Journal of Cleaner Production 315 (2021) 128019

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The environmental and social footprint of the university of the Basque Country UPV/EHU

G. Bueno [*], M. de Blas, E. Pérez-Iribarren, I. Zuazo, E. Torre-Pascual, A. Erauskin, I. Etxano, U. Tamayo, M. García, O. Akizu-Gardoki, I. León, C. Marieta, G. Zulueta, I. Barrio

University of the Basque Country UPV/EHU, Spain

ARTICLE INFO

Handling editor: Zhifu Mi

Keywords:
Organisation environmental footprint
Organisational life cycle assessment
O-LCA
Social life cycle assessment
S-LCA
Higher education institution
LCA

ABSTRACT

This work has calculated the organisational environmental and social footprint of the University of the Basque Country (UPV/EHU) in 2016. First, input and output data flows of the UPV/EHU activity were collected. Next, the environmental and social impacts of the academic activity were modelled, using the Ecoinvent 3.3 database with the PSILCA-based Soca v1 module in openLCA software. In order to evaluate the environmental impacts, CML and ReCiPe LCIA methods were used. The Social Impact Weighting Method was adjusted for the assessment of specific social impacts.

The modelling has identified some hotspots in the organisation. The contribution of transport (8,900 km per user, annually) is close to 60% in most of the environmental impacts considered. The life cycle of computers stands out among the impacts derived from the consumption of material products. More than half of environmental impacts are located outside the Basque Country. This work has also made it possible to estimate some of the impacts of the organisational social footprint, such as accidents at work, only some of which occur at the UPV/EHU. Traces of child labour and illiteracy have also been detected in the social footprint that supports the activity of the UPV/EHU. Some of the social and environmental impacts analysed are not directly generated by the UPV/EHU, but they all demand attention and co-responsibility.

Based on the modelling performed, this work explores alternative scenarios and recommends some improvement actions which may reduce (in some cases over 30%) the environmental and social impacts of the UPV/EHU's activity. These scenarios and improvement actions will feed a process with stakeholders in the UPV/EHU based on the Multi-criteria Decision Analysis (MCDA) methodology.

1. Introduction

The University of the Basque Country UPV/EHU is the public university of the Autonomous Community of the Basque Country, located on the northern coast of Spain. Its faculties and schools –around 30 centres– are distributed among three campuses, one for each of the three provinces of the Basque Country: the Campus of Araba (located in Vitoria-Gasteiz), the Campus of Bizkaia (Leioa, Bilbao, and Portugalete), and the Campus of Gipuzkoa (Donostia-San Sebastián and Eibar) (UPV/EHU, 2020a). In the 2016-17 academic year, 68 Bachelor's degrees, 111 Official postgraduate Master's courses, 65 PhD programmes, and 34 own qualifications were offered (UPV/EHU, 2020b).

The implementation of sustainable development in the daily work of higher education institutions is increasingly widespread (Caeiro et al., 2013; Lozano et al., 2015). The UPV/EHU, for its part, considers the 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs) set out by the UN General Assembly in September 2015 (UN, 2015) a route map to bring the university's work into line with the major challenges facing the planet and people, so that 'no one will be left behind' (Sáez de Cámara et al., 2021; UPV/EHU, 2019).

Given this context, it is essential that organisations have the tools to assess the consequences of their activity in different spheres, environmental issues being among the most important, although not the only ones. Whereas the standardisation of environmental management has had organisations in its sights from the beginning (Finkbeiner et al., 1998), the standardisation of life-cycle thinking (Mazzi, 2019) through ISO 14040 and ISO 14044 started by taking products and services as a reference (ISO, 2006a, 2006b), leaving the standardisation of organisational assessment for a later stage through ISO/TS 14072 (ISO, 2014).

---

* Corresponding author.
E-mail address: gorka.bueno@ehu.eus (G. Bueno).

https://doi.org/10.1016/j.jclepro.2021.128019
Received 29 September 2020; Received in revised form 31 May 2021; Accepted 17 June 2021

In fact, the extension of international standards with a life cycle perspective to other fields continues unabated (Toniolo et al., 2019). During the last decade two main different frameworks for the calculation of the organisational LCA have developed in parallel (Martínez-Blanco and Finkbeiner, 2018). At the same time as the UNEP/SETAC Life Cycle Initiative was pushing its 'Guidance on organizational LCA' (UNEP/SETAC, 2015), the European Commission published its 'Organisation Environmental Footprint (OEF) Guide' (Pelletier et al., 2012, 2014).

The organisation environmental footprint, or organisational LCA, is a multi-criteria measure of the environmental behaviour of an organisation that provides goods or services, according to the perspective of the entire life cycle (Ihobe, 2018). Its objective is to estimate the environmental impacts derived from the activity of an organisation, in order to improve its environmental performance (Martínez-Blanco et al., 2015a, 2015b, 2015b; Manzardo et al., 2016). This work has followed the recommendations provided by the European Commission and the UNEP/SETAC initiative. In recent years, there have been numerous organisations that have followed some type of procedure for the calculation of their OEF in the framework of the UNEP/SETAC Life Cycle Initiative, in sectors such as energy, finance, automotive, chemical, food and agriculture, cosmetic, municipalities, academic institutions and textile (Forin et al., 2019; Resta et al., 2016). There are also interesting case studies that apply the framework provided by the European Commission's OEF Guide in the beverage-packaging sector (Manzardo et al., 2016) and construction sectors (Neppach et al., 2017; Martinez et al., 2019). Applications to organisations in the service sector, however, are scarcer, such as in the hotel sector (Martínez-Blanco et al., 2016) or in an Institution of Higher Education (Lo-Iacono-Ferreira et al., 2017).

The literature includes some other case studies of Higher Education Institutions (HEI), but limited to some specific environmental categories. Lopes Silva et al. (2015) performed a combined Material Flow Analysis and LCA to calculate the impacts of the Autonomous University of Barcelona, using the ReCiPe-2008 LCIA method, concluding that 50% of impacts were caused by energy consumption and that 92% of the total normalised impact was related to the Climate Change Potential category, or the equivalent of 314.11 kg CO_2eq·cap^{-1}·year^{-1}, although commuting and other transport needs were not considered in the inventory. Lo-Iacono-Ferreira et al. (2017) provide for the EPSA (small HEI in Alcoy, Spain) an impact on Climate Change of 677.9 t CO_2eq·year^{-1}, but commuting of staff and students were not considered, either. Sinha et al. (2010) concluded that Greenhouse Gas (GHG) emissions from US HEIs accounted for 121 Mt CO_2eq in 2005, nearly 2% of the total annual national emissions in that year, or 7.67 t CO_2eq per full-time equivalent student; emissions from purchased electricity, stationary combustion and commuting accounted for approximately 88% of the total. In Scotland, the Higher Education sector emitted 316 Mt CO_2eq in 2007-08, although student and staff commuting was excluded from the inventory (EAUC-Scotland, 2016). Shields (2019) estimated the GHG emissions associated with global international student mobility in 2014 to be between 14.01 and 38.54 Mt CO_2eq. Most of the case studies on HEIs focus on carbon footprint (Alvarez et al., 2014; Gómez et al., 2016; Larsen et al., 2013; Norgate and Haque, 2012; Ozawa-Meida et al., 2013; Sippel et al., 2018; Townsend and Barrett, 2015; Ullah et al., 2020), but some others also cover energy and water footprints (Gu et al., 2019) or nitrogen footprint (Leach et al., 2013; Liang et al., 2018). Lang and Kennedy (2016) assessed, using the environmentally extended global multiregional input-output (EE GMRIO) approach, the global operational footprint of Higher Education for energy, carbon dioxide emissions, water, materials and land use.

Trying to fill these gaps, this work presents the organisational environmental and social footprint of the UPV/EHU, an institution of Higher Education, which despite being a sector with few case studies in the LCA field, is assumed to have a strong concern for sustainability (Amador and Padrel Oliveira, 2013). The study has been developed in the context of the EHU-Aztarna project, which involves a multidisciplinary team formed by teaching and research staff, administration and service staff and students of the UPV/EHU. This work describes the results obtained in the modelling for academic activities carried out in buildings of the UPV/EHU, used in 2016 by almost 97% of the academic community, considering various inflows and outflows, as well as the transportation needs of the academic community (students and workers). As a novelty, these results include not only the environmental impacts derived from the academic activity of the UPV/EHU, but also its social footprint. Social LCA is an expansion of the LCA framework, in order to assess social impacts related to products and services (Moltesen et al., 2018), and can also be applied to organisations (Martínez-Blanco et al., 2015c). This combination of social and organisational LCA was also pointed out by the Life Cycle Initiative in 2015 (UNEP/SETAC, 2015), and is now consolidated with the recent publication of the Guidelines for Social Life Cycle Assessment of Products and Organisations (Benoît et al., 2020). The European Commission's OEF Guide, on the other hand, does not integrate social LCA into its framework, for the time being.

