the HESCET 2019-20 Report. However, the characterisation factors used in the HESCET report are outdated and results are reliant on accurate coding of university spend. See main report for further discussion (section 2.2) 2) Note that a breakdown of individual Kyoto Protocol GHGs is not provided here but is available in the HESCET Report.	High

Resource Use & Waste

Tier	*Activity*	*Impact*	*Activity data source*	*Midpoint CF source (s)*	*Midpoint CF value and metric (s)*	*ReCiPe2016 Mid-End-point CF (s)*	*Additional data notes & assumptions made in calculations*	*Uncertainty*
II	Waste disposal: Waste-to-energy (incineration)	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Waste disposal; Refuse; Household residual waste; combustion	21.317 kg CO_2e / tonne waste	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made, activity data taken from the EMR report.	Low
II	Waste disposal: Recycled	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Waste disposal; Refuse; Household residual waste; recycling (NB Defra values for open-loop and closed-loop recycling are the same)	21.317 kg CO_2e / tonne waste	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No breakdown of types of recycled waste provided in the EMR dataset, so a generic value for municipal waste recycling is used here	Medium

II	Waste disposal: Composted	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Waste disposal; Refuse; Composting	10.204 kg CO_2e / tonne waste	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made, activity data taken from the EMR report.	Low
II	Waste disposal: anaerobic digestion	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Waste disposal; Refuse; anaerobic digestion	10.204 kg CO_2e / tonne waste	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made, activity data taken from the EMR report.	Low
II	Waste disposal: hazardous waste	GHG	EMR 2019-20	DEFRA / DBEIS GHG emissions factors (2020) - Waste disposal; Electrical items; batteries; open-loop	21.317 kg CO_2e / tonne waste	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No breakdown of hazardous waste types provided in the EMR dataset, so all hazardous waste was characterised using Defra CFs for batteries (NB the Defra waste factors do not include other types of hazardous waste)	Medium
II	Laboratory equipment & resources (supply chain)	GHG	HESCET Report 2020 Defra 311 sectors: - 6.1.1.3 Other medical products - 6.1.1.4 Non-optical appliances and equipment	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	*Kg CO_2e / £*	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	(1) Figures for CO_2e taken directly from the HESCET 2019-20 Report. However, the characterisation factors used in the HESCET report are outdated and results are reliant on accurate coding of university spend. In general, 'Laboratory equipment and resources' is a very broad category that encompasses GHG emissions from a large range of sources, some of which are questionable in how they have been calculated in the HESCET report. This is discussed in detail in section 2.2 of the main report 3) Note that a breakdown of individual Kyoto Protocol GHGs is not provided here but is available in the HESCET Report.	Very High
II	Paper (supply chain)	GHG	HESCET Report (2020) - 9.5.2 Diaries, address books, cards etc - 9.5.3 Cards, calendars, posters and other printed matter 9.5.5 Magazines and periodicals	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	Kg CO_2e / £	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	1) No assumptions made directly in this analysis, figures for CO_2e taken from the HESCET 2019-20 Report. However, the characterisation factors used in the HESCET report are outdated and results are reliant on accurate coding of university spend. No breakdown of recycled/virgin paper purchased was available. See main report (sections 2.2 and 3.5.6 for further discussion. 2) Note that a breakdown of individual Kyoto Protocol GHGs is not provided here but is available in the HESCET Report.	Very high

II	IT (supply chain)	GHG	HESCET Report (2020) Defra 311 sectors: - 9.3.2.1 Computer software and games cartridges - 9.1.2.7 Personal computers, printers and calculators - 5.5.5 Electrical consumables - 9.1.1.1 Audio equipment, CD players incl. in car - 9.1.1.2 Audio accessories e.g. tapes, CDs, headphones - 9.1.2.9 Repair of AV - 5.5.1 Electrical tools - 9.1.3.1 Photographic and cine equipment - 8.3.2 Telephone coin and other payments - 8.4 Internet subscription fees - 8.3.4 Mobile phone other payments - 9.1.2.8 Spare parts for TV, video, audio - 5.3.7 Small electric household appliances - 8.2.1 Telephone purchase - 8.2.2 Mobile phone purchase - 8.2.3 Answering machine, fax machine purchase - 8.3.1 Telephone account - 8.3.3 Mobile phone account - 9.1.2.1 Purchase of TV and digital decoder - 9.1.2.2 Satellite dish purchase and installation - 9.1.2.3 Cable TV connection - 9.1.2.4 Video recorder	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	*Kg CO_2e / £*	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	1) No assumptions made in this analysis, figures for CO_2e taken directly from the HESCET 2019-20 Report. However, the characterisation factors used in the HESCET report are outdated and results are reliant on accurate coding of university spend. See main report for further discussion (section 2.2) 2) Note that a breakdown of individual Kyoto Protocol GHGs is not provided here but is available in the HESCET Report.	Very high