Another novelty of this paper is the scope of the study when compared with similar studies in the literature. In this case, all phases of LCA methodology have been considered, including an approximate guess of the impacts due to building construction. Moreover, both environmental and social impacts have been evaluated. The remainder of the paper is organised as follows: Section 2 presents the methodology, where the goal and scope of the environmental and social footprint (Section 2.1), the compilation and quantification of the inventory (Section 2.2) and the modelling through openLCA (Section 2.3) are detailed. Section 3 presents and discusses the results, divided into environmental impacts (Section 3.1), social and economic impacts (Section 3.2) and a comparison of results (Section 3.3), preceding the conclusions (Section 4). Additional detail on primary and secondary data, methodology and results are presented in an accompanying "Data in Brief" article (Bueno et al., 2021).

2. Methodology

2.1. Goal and scope of the environmental and social footprint

The goal of the environmental and social footprint of the UPV/EHU –the reporting organisation– is (i) to monitor its performance for a reference year; (ii) to identify the environmental and social hotspots related to its academic activity; and (iii) to explore some alternative scenarios to reduce environmental impacts. Following the guidance proposed by the European Commission (Pelletier et al., 2012) and facilitated by Ihobe (2018), the modelling of the environmental and social impacts of the UPV/EHU has been carried out taking 2016 as a base year. Adding teaching and research staff, administration and service staff and students, the UPV/EHU had 46,813 users that year. Table 1 summarises the number of students, teaching and research staff, and administration and service staff at the UPV/EHU, divided by Campuses.

The scope of our model has covered the academic activity in buildings that were used by 45,306 users, accounting for 96.8% of total users

Table 1
Number of students, teaching and research staff, and administration and service staff at the UPV/EHU, 2016/17 academic year.

Campus	Students	Teaching and research staff	Admin and services staff	Total	Percentage (%)
Araba	7,163	979	254	8,396	17.9
Bizkaia	22,078	3,241	1,219	26,538	56.7
Gipuzkoa	10,119	1,376	384	11,879	25.4
Total	39,360	5,596	1,857	46,813	100.0
Percentage (%)	84.0	12.0	4.0	100.0	–

of the UPV/EHU. These buildings make up the reporting unit. The reporting flow is the academic activity performed in these buildings of the UPV/EHU in year 2016. Table 2 shows the users involved in each faculty, centre or building under management of the UPV/EHU. No faculty was excluded from the Araba Campus. In the Bizkaia and Gipuzkoa Campuses, Medicine Teaching Units were excluded, as they are based in University Hospitals whose direct management is not the responsibility of the UPV/EHU. They account for 2.5% of total users. The Faculty of Engineering (Navigation and Naval Machines), with 0.6% of total users, was also excluded. This building is located in Portugalete (Bizkaia), next to the Bilbao estuary but far away from the other buildings of the Faculty of Engineering of Bilbao, and with entirely independent management. Finally, the remaining entities managed by the UPV/EHU were excluded from the study, as they are isolated from other buildings and have less than 25 users: university residences on all three campuses and the Research Centre for Experimental Marine Biology & Biotechnology in Plentzia. Some other research units shared with other institutions and some isolated common infrastructures (Bizkaia Aretoa) have also been excluded, as the inventory phase presented serious problems in these centres from the point of view of data collection and allocation.

2.2. Inventory: quantification of input and output fluxes

In order to carry out the inventory, both consumption (electricity, fuels, main materials and products) and the generation of waste (urban waste, hazardous waste, electrical and electronic equipment waste, wastewater) have been taken into account. Some flows (electricity, gas, water, hazardous waste) have been systematically quantified. The rest have been estimated from the data provided by those agents responsible for maintenance, canteen and cleaning services or by the administrators of the UPV/EHU facilities, which, in some cases, are subject to Environmental Improvement Plans and quality processes. The year 2016 has been considered as the base year (calendar year: January–December), although for some flows it has been necessary to take the academic year as a unit (September 2016–August 2017), or later years.

Transportation needs derived from the academic activity at the UPV/EHU have also been considered in this work, as established by the European Commission Guide (Pelletier et al., 2012). For this, the data from a survey conducted by the Directorate of Sustainability of the UPV/EHU among the entire academic community in summer 2018 has been used (INGARTEK, 2018). Survey characteristics, questions and possible answers are detailed in the Data in Brief article (Bueno et al., 2021). The survey was answered by 2,966 students and 603 staff members, providing an error margin of 1.7% and 3.8%, respectively. The survey characterises the daily commuting of users to and from University centres (80% of total transport needs, measured in passenger-kilometres (pkm)), changes of residence at weekends (11% of total) and punctual displacements to meetings, conferences and so on (9%, with almost no contribution from students) (See Table 3).

Of total transport needs, 57.4% are satisfied by bus and coach, 22.2% by private car, 5.3% by aeroplane, 11.1% by other modes (mainly regional trains and metro) and 4.2% by walking, as shown in Fig. 1. Students' transport is much more efficient than staff transport. While 43.8% of staff transport (excluding aeroplane) are satisfied by private car with an average occupancy rate of 1.84 passengers, students reduce private car transport down to 16.6% of the total, in vehicles with a higher average occupancy rate of 2.05 passengers per car. As shown in the Data in Brief article, the use of public transport decreases with age, women use a little more public transport, more the bus and less the metro and bicycle than men. The modelling of transport needs at the UPV/EHU and their impacts is explored in more detail in another paper (Zuazo et al., 2021).

Table 4 summarises the concepts included in the inventory, and the strategy followed to collect the data for each item, at each campus/building. In the case of some specific flows such as electricity, natural

Table 2
Number of users and percentage of total users of the faculties, centres, and buildings under management of the UPV/EHU. Excluded entities are marked with an asterisk (*).

Faculty, centre or building, service	Users	Percentage of total users in UPV/EHU (%)
Campus of Araba		
Faculty of Engineering Vitoria-Gasteiz	939	2.01
Faculty of Business and Economics (Vitoria-Gasteiz)	511	1.09
Education and Sport Faculty (Physical Activity and Sport)	576	1.23
Education and Sport Faculty (Education)	1,125	2.40
Faculty of Pharmacy	1,706	3.64
Faculty of Arts	2,572	5.49
Faculty of Labour Relations and Social Work (Vitoria-Gasteiz)	593	1.27
Faculty of Medicine and Odontology (Teaching Unit Vitoria-Gasteiz)	266	0.57
Library	28	0.06
Vice-Chancellor of Araba Campus	28	0.06
Others Araba (<0.05%)	52	0.11
Campus of Bizkaia		
Faculty of Engineering (Higher Engineering)	3,335	7.12
Faculty of Engineering (Technical Engineering of Mines and Public Works)	598	1.28
Faculty of Engineering (Industrial Technical Engineering)	1,932	4.13
Faculty of Engineering (Navigation and Naval Machines)*	266	0.57
Faculty of Education - Bilbao	2,111	4.51
Faculty of Fine Arts	1,547	3.30
Faculty of Science and Technology	3,718	7.94
Faculty of Social and Communication Sciences	2,922	6.24
Faculty of Law. Bizkaia Section	718	1.53
Faculty of Business and Economics (Elkano)	1,086	2.32
Faculty of Business and Economics (Sarriko)	3,425	7.32
Faculty of Medicine and Nursing (Nursing Leioa)	766	1.64
Faculty of Medicine and Nursing (Medicine and Odontology)	1,957	4.18
Faculty of Labour Relations and Social Work (Leioa)	642	1.37
Faculty of Medicine and Odontology (Teaching Unit Basurto)*	408	0.87
Faculty of Medicine and Odontology (Teaching Unit Cruces)*	419	0.90
Architecture and Building Works	28	0.06
Management Computing Centre	34	0.07
Computer, Teaching, Research and Network Centre (Bizkaia)	41	0.09
Library building - Leioa	35	0.07
Academic Management	43	0.09
General Secretariat	27	0.06
Vice-Chancellor of Accounting and Budgeting	32	0.07
Vice-Chancellor of Management of Patrimony and Contracting	25	0.05
Vice-Chancellor of Staff	57	0.12
Vice-Rectorate for Undergraduate Studies and Innovation	29	0.06
Vice-Rectorate for Research	54	0.12
Other Bizkaia included (<0.05%)	249	0.53
Other Bizkaia excluded (<0.05%)*	34	0.07
Campus of Gipuzkoa		
Faculty of Engineering, Gipuzkoa (Donostia-San Sebastián)	1,537	3.28
Faculty of Engineering, Gipuzkoa (Eibar)	344	0.73
School of Architecture	920	1.97
Faculty of Chemistry	601	1.28
Faculty of Law	1,258	2.69
Faculty of Economics and Business (Donostia-San Sebastián)	1,161	2.48
Faculty of Education, Philosophy and Anthropology (Philosophy and Education Sciences)	1,548	3.31
Faculty of Education, Philosophy and Anthropology (Education)	1,182	2.52

(*continued on next page*)

Table 2 (*continued*)

Faculty, centre or building, service	Users	Percentage of total users in UPV/EHU (%)
Faculty of Computer Science	845	1.81
Faculty of Medicine and Nursing (Nursing - Donostia-San Sebastián)	558	1.19
Faculty of Psychology	1,335	2.85
Faculty of Medicine and Odontology (Teaching Unit Donostia-San Sebastián)*	342	0.73
Library	39	0.08
Carlos Santamaria Centre	46	0.10
Computer, Teaching, Research and Network Centre (Gipuzkoa)	32	0.07
Vice-Chancellor of Gipuzkoa Campus	39	0.08
Others Gipuzkoa, included (<0.05%)	54	0.12
Others Gipuzkoa, excluded (<0.05%)*	38	0.08
Total included	45,306	96.78
Total excluded*	1,507	3.22

Table 3
Distribution of total transport according to modes (% of pkm).

	Daily commuting	Change of residence at weekends	Punctual work displacements (meetings, conferences)
Students	61.6%	9.6%	–
Staff	19.4%	1.1%	8.3%

gas or water consumption, it was possible to collect data of the highest quality, through direct measurements. In other cases, the information was collected from the billing of supplies, i.e. that of diesel or paper consumption. Finally, some information was provided by the suppliers of the service to be inventoried. Such is the case of the collection of some waste fractions, i.e. hazardous waste, or residual waste derived to incineration.

Occasionally, individual interviews have been carried out with personnel in charge of some specific services at the university –for example, with those responsible for cleaning services in most centres, and staff in charge of canteens and cafeterias– in order to identify the different waste fractions collected in a year. As it has already been pointed out, a massive survey has also been carried out among UPV/EHU workers and students to determine their annual transportation needs. In some specific cases in which it has been impossible to obtain data on a specific flow in a given centre, projections have been made based on data from some other centre with similar characteristics and with better inventory quality. Finally, in some very specific cases, reasonable estimates had to be made. For instance, it has been assumed that the annual consumption of sanitary water is equivalent to the annual generation of wastewater; similarly, the demand for toner or fluorescent lamps has been calculated from the registered number of discarded units, assuming a replacement rate of 1:1. The activity of the canteens and cafeterias within the university has also been inventoried. In fact, for example, all the organic waste collected in 2016 came from them (21.8 tonnes, see Table 4). Other flows, such as the consumption of electricity, water and heating, are not recorded separately within the buildings, not allowing a segregated analysis.

Current regulations require organisations to provide some data, which makes it easier to complete inventories; for example, both the amount and type of hazardous waste produced at the UPV/EHU facilities need to be registered in order to manage them according to Law 22/2011 on waste and contaminated soils, which incorporated Directive 2008/98/EC on waste into Spanish national law (BOE, 2011). According to Law 4/2019 on Energy Sustainability of the Basque Autonomous Community (BOPV, 2019), it is compulsory for public administrations to carry out an inventory of existing buildings, vehicle fleet and public lighting installations within their scope of action (Article 11). Moreover, some faculties and centres of the UPV/EHU (e.g., Elkano and EIB-Bilbao) have already voluntarily implemented environmental management systems following the Ekoscan standard promoted by Ihobe (2004). This standard requires quantifying some consumption flows (white and recycled paper, toner, plastic cups, cleaning products, etc.) and waste (fluorescents, WEEE, paper and cardboard, etc.). In contrast, most flows are not systematically registered and their diverse typology and variability depending on the faculty, centre and building, makes it very

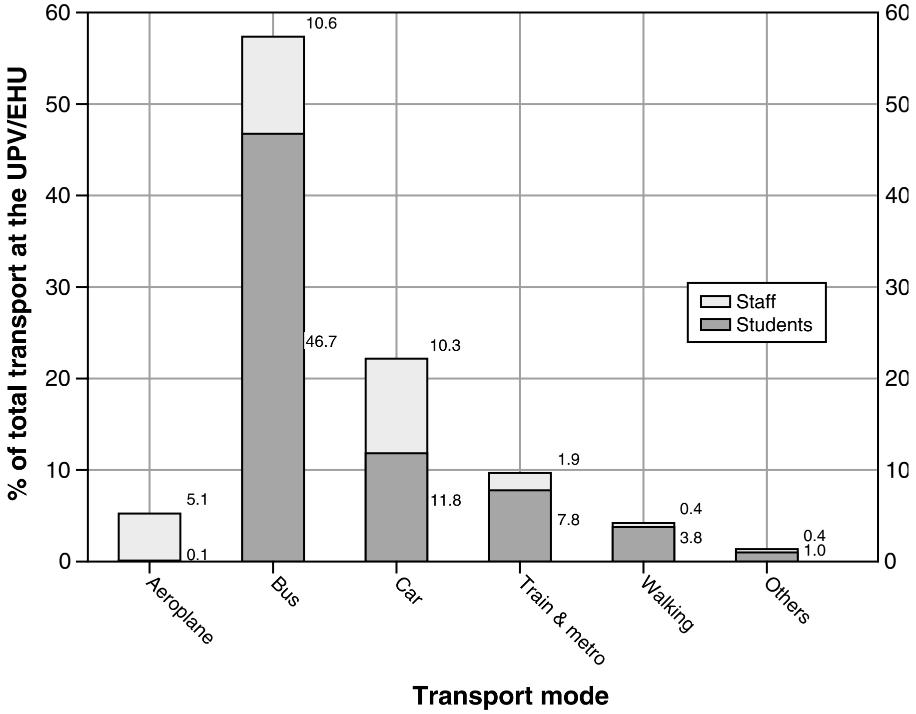

Fig. 1. Distribution of total transport for students and staff in different modes, according to passenger-kilometres (pkm) for each transport mode (other modes correspond to scooter, tram and bicycle).

Table 4
Inventory of flows of energy consumption, material consumption, waste generation and transportation that support the academic activity of the UPV/EHU in 2016; strategy followed to collect the data, when not obtained by direct measurement (^{B} Service provider/Bills, ^{S} Survey/Interviews, ^{P} Projection from other faculties, ^{G} Educated guess). All figures provided are considered significant.

Concept	Unit	Leioa	EIB-Bilbao	Sarriko	Elkano	Donostia-San Sebastián	Eibar	Vitoria-Gasteiz
Users	Person	15,024	5,865	3,441	1,086	11,879	344	8,396
Energy resources								
Electricity	MWh	15,989	4,204	1,019	168	7,400	100 ^{G}	5,074
Natural gas	MWh	14,192	1985	2,194	178	8,834	0	7,727
Gas-oil	L	0	113,694 ^{B}	0	0	90 ^{B}	39,000 ^{B}	0
Material resources								
Water supply	m^3	116,963	23,718	9,925	1,085	27,979	350 ^{G}	19,045
Paper	kg	55,022 ^{B}	29,702 ^{B}	8,738 ^{B}	1,263 ^{B}	18,939 ^{B}	323 ^{B}	13,183 ^{P}
Computers	Units	1,161 ^{G}	643 ^{G}	235 ^{G}	59 ^{G}	977 ^{G}	46 ^{G}	545 ^{G}
Batteries	kg	421.5 ^{B}	65.8 ^{B}	80 ^{B}	14 ^{B}	81 ^{B}	4 ^{G}	185 ^{B}
Fluorescent lamps	Units	10,623 ^{B}	2,400 ^{B}	260 ^{G}	38	500 ^{P}	200 ^{G}	200 ^{G}
Toners	Units	1,083 ^{G}	277 ^{G}	214 ^{G}	150 ^{G}	661 ^{G}	40 ^{G}	803 ^{G}
Waste treatment								
Hazardous waste	kg	23,138 ^{B}	6,176 ^{B}	0	0	25,616 ^{B}	0	9,718 ^{B}
Light packaging waste	kg	21,622 ^{B}	3,856 ^{S}	3,634 ^{S}	3,744 ^{S}	5,060 ^{S}	1,200 ^{G}	2,996 ^{S}
Paper waste	kg	134,200 ^{B}	9,855 ^{B}	13,909 ^{S}	4,368 ^{B}	48,182 ^{B}	400 ^{G}	16,754 ^{P}
Glass waste	kg	2,171 ^{B}	300 ^{S}	300 ^{S}	0	621 ^{S}	0	1,647 ^{S}
Organic waste	kg	0	0	0	0	20,330 ^{S}	0	1,488 ^{S}
Residual waste	kg	222,000	60,613 ^{S}	50,504 ^{S}	12,480 ^{S}	19,534 ^{P}	4,000 ^{G}	80,126 ^{P}
WEEE	kg	10,704 ^{B}	3,500 ^{B}	1,907 ^{B}	900 ^{B}	2,352 ^{B}	3,000 ^{G}	2,080 ^{B}
Toner waste	Units	1,083 ^{B}	277 ^{B}	214 ^{B}	150 ^{B}	661 ^{B}	40 ^{B}	803 ^{B}
Fluorescent waste	kg	3,400 ^{G}	768 ^{G}	83 ^{B}	12 ^{G}	160 ^{G}	64 ^{G}	64 ^{B}
Sanitary wastewater	m^3	116,963 ^{G}	23,718 ^{G}	9,925 ^{G}	1,085 ^{G}	27,979 ^{G}	35 ^{G} 0	19,045 ^{G}
Transport								
Transport needs	× 10^6 p·km	141.16 ^{S}	42.12 ^{S}	23.87 ^{S}	7.28 ^{S}	101.03 ^{S}	3.14 ^{S}	84.87 ^{S}

difficult to quantify them. Since unregistered fluxes may not be included in the inventory, environmental and social impacts may be underestimated. Hence, in the future, similar model sheets to those used in this work should be used in order to register data flows in each faculty, centre or building in a normalised and systematic way.

Table 5
Environmental impacts derived from the academic activity of the UPV/EHU, for each of the categories of CML and ReCiPe environmental assessment methods.