			- 9.1.2.5 DVD player/recorder - 9.1.2.6 Blank, pre-recorded video cassettes and DVDs - 9.1.3.2 Camera films - 9.1.3.3 Optical instruments, binoculars, telescopes 9.3.2.2 Console computer games					
II	Business services	GHG	HESCET Report (2020) Defra 311 sectors: - 8.1 Postal services - 12.4.1.1 Structure insurance - 12.5.2.1 Bank building society fees - Gross fixed capital formation - 12.4.1.2 Contents insurance - 12.4.1.3 Insurance for household items - 12.4.2 Medical insurance premiums - 12.4.3.1 Vehicle insurance - 12.4.3.2 Boat insurance - 12.4.4 Non package holiday, other travel insurance - 12.5.1.2 Property transaction - purchase and sale - 12.5.1.3 Property transaction - sale only - 12.5.1.4 Property transaction - purchase only - 12.5.1.5 Property transaction - other payments - 12.5.2.2 Bank and post office counter charges - 12.5.2.3 Credit card fees - 12.5.3.1 Other professional fees - 12.5.3.2 Legal fees - 12.5.3.3 Funeral expenses	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	Kg CO_2e / £	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	No assumptions made in this analysis, figures for CO_2e taken directly from the HESCET 2019-20 Report. However, the characterisation factors used in the HESCET report are outdated and results are reliant on accurate coding of university spend. See main report for further discussion (section 2.2) Note that a breakdown of individual Kyoto Protocol GHGs is not provided here but is available in the HESCET Report.	Very high

			- 12.5.3.4 TU and professional organisations 12.5.3.5 Other payments for services					
II	Educational services	GHG	HESCET Report (2020) Education Defra 311 sectors: - 10.1 Education	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	Kg CO_2e / £	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	As above	Very high
II	Other goods & services	GHG	HESCET Report (2020) - 3.1.9.4 Protective head gear - 5.3.9 Rental/hire of major household appliances - 9.3.3 Equipment for sport, camping and open-air recreation - 11.2.3 Room hire - 9.3.5.1 Pet food - 12.5.1.1 Moving and storage of furniture - 4.2.4 Equipment hire, small materials - 3.1.11.1 Dry cleaners and dyeing - 3.1.11.2 Laundry, laundrettes - 3.1.1 Men's outer garments - 5.6.3.1 Domestic services including cleaners, gardeners, au pairs - 5.6.2.4 Pins, needles, tape measures, nails, nuts and bolts - 9.2.4 Musical instruments - 5.6.1.1 Detergents, washing-up liquid, washing powder - 6.2.1.3 Other services - 6.1.1.2 Medicines and medical goods (not NHS) - 11.2.1 Holiday in the UK - 11.2.2 Holiday abroad - 4.2.2 House maintenance	*2011 Defra / DECC's GHG Conversion Factors for Company Reporting*	Kg CO_2e / £	Global Warming - Terrestrial ecosystems Global Warming - Freshwater ecosystems	As above	High

			- 5.4.1 Glassware, china, pottery, cutlery and silverware - 9.2.3 Accessories for boats, horses, caravans and motorhomes - 7.2.4.5 Anti-freeze, battery water, cleaning materials - 5.4.4 Storage and other durable household articles - 5.5.4 Door, electrical and other fittings - 4.3.2 Other regular housing payments incl service charge for rent - 5.3.8 Spare parts for appliances and repairs - 4.3.1 Water charges - 4.3.3 Refuse collection including skip hire - 5.1.1.1 Furniture - 9.2.2 Purchase of caravans, mobile homes - 5.6.1.2 Disinfectants, polishes, other cleaning materials, some pest controls - 3.1.10 Haberdashery, clothing materials and clothing hire - 5.4.3 Repair of glassware, tableware and household utensils - 9.3.5.3 Veterinary and other services for pets - 9.2.6 Maintenance and repair or other major durables for recreation and culture - 6.2.1.1 NHS medical, optical, dental and medical auxiliary services - 5.6.3.3 Hire/repair of household furniture and furnishings - 9.4.2.2 Live entertainment, theatre, concerts, shows - 5.2.1 Bedroom textiles including duvets and pillows					