Method	Impact category	Unit	Impact	Impact/ user
CML	Terrestrial ecotoxicity	kg 1.4-dichlorobenzene eq	$2.54{\cdot}10^5$	5.52
	Ozone layer depletion	kg CFC-11 eq	8.88	$1.93{\cdot}10^{-4}$
	Climate change*	t CO_2 eq	$5.60{\cdot}10^4$	1.22
	Photochemical oxidation - high NO_x*	kg ethylene eq	$1.19{\cdot}10^4$	0.258
	Acidification potential	kg SO_2 eq	$2.57{\cdot}10^5$	5.57
	Eutrophication	kg PO_4^{3-} eq	$7.31{\cdot}10^4$	1.59
	Marine aquatic ecotoxicity	kg 1.4-dichlorobenzene eq	$1.20{\cdot}10^{11}$	$2.62{\cdot}10^6$
	Depletion of abiotic resources - fossil fuels	GJ	$7.57{\cdot}10^5$	16.4
	Human toxicity*	t 1.4-dichlorobenzene eq	$3.31{\cdot}10^4$	0.720
	Depletion of abiotic resources - elements, ultimate reserves*	kg antimony eq	446	$9.69{\cdot}10^{-3}$
	Freshwater aquatic ecotoxicity*	t 1.4-dichlorobenzene eq	$2.97{\cdot}10^4$	0.645
ReCiPe	Human Health*	DALY (Disability Adjusted Life Year)	118	$2.56{\cdot}10^{-3}$
	Resources*	$	$3.22{\cdot}10^6$	70.0
	Ecosystems*	species·yr	0.569	$1.24{\cdot}10^{-5}$

2.3. Modelling through openLCA

The modelling of the environmental and social impacts derived from the activity of the UPV/EHU was carried out with the openLCA free software (Ciroth, 2007) and the Ecoinvent 3.3 database (Wernet et al., 2016), using the Cut-Off approach for system modelling, according to which the producer of a recyclable material does not receive any credit (Steubing et al., 2016). The modelling of the processes that give rise to each of the inventoried flows have been selected from among the processes available in Ecoinvent, making the appropriate adjustments to adapt them to the context of the UPV/EHU (electricity mix, efficiencies of combustion equipment, location). More information regarding the modelling of transport modes can be found in the Data in Brief article (Bueno et al., 2021).

Following the recommendation provided by UNEP/SETAC (2015), environmental impacts have been estimated using the CML (Baseline) (Guinée et al., 2001) and ReCiPe (Huijbregts et al., 2017) impact assessment methods. The CML methodology is a midpoint methodology (classification and characterisation) that considers eleven significant impact categories including, for example, global warming potential, reduction of non-renewable abiotic resources, human toxicity and photochemical oxidation (Section 3.1, Table 5). The ReCiPe methodology contemplates three endpoint categories (normalisation and weighting; in this study the Hierarchical perspective has been used), which shows the impact on three levels of aggregation: effects on human health, biodiversity and resource scarcity (Section 3.1, Table 5).

The social impact assessment was carried out using the Social Impact Weighting Method provided by the Soca module (Eisfeldt, 2017). This module incorporates into the Ecoinvent database for openLCA the social impact information from the PSILCA database (Ciroth and Eisfeldt, 2016), which in turn covers 53 social indicators for almost 15,000 industrial sectors and goods in 189 countries. This module allows S-LCA and E-LCA (Social and Environmental Life Cycle Assessments) to be combined with LCC (Life Cycle Costing). The activity variable considered for the calculation of social impacts is the “hours of work” in each of the modelled processes and in the work activity of the UPV/EHU. The results of the modelling of social impacts are provided in the form of “risk hours” according to different levels (from non-existent to very high risk), which require further processing and the appropriate interpretation. Among the 53 available indicators, grouped into four categories (local community, society, value chain and workers), seven significant indicators have been selected. Some of them are related to the direct social impact of the academic activity (fatal and non-fatal accidents, economic costs), while others are related to the socioeconomic context that supports the academic activity (indirect social impacts; see Table 9, Section 3.2). The social impacts of labour activity at the UPV/EHU have been modelled by adjusting the indicators available in Soca for Spain to the context of the Autonomous Community of the Basque Country, and assuming an annual workday of 1,500 h and the average labour cost taken from the annual budgets of the UPV/EHU for 2016.

3. Results and discussion

3.1. Environmental impacts

Table 5 shows the impacts of the academic activity at the UPV/EHU in the midpoint impact categories of the CML (Baseline) method and in the endpoint categories of the ReCiPe method. The eight categories indicated with an asterisk (*) have been subjected to a more detailed analysis, breaking them down according to the nature of the processes involved, as well as the geographical location of the impacts (Figs. 2 and 3). In order to have a reference of these impacts, Table 8 below shows the annual life-cycle impacts of a set of multi-storey buildings (Ecoinvent dataset) with the same constructed area as in the UPV/EHU.

Environmental impacts by campus and faculty follow proportions similar to those of the number of users, with deviations related mainly to the specific characteristics of transport and waste treatment in each location.

Fig. 2 shows the relative contribution of transport, energy consumption, consumption of material products and the generation of waste and its treatment in each of the eight selected impact categories (* in Table 5). The satisfaction of transportation needs is the most significant subprocess considered, as it gives rise to almost 60% of the total impact in ReCiPe endpoint categories, and between 37 and 63% in the selected CML midpoint categories.

The impact category of *depletion of abiotic resources-elements* is dominated by subprocesses related to the consumption of materials (54.2%, mainly the consumption of the Information and Communications Technology infrastructure, ICT), followed by transport needs (43.9%, half of which is due to private car life-cycles; in fact, on the Vitoria-Gasteiz campus, the impact of transport is even slightly higher than that of ICT) and residual contributions for energy consumption and waste treatment (less than 2%). The most important contributor to the impact category of *freshwater aquatic ecotoxicity* is waste treatment (42.6%; the direct incineration without any pretreatment of 222 tonnes of residual waste collected in the Leioa campus accounts for 31% of total impacts), followed by transport (36.6%; mostly private car transport). Energy consumption is also significant in the *climate change* (39.3%) and *photochemical oxidation* (35.1%) categories; electricity-related impacts (34.0 GWh) are higher than those linked to natural gas (35.1 GWh), as just 43.3% of electricity consumed at the UPV/EHU in 2016 was of renewable origin (36.4% from fossil fuels and 20.3% of nuclear origin) (CNMC, 2017). Energy contributions to *human toxicity* (16%) and *freshwater aquatic ecotoxicity* (12%) are less significant, but not negligible. The subprocesses with the least contribution are consumption of materials (2.4–14.3%, depending on impact; except in *depletion of abiotic resources-elements*, where its contribution is 54.2%) and waste treatment (less than 1.2%, except in *freshwater aquatic ecotoxicity*, with a contribution of 42.6%, and in *human toxicity*, with 6.5%).

In the three endpoint categories of ReCiPe (*human health*, *resources* and *ecosystems*, Fig. 2), transport shows a similar contribution of almost 60%, the contribution of energy consumption stands at around 36%, that of material consumption is around 5% and that linked to waste treatment is less than 1%.

Fig. 3 shows the analysis of the location of the environmental impacts derived from the academic activity of the UPV/EHU. These have been grouped as they are located inside the Basque Country, outside the Basque Country, or in locations not defined according to the available information. No impact in the category of *depletion of resources-elements* is explicitly located within the Basque Country. Only a small part of the

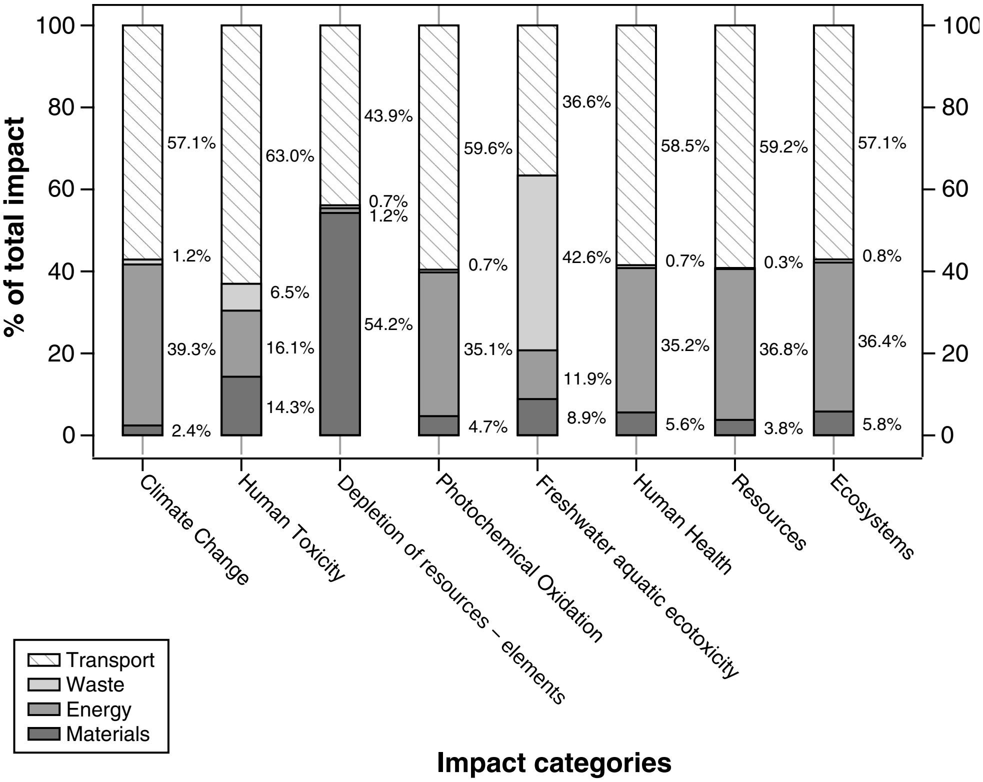

Fig. 2. Relative contribution of transportation, energy and material consumption and waste treatment to selected environmental impact categories, derived from the academic activity of the UPV/EHU.

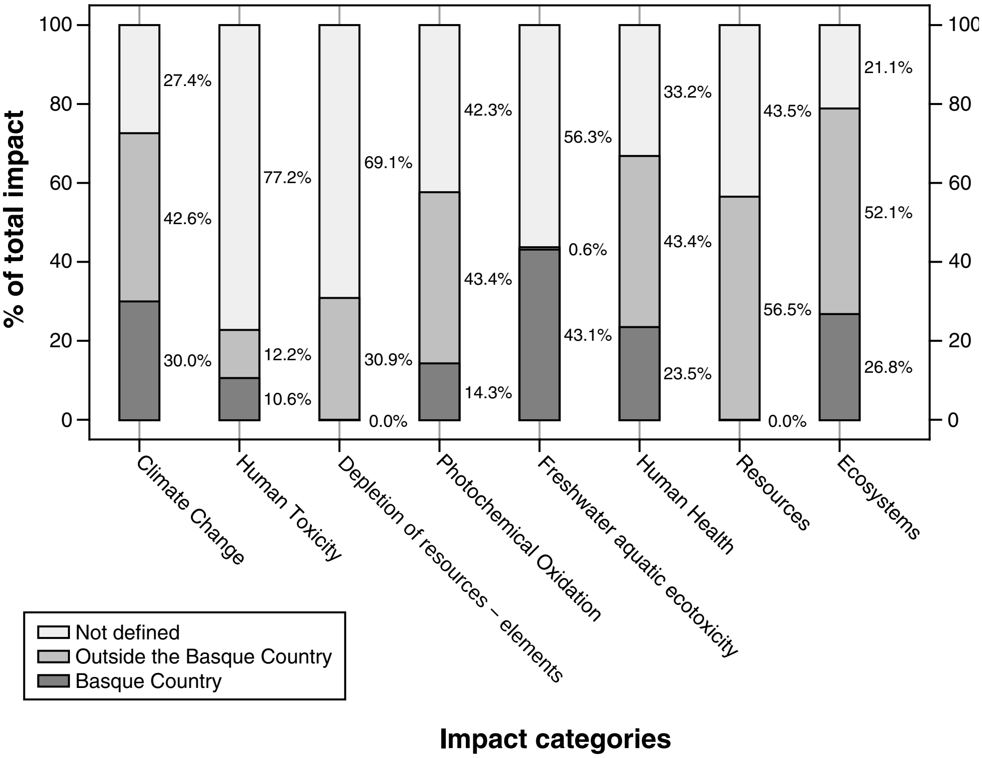

Fig. 3. Location of the environmental impacts derived from the academic activity of the UPV/EHU, for selected environmental impact categories.

impacts are located in the Basque Country in the categories of *human toxicity* (10.6%; predominantly waste incineration and private car driving) and *photochemical oxidation* (14.3%; essentially due to transport). Local impacts on *climate change* (30.0%) are largely due to transport, followed by natural gas consumption for heat and hot water supply. Local impacts on *freshwater aquatic ecotoxicity* (43.1%) are almost completely due to waste incineration. The impacts explicitly located outside the Basque Country, according to category, represent from 0.6% in *freshwater aquatic ecotoxicity* to 42.6% in *climate change* and 43.4% in *photochemical oxidation*, being primarily due to transport and electricity supply in both categories. Regarding impacts located abroad, in the *human toxicity* category (12.2%) they are mainly linked to energy supply, while those under *depletion of resources-elements* (30.9%) are overwhelmingly related to the consumption of precious materials needed for the ICT infrastructure. The endpoint categories of the ReCiPe method reveal an explicitly foreign contribution of impacts of between 43.4% (*human health*) and 56.5% (*resources*).

Finally, due to the uncertainty associated with the methodology itself, there are impacts whose location is not defined, with a contribution varying between 21.1% (*ecosystems*) and 77.2% (*human toxicity*) of the total, as some important subprocesses in the Ecoinvent database are modelled for a geographic scope that covers a much broader territory than the Basque Country: Global (World), Europe, Western Europe, and others. Such is the case of the treatment of sulfidic tailing, produced in mining (Nehdi and Tariq, 2007), and in ferrochromium production (Schulte and Tuck, 2020), mainly for stainless steel production –both located not in the Basque Country, but modelled as global processes in Ecoinvent–, which account for 14% and 13% respectively of total *human toxicity* impacts; or the case of gold, zinc and lead production (Althaus and Classen, 2005; Norgate and Haque, 2012), which globally account for 53% of total *depletion of abiotic resources-elements* and are modelled in Ecoinvent as global (lead, zinc) or as world excluding main producers (RoW, for gold) but should be considered as impacts located outside the Basque Country, as there is no mining of these materials there.

Most of the impacts associated with the consumption of materials derive from the renovation of computer equipment, and are much larger than the impacts derived from paper consumption or sanitary water consumption. The energy consumption demanded by cloud services and the computing infrastructure in the UPV/EHU accounts for 9.6% of all electricity consumption at the UPV/EHU (see calculation in Table 6). This percentage is higher than values registered for other areas. Shehabi et al. (2016) report that data centres in USA would be responsible for 2.1% of final electricity consumption in 2017, and Cho and Ko (2018) estimate that data centres worldwide accounted in 2017 for up to 3% of all global electricity consumption. Furthermore, the ICT sector in EU-25 accounted for 8% of electricity consumption in 2005 (Beton et al., 2008). The environmental impacts derived from the renewal of the ICT infrastructure represent the most important contribution among those related to the supply of materials. As shown in Table 4, the inventory carried out has counted 18,609 desktop computers, 6,793 laptops and 269 servers. Based on the rates of equipment renewal observed in some centres, our model considered that computers have an average lifetime of 7 years, and computer displays of 14 years. The supply of these products gives rise to significant environmental impacts, which in the case of the *depletion of abiotic resources-elements* category accounts for 54.3% of total impacts at the UPV/EHU.

Modelling of scenarios. Once the main sub-processes that support the academic activity of the UPV/EHU have been inventoried and modelled, the modification of specific parameters of the model allows us to explore other possible scenarios in order to reduce environmental impacts. Five scenarios have been explored: Scenario A, in which the lifespan of computer equipment is extended by two years; Scenario B, where electricity supplied to the UPV/EHU is of 100% renewable origin; Scenario C, in which a change in transport habits transfers half of the transport made by private car to bus and coach; Scenario D, where natural gas and gas-oil boilers used for thermal energy production are replaced by air-source heat pumps, which use R134a as the working fluid and have a seasonal coefficient of operation of 4; and Scenario E, in which Scenario B and Scenario D are combined. Table 7 summarises the changes in impact categories in these scenarios. Impact values are gathered in the Data in Brief article accompanying this manuscript (Bueno et al., 2021).

Table 6
Inventory of the Information and Communication Technology (ICT) infrastructure and its electricity consumption at the UPV/EHU.

	Network Switches	Personal Computers	Laptops	Peripherals	Servers	TOTAL
Units	1,091	18,609	6,793	4,691	269	
Consumption (W/unit)	5	5	5	5	800	
Consumption (MWh)	47.8	815.1	297.5	205.5	1,885.2	3,251.1

Although technological development may require, in some specific cases, the renewal of computer equipment regardless of its age, lengthening the years of use seems viable in many other cases, such as: computer screens, teaching equipment in computer classrooms, or administrative workplaces that require office automation tasks. Extending the lifespan of computer equipment by two years would reduce *depletion of abiotic resources-elements* by 10.6%, *eutrophication* by 2.6% and *human toxicity* by 2.7%.

Consuming 100% renewable electricity would reduce *climate change* by 19.2%, *ozone layer depletion* by 16.9%, *photochemical oxidation* by 23.5% and *acidification potential* by 29.4%. However, a greater demand of renewable technology would also increase *depletion of abiotic resources-elements* by 0.6% and *terrestrial ecotoxicity* by 2.4%.

A change in transport habits that involves the transfer of half of the transport made by private car to bus or coach would reduce the impact on *human toxicity* by 19.4% and the *depletion of abiotic resources-elements* by 18.5%. *Freshwater aquatic ecotoxicity* would be reduced by 12.6% and *terrestrial ecotoxicity* by 15.0%. Other possible scenarios related to transport are explored in more detail in Zuazo et al. (2021).