			- 5.3.2 Electric cookers, combined gas/electric cookers - 12.2.1.1 Jewellery clocks and watches and other personal effects - 5.6.2.2 Household hardware and appliances, matches - 5.3.6 Fire extinguishers - 9.4.2.3 Museums, zoological gardens, theme parks - 9.3.5.2 Pet purchase and accessories - 5.3.5 Other major electrical appliances e.g. dish washers, microwaves, vacuum cleaners, heaters -					
II	Purchasing Supply Chain (Operations and Research)	Air Pollution	Procurement Data 2019-20	*Various CFs which are embedded within the LCAIs that are compatible with Exiobase 3. For more detail, read Stadler et al, 2018.* *Life cycle impact assessment method: CML 2001*	Multiple CFs, as detailed in Stadler et al, 2018.	Acidification - Terrestrial ecosystems	See Section 2.2. for a full list of assumptions and limitations of using the procurement data and Exiobase 3 to analyse the mid-point impacts associated with procurement spend data.	Very High
II	Purchasing Supply Chain (Operations and Research)	Water Pollution	Procurement Data 2019-20	*Various CFs which are embedded within the LCAIs that are compatible with Exiobase 3. For more detail, read Stadler et al, 2018.* *Life cycle impact assessment methods: CML 2001*	Multiple CFs, as detailed in Stadler et al, 2018.	Eutrophication - Freshwater ecosystems Toxicity - Marine ecosystems Toxicity Aquatic ecosystems Toxicity – Terrestrial ecosystems	See Section 2.2. for a full list of assumptions and limitations of using the procurement data and Exiobase 3 to analyse the mid-point impacts associated with procurement spend data.	Very High

II	Purchasing Supply Chain (Operations and Research)	Land Use	Procurement Data 2019-20	*Various CFs which are embedded within the LCAIs that are compatible with Exiobase 3. For more detail, read Stadler et al, 2018.* *Life cycle impact assessment methods: Exiobase 3 (Other Impacts)*	Multiple CFs, as detailed in Stadler et al, 2018.	Land use - occupation	See Section 2.2. for a full list of assumptions and limitations of using the procurement data and Exiobase 3 to analyse the mid-point impacts associated with procurement spend data. The 'Exiobase – other impacts' metric used is land competition – which is occupied area*time. It does not specify what type of land is occupied, but the source of these land use impacts are specified by previous links in the supply chain. These are often agriculturally based, thus land use impacts from the CML 2001 LCIA are taken to be equivalent to land use for crops. This is assumption is required to calculate the end-point biodiversity impact for land occupation.	Very High
II	Purchasing Supply Chain (Operations and Research)	Water Use	Procurement Data 2019-20	*Various CFs which are embedded within the LCAIs that are compatible with Exiobase 3. For more detail, read Stadler et al, 2018.* *Life cycle impact assessment methods: Exiobase 3 (Other Impacts)*	Multiple CFs, as detailed in Stadler et al, 2018.	Water consumption - terrestrial ecosystems	See Section 2.2. for a full list of assumptions and limitations of using the procurement data and Exiobase 3 to analyse the mid-point impacts associated with procurement spend data. Mid-point impact values for water consumption are taken to be the sum of all blue and green water consumptions.	Very High

***Table 6**: summary of mid-point impact categories and metrics, and characterisation factors used to determine end-point impacts*

Mid-point impact	Pressure(s) on biodiversity	Metrics	ReCiPe CF for terrestrial ecosystems	ReCiPe CF for freshwater ecosystems	ReCiPe CF for marine ecosystems
GHG Emissions	Climate change	Mass of carbon dioxide equivalent (kg CO_2e)	2.80×10^{-09} species.year / kg CO_2 eq.	7.65×10^{-14} species.year / kg CO_2 eq.	n/a
Land Use	Habitat loss/ degradation	Area and type of land (m^2)	8.88×10^{-09} Species / m^2 annual crop eq.	n/a	n/a

Water Consumption	Reduction of freshwater availability; Reduced river discharge	Volume of water consumed (m^3)	1.35 x 10^{-08} species.year / m^3 consumed	6.04 x 10^{-13} species.year / m^3 consumed	n/a
Water Pollution	Eutrophication (freshwater, marine); Ecotoxicity (Terrestrial, Freshwater, Marine)	Mass and type of pollutant (kg P eq., N eq., or 1.4 DCB eq.)	1.14E-11 species.yr/kg 1,4-DBC emitted to industrial soil eq.	6.71 x 10^{-07} species.year / kg P to freshwater eq. 6.95 x 10^{-10} species.year / kg 1.4-DBC emitted to freshwater eq.	1.70 x 10^{-09} species.year / kg N to marine water eq. 1.05 x 10^{-10} species.year / kg 1.4-DBC emitted to sea water eq.
Air Pollution	Terrestrial acidification; Photochemical ozone formation	Mass and type of pollutant (kg SO_2 eq., kg NO_x eq.)	2.12 x 10^{-07} species.year / kg SO_2 eq. 1.29 x 10^{-07} species.year / kg NO_x eq.	n/a	n/a