The replacement of diesel or natural gas boilers by air-source heat pumps for heat production would reduce *depletion of abiotic resources-fossil fuels* by 16.5%, *ozone layer depletion* by 12.1%, *climate change* by 11.4% and *photochemical oxidation* by 0.7%. On the other hand, greater non-renewable electricity production would increase *eutrophication* (3.8%), *acidification* (3.7%), *human toxicity* (2.8%), *marine aquatic ecotoxicity* (2.5%) and *freshwater aquatic ecotoxicity* (2.2%). These impact categories could be reduced by using 100% renewable electricity, as shown in Scenario E. The combination of Scenarios B and D would reduce *depletion of abiotic resources-fossil fuels* by 37.9%, *climate change* by 35.0%, *acidification potential* by 33.1% and *ozone layer depletion* by 32.8%. As aforementioned, a greater consumption of renewable electricity would imply an increase in *depletion of abiotic resources-elements* of 2.2% and in *terrestrial ecotoxicity* of 6.0%.

Impacts related to building construction. The construction and maintenance of UPV/EHU buildings are indirectly attributable upstream activities to be considered within the system under assessment (Pelletier et al., 2012). Our work, however, has not included in the inventory the input and output flows related to the construction and maintenance of the UPV/EHU buildings, in line with some other case studies (Lo-Iacono-Ferreira et al., 2017; Resta et al., 2016). This is a clear limitation that requires a justification, or at least an estimation of the resulting error. It seems that the construction and sometimes even the maintenance of buildings tends to be systematically excluded from the systems under assessment, surely under the assumption that long life-spans tend to minimise their contribution, but also due to the extreme difficulty involved in an adequate inventory compilation in this aspect. As a reference, Martínez-Blanco et al. (2016) provide useful information about the OEF assessment performed by the French hotel group Accor in 2011, in which the construction and renovation of hotel building structures and building materials were included within the system boundaries. In that work, the construction and renovation of buildings accounted for 4.5% of total energy use and climate change categories; 0.15% of total water consumption; and 67% of total waste generation. Therefore, it might seem that the error made could be less than 10% in energy-related impact categories, and only significant in waste-related impact categories. In order to verify whether this exclusion is justified, we have made a rough estimate of the impacts not considered, following an alternative strategy.

According to the data provided by the UPV/EHU, the buildings used by the 45,306 students and workers considered in this work add up to a total constructed area of 727,727 m^2. Assuming an average height of 3 m, this equates to a total constructed volume of $2.18 \cdot 10^6$ m^3. As an approximation of the environmental impacts linked to this built surface, we have taken as a reference the Ecoinvent 3.3 dataset for the construction of a multi-storey building in Europe (RER), which considers for its inventory the combination of two concrete buildings, one built in 1927 and the other in 1972, and assumes the life of the constructions to be 80 years. The buildings of the UPV/EHU have an age, averaged across the constructed area, of 20 years in the Araba campus, 17 years in the Gipuzkoa campus and an average of 28 years in the Bizkaia campuses.

Table 7
Percentage change in impact categories in relation to 2016 context, for five scenarios: A, computer equipment lifespan extended; B, electricity 100% of renewable origin; C, half of the transport by private car moves to bus and coach; D, thermal demand provided by heat pumps; E, thermal demand provided by heat pumps and electricity of 100% renewable origin.

Method	Impact category	A computer lifespan extended Δ%	B electricity 100% renewable Δ%	C transport from car to bus/coach Δ%	D heat production by heat pumps Δ%	E heat production by heat pumps 100% renew. Δ%
CML	Terrestrial ecotoxicity	−1.84	+2.42	−15.0	+2.87	+5.97
	Ozone layer depletion	−0.51	−16.9	−3.73	−12.1	−32.8
	Climate change	−0.73	−19.2	−5.02	−11.4	−35.1
	Photochemical oxidation - high NO_x	−0.90	−23.5	−6.05	−0.67	−30.1
	Acidification potential	−0.65	−29.4	−0.35	+3.68	−33.1
	Eutrophication	−2.58	−19.2	−2.21	+3.75	−20.3
	Marine aquatic ecotoxicity	−1.63	−12.5	−4.32	+2.53	−13.2
	Depletion of abiotic resources - fossil fuels	−0.70	−17.5	−5.31	−16.5	−37.9
	Human toxicity	−2.65	−8.36	−19.36	+2.79	−7.63
	Depletion of abiotic resources - elements, ultimate reserves	−10.6	+0.56	−18.5	+1.48	+2.19
	Freshwater aquatic ecotoxicity	−1.65	−6.41	−12.6	+2.22	−5.81
ReCiPe	Human Health	−1.19	−20.0	−4.60	−6.36	−31.2
	Resources	−1.02	−16.0	−6.38	−15.1	−34.7
	Ecosystems	−0.84	−10.3	−5.45	−8.28	−20.9

Table 8 gathers the annual impacts of a construction (total life-cycle impacts divided by 80 years), for the CML and ReCiPe impact categories, with the same built volume as that of our system for the multi-storey Ecoinvent dataset, and as a percentage of the total global impacts provided by our modelling for the UPV/EHU in the reference year.

Although not specifically inventoried, environmental impacts related to building construction and maintenance could vary widely from less than 12% of total estimation for some categories (*climate change*, 11.5%; *depletion of fossil fuels*, 10.5%; *ozone layer depletion*, 5.3%) to more than 100% for other categories (*human toxicity*, 203%; *ecosystems-ReCiPe*, 159%). Although long life-spans have to be considered for the calculation of environmental impacts for buildings on an annual basis, the construction of a new infrastructure should not be ignored for the calculation of OEF. Much effort will have to be put into sustainable construction.

3.2. Social and economic impacts

This section describes the assessment of social impacts estimated from the results provided by openLCA (Ciroth, 2007) and Soca/PSILCA (Eisfeldt, 2017; Ciroth and Eisfeldt, 2016). The methodology used for the social impact of the UPV/EHU is explained in more detail in another paper (Erauskin-Tolosa et al., 2021). The Social Impact Weighting Method provides 53 social impact categories. This work focuses on seven social impact categories, which are listed in Table 9 along with their corresponding numerical value, a brief explanation of the category and the value of reference for them in the Basque Country. Information related to all indicators provided by the Social Impact Weighting Method are gathered in the Data in Brief article accompanying this manuscript (Bueno et al., 2021).

Table 8
Annual CML and ReCiPe life-cycle impacts of a set of multi-storey buildings (Ecoinvent dataset) with the same constructed area as in the UPV/EHU, as a percentage of the total global impacts provided by our modelling for the UPV/EHU.

Method	Impact category	Unit	Annual impact of buildings	Annual impact of buildings as percentage of estimated impacts in 2016
CML	Terrestrial ecotoxicity	kg 1.4-dichloro-benzene eq	$2.43 \cdot 10^4$	95.5%
	Ozone layer depletion	kg CFC-11 eq	0.467	5.3%
	Climate change	t CO_2 eq	$6.44 \cdot 10^3$	11.5%
	Photochemical oxidation - high NO_x	kg ethylene eq	$5.87 \cdot 10^3$	49.4%
	Acidification potential	kg SO_2 eq	$1.25 \cdot 10^5$	48.8%
	Eutrophication	kg PO_4^{3-} eq	$7.15 \cdot 10^4$	97.9%
	Marine aquatic ecotoxicity	kg 1.4-dichloro-benzene eq	$9.02 \cdot 10^{10}$	74.9%
	Depletion of abiotic resources - fossil fuels	GJ	$7.98 \cdot 10^4$	10.5%
	Human toxicity	t 1.4-dichlorobenzene eq	$6.74 \cdot 10^4$	203%
	Depletion of abiotic resources - elements, ultimate reserves	kg antimony eq	429	96.2%
	Freshwater aquatic ecotoxicity	t 1.4-dichlorobenzene eq	$1.95 \cdot 10^4$	65.7%
ReCiPe	Human Health	DALY (Disability Adjusted Life Year)	55.2	46.9%
	Resources	$	$9.06 \cdot 10^5$	28.1%
	Ecosystems	species·yr	0.903	159%

The socio-economic activity that supports the academic activity of the UPV/EHU gives rise to direct social impacts, such as workplace accidents. According to our estimation, 147 *work-related accidents* and 0.75 *fatal accidents* (a rate of three deaths every four years) would have been related to the UPV/EHU academic activity in 2016. In addition, Soca and openLCA, following the methodology proposed and used by Moreau and Weidema (2015) for environmental Life Cycle Costing (LCC), also allow for the assessment of the costs of the UPV/EHU's academic activities throughout its life cycle. According to these authors, the life cycle cost is the sum of the added value generated throughout the life cycle, which for our case study amounts to 314 M€. This amount is 22% lower than the UPV/EHU's annual budget in 2016, which was 403 M€ (UPV/EHU, 2020c). This difference is due to the fact that a number of relatively immaterial services, such as financial services or software licences, are not considered in our inventory but also incur costs; there are also activities that have been excluded from the inventory, such as building maintenance, which incur significant costs. Conversely, the LCC integrates a valuation of user transport costs, which is outside the university's annual budget.

This methodology also allows us to characterise the socioeconomic context that supports the academic activity of the UPV/EHU through impact categories that we label as indirect. To this end, it is relevant to compare the result provided by the model with the value of reference in the closest context; in this case, the Basque Country. While *child labour* is non-existent in the Basque Country, it would rise to 2.8% in the context of the socioeconomic activity that supports the UPV/EHU, and which extends far beyond the Basque Country. A similar trend is observed with *illiteracy*. Although very low in the Basque Country (0.36%), it would reach almost 6% in the socioeconomic context that supports the academic activity of the UPV/EHU. The subjective perception of *pollution*, measured by the *Numbeo* index, would also rise from 32 points in the Basque Country up to 52 points in the context supporting the UPV/EHU.

The methodology used also allows for a disaggregated analysis of social impacts. As in the analysis of environmental impacts, some social impact categories have been subjected to a more detailed analysis, breaking them down according to the nature of the processes involved (contributions from transportation, energy consumption, material consumption, waste treatment and labour activity at the UPV/EHU) and to the geographical location of the impacts (located in the Basque Country, outside of the Basque Country and in undefined locations). Results are gathered in Figs. 4 and 5; the analysis is extended to eleven indicators in the Data in Brief article accompanying this manuscript (Bueno et al., 2021).

As shown in Fig. 4, work activity at the UPV/EHU has a significant weight in the social impact categories analysed. UPV/EHU labour costs constitute more than 93% of the total estimated costs. In work-related accidents, the weight of labour activity at the UPV/EHU is also very significant; above 75%. The satisfaction of transportation needs accounts for almost 16% of total non-fatal accidents. In the case of fatal accidents, the weight of the UPV/EHU falls below 30% and transport-related accidents exceed 42%, while the satisfaction of energy and material needs remains in the range of 13–15%. It should be noted that these data do not include traffic accidents, except in cases of professional labour activity in the transport sector.

With regard to the location of the social impacts, Fig. 5 shows that more than 22% of work-related accidents linked to UPV/EHU activity are likely to be linked to socioeconomic activities outside the University, and surely also outside the Basque Country, to a great extent. In the case of fatal accidents, almost 68% would be linked to activities outside the University.

3.3. Impact comparison and future work

Table 10 shows a comparison of some of the environmental and social impacts linked to the UPV/EHU with other regional or global

Table 9
Social impacts derived from the academic activity of the UPV/EHU for selected categories. Impact categories labelled as direct imply a direct social impact of academic activity (e.g. work-related accidents), while categories labelled as indirect characterise the socio-economic context that supports the activity under assessment (e.g. child labour, perception of pollution).

Social impact categories		Value in UPV/EHU (life-cycle perspective)	Value of reference in the Basque Country	Description
Illiteracy	Indirect	5.8%	0.36%	Average percentage of population over 15 years of age who cannot read or write correctly
Pollution level	Indirect	51.6	32.0	*Numbeo* index (average of subjective perception of pollution, 0–100)
Gender wage gap	Indirect	23.3%	24.3%	Percentage of the wage gap between men and women
Child labour	Indirect	2.8%	0.0%	Average percentage of minors between 7 and 14 years old who carry out at least 1 h of work activity per week
Fatal accidents	Direct	0.75	2.19 #/yr·100000 empl. ([a])	Annual rate of fatal accidents
Non-fatal accidents	Direct	147	1719 #/yr·100000 empl. ([a])	Annual rate of non-fatal accidents
Costs	Direct	$314 \cdot 10^6$ €	–	Annual costs

[a] (EUSTAT, 2020).

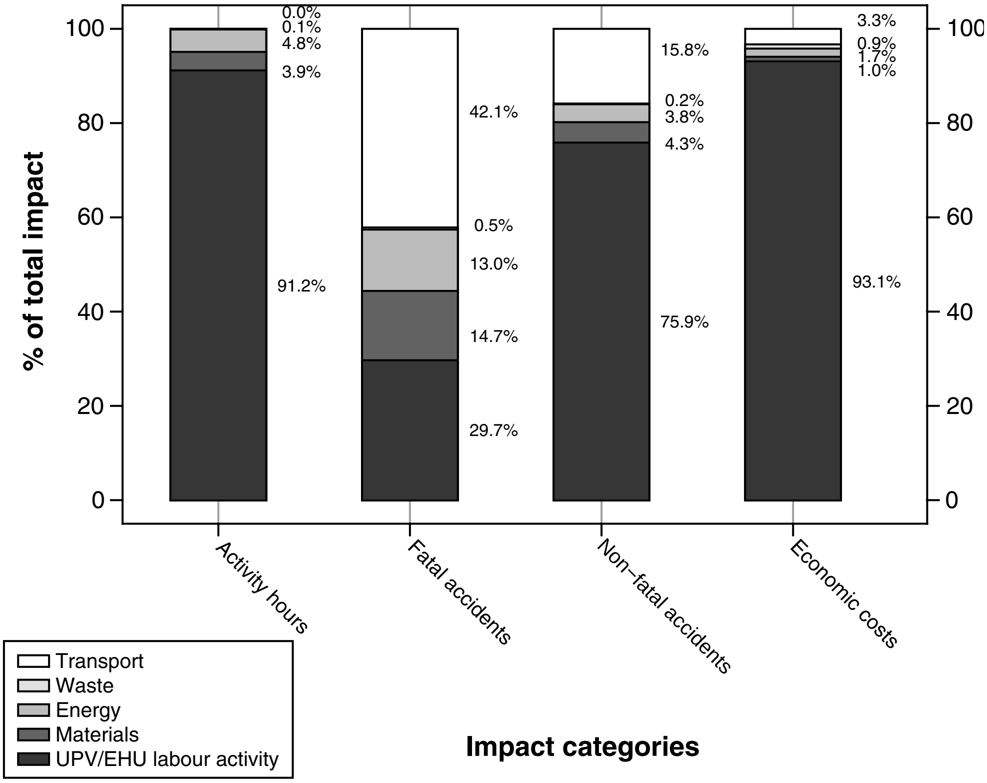

Fig. 4. Relative contribution of work activity at the UPV/EHU, transportation, energy consumption, material consumption and waste treatment linked to the academic activity of the UPV/EHU to selected social impact categories.

benchmarks that may serve as a reference. The impact on *climate change* of the UPV/EHU activity in the reference year (2016) was 1.22 t CO_2eq/user, or 14.2% of GHG emissions per capita in the Basque Country (8.57 t CO_2eq/cap); the *depletion of fossil fuels* was 16.4 GJ/user, or 13.6% of primary energy supply in the Basque Country (120.3 GJ/cap); the *depletion of ultimate reserves of element materials* was 9.6 g Sb eq per user, or 1.2% of global abiotic depletion potential (818 g Sb eq/cap); the impact on *human health* was 2.54 DALY per thousand user, below 1% of world disease derived from injuries and diseases (400 DALY per thousand person in 2011); the impact on *ecosystems* was a temporal diversity loss of 0.569 species·yr, while the background rate of biodiversity loss due to complete extinction is estimated at 3.6 species annually lost worldwide, and the average rate of vertebrate species loss over the last century is estimated at 360 species annually. In relation to social impacts, our analysis shows that there may be traces of *child labour* and *illiteracy* in the socioeconomic context that supports the academic activity of the UPV/EHU. This is because part of the processes involved in the supply chain of energy, materials and transport services to the UPV/EHU are located in countries with these serious social problems. In any case, despite being able to make an approximation as to their quantification, it is difficult to determine the location of such social impacts, which occur far beyond the geographical scope of the UPV/EHU. Consequently, all these social impacts are clearly not internalised by the direct economic cost paid by the users and society for university services.

These social and environmental impacts are not negligible, but they seem to be moderate, as would be expected from the service activity of a HEI, in comparison with the impacts linked to the average societal activity in a developed region or the world. For some categories, these impacts are also higher than those provided by the O-LCA study of the

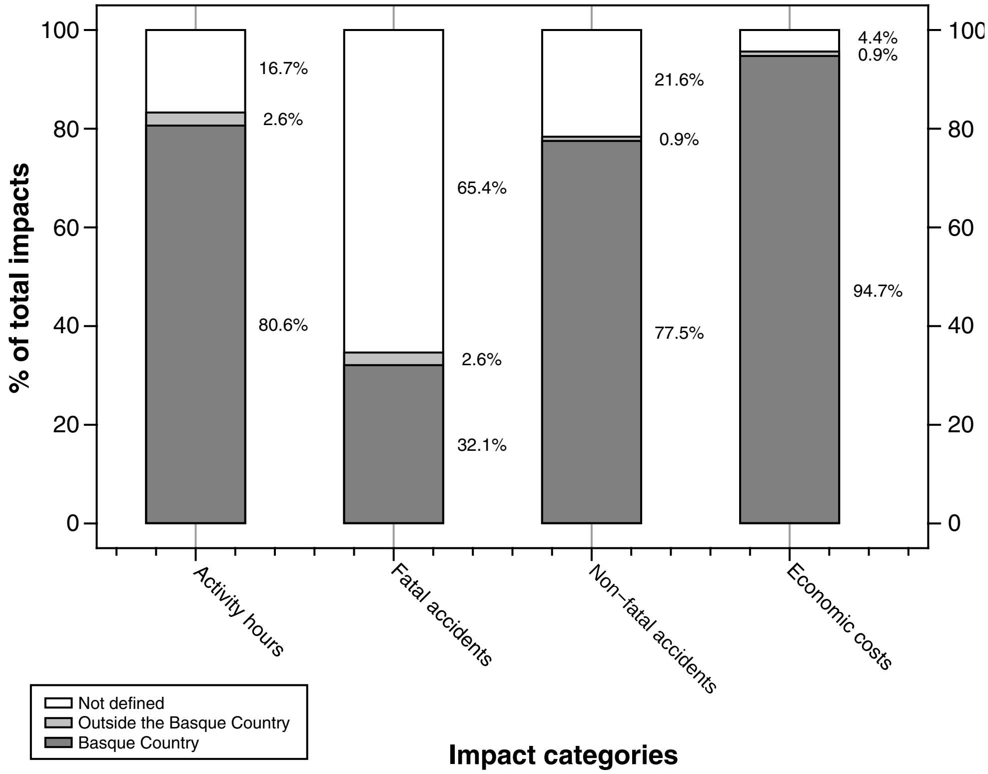

Fig. 5. Location of the social impacts linked to the academic activity of the UPV/EHU, for selected categories.

Faculty of Science and Technology (UPH, Indonesia), when compared in per user terms: 67% higher in the *climate change* category, 129% higher in *eutrophication*, and 50% higher in *depletion of fossil fuels* (Martínez-Blanco et al., 2017). At this point in time, however, it is difficult to compare these impacts with those of other organisations, mainly due to the insufficient standardisation in the procedures. The development of Organisation Environmental Footprint Sector Rules (OEFSR) for HEIs, in the framework of the European Commission's Environmental Footprinting initiative, will undoubtedly be of great help (Pelletier et al., 2012). Until then, ISO/TS 14072 states that O-LCA shall not be used for comparative assertions (Martínez-Blanco et al., 2015), but "to drive improvement in the given organization" (ISO, 2014).

In that sense, we believe that the most useful and interesting comparisons provided by this work are those that are made within the system under study itself, through the disaggregated analysis by subprocesses, in order to detect hotspots in the functioning of the organisation, and through scenario analysis, so that studies such as this can be used to implement specific policies to reduce environmental and social impacts linked to the life cycle of the academic activity. Actually, this work will continue with an assessment of possible future scenarios (i.e. extending the lifespan of ICT infrastructure, transferring journeys from private cars to public transport, installing fossil-free heating and cooling systems) that, focusing on the hotspots detected through the disaggregated analysis, will allow us to devise concrete action measures associated with those scenarios. This task is already being carried out by means of the Multi-criteria Decision Analysis (MCDA) methodology (see Figueira et al., 2016; Doumpos et al., 2019) and with the participation of the stakeholders involved in the management of the UPV/EHU. Results are expected in the near future.

4. Conclusions

In this study, data collection and the evaluation of environmental and social impacts derived from the academic activity of the University of the Basque Country UPV/EHU have been presented in detail. Although this work is focused on a specific case study, we truly believe that both the proposed methodology and the set of conclusions could be applied to other academic institutions and organisations.

The results provided by the environmental footprint of the UPV/EHU indicate that the contribution of transport is very significant and close to 60% in most of the environmental impacts considered, while energy consumption, materials consumption and waste treatment present smaller contributions. A very relevant part of these impacts was located outside the Basque Country. Regarding social impacts, the contribution of labour activity at the UPV/EHU stands out. For that reason, social impacts are mainly located in the Basque Country. But the life cycle of the academic activity also includes socioeconomic activities abroad, and this has led to the detection of traces of *child labour* and *illiteracy* in the social footprint of the UPV/EHU.

The calculation of the organisational footprint is a powerful tool to evaluate possible measures aimed at reducing the environmental and social impacts of the academic activity, and can be helpful in moving towards sustainability. There seem to be a wide variety of measures of a very varied nature that may bring about significant reductions of environmental and social impacts, not only in the Basque Country, but also abroad. These measures should include a shift to renewable energy sources and renewable electric air conditioning (*ozone layer depletion*, *climate change*, *photochemical oxidation* and *acidification potential* may be reduced by more than 30%); the lengthening of the useful lifespan of computer equipment (*depletion of abiotic resources-elements* may reduce by 10% with a two-year extension); improving separate collection of residues to increase recycling and composting and to avoid waste incineration; modal shift from private car to public transportation (*human toxicity* may reduce by almost 20% if half of private car transport moves to bus and coach).

This work shows the margin for improvement still existing at the UPV/EHU in order for it to become a more sustainable university. The implementation of concrete measures needs an in-depth analysis that will be addressed in the future by means of the MCDA methodology and with the participation of stakeholders involved in the management of

Table 10
Comparison of the UPV/EHU's impacts in some environmental and social categories with other global or regional benchmarks. Environmental results are also shown in terms per user (UPV/EHU) and per capita (global/region).

Impact category	Impact for UPV/EHU	Impact reference
Ozone layer depletion	8.88 kg CFC-11 eq (0.192 g CFC-11 eq/user)	Global CFC-11 emissions in 2019: $52{\cdot}10^6$ kg CFC-11 (6.78 g CFC-11/cap) Montzka et al. (2021)
Climate change	56.0 kt CO_2eq (1.22 t CO_2eq/user)	GHG emissions in ACBC (2016): 8.57 t CO_2eq/cap (Ihobe, 2020)
Acidification potential	$2.57{\cdot}10^5$ kg SO_2 eq (5.55 kg SO_2 eq/user)	Global SO_2 emissions in 2006: 100 Tg SO_2 (15.4 kg SO_2 eq/cap) (Lee et al., 2011)
Eutrophication	$7.31{\cdot}10^4$ kg PO_4^{3-} eq (1.54 kg PO_4^{3-} eq/user)	Global P transport to ocean in 2000: 9 Tg P (4.51 kg PO_4^{3-} eq/cap) (Beusen et al., 2016)
Depletion of abiotic resources - fossil fuels	757 TJ (16.4 GJ/user)	Primary energy supply in ACBC (2016): 120.3 GJ/cap (EVE, 2017)
Depletion of abiotic resources - elements, ultimate reserves	446 kg Sb eq (9.6 g Sb eq/user)	Global abiotic depletion potential in 2016: 818 g Sb eq/cap (Van Oers et al., 2020)
Freshwater aquatic ecotoxicity	$2.97{\cdot}10^4$ kg 1.4-DB eq (0.645 kg 1.4-DB eq/user)	Impact from the urban metabolism of the city of London in year 2000, in per capita terms: 35.2 kg 1.4-DB eq/cap (Goldstein et al., 2013)
Human Health	118 DALY (2.54 DALY/thousand user)	World disease burdens measured in DALY per thousand person in 2011, derived from injuries and diseases: 400 DALY (Gao et al., 2015)
Ecosystems	0.569 species·yr (temporal biodiversity loss)	Background rate of biodiversity loss due to complete extinction: 2 E/MSY or 3.6 species annually lost worldwide; average rate of vertebrate species loss over the last century: 360 species annually (Ceballos et al., 2015)
Illiteracy	5.8%	Percentage of population over 15 years of age who cannot read or write correctly in ACBC: 0.36% (Erauskin-Tolosa et al., 2021)
Child labour	2.8%	Percentage of minors between 7 and 14 years old who carry out at least 1 h of work activity per week in Spain: 0.0% (Erauskin-Tolosa et al., 2021)
Fatal accidents	10 accidents/yr·100000 employees	Annual rate of fatal accidents in ACBC: 2.19 accidents/yr·100000 empl. (Erauskin-Tolosa et al., 2021)
Non-fatal accidents	1963 accidents/yr·100000 employees	Annual rate of non-fatal accidents in ACBC: 1719 accidents/yr·100000 empl. (Erauskin-Tolosa et al., 2021)

the UPV/EHU, but here we outline some of them as follows, differentiated according to the areas studied:

- Transport: (i) work/study one day a week from home, thus reducing the presence at the faculties; (ii) encourage greater use of ICT for meetings, seminars, classes, etc. Both measures would lead to higher electricity consumption due to the increased use of ICTs, which should be compensated by reduced mobility.
- Energy: (i) prioritising power supply from renewable sources in buildings (actually, these are the conditions of contract at the UPV/EHU since 2018); (ii) insisting on the adoption of measures to reduce electricity and gas consumption by faculties, implementing environmental management plans at all the centres; (iii) installing systems of electricity self-consumption by faculties (e.g., by means of photovoltaic systems); (iv) restoration of the envelope of buildings, replacement of gas-oil or natural gas boilers by air source heat pumps, LED light replacement and lighting control systems.
- Materials: (i) establishment of environmental and social clauses for suppliers (e.g., in the acquisition of computer equipment, ensuring that their materials come from conflict free areas); (ii) measures to extend the useful lifespan of computers (periodic control, technical updates, maintenance, etc.); (iii) greater coordination between university bodies when supplying computers to users.
- Waste: (i) to encourage the separate collection of all municipal waste fractions; (ii) to promote the composting of organic food waste within the UPV/EHU; (iii) to completely avoid the incineration of waste collected without separation, as is currently the case on the Leioa campus.

All these specific measures must be complemented, on the one hand, with significant improvements in the methodology for collecting inventory data on the different flows in a normalised and systematic way, and on the other hand, with information and awareness campaigns for university managers, staff and students.

CRediT authorship contribution statement

G. Bueno: Conceptualization, Methodology, Writing – original draft, Investigation. **M. de Blas:** Methodology, Writing – review & editing, Investigation. **E. Pérez-Iribarren:** Methodology, Writing – review & editing, Investigation. **I. Zuazo:** Methodology, Writing – review & editing, Investigation. **E. Torre-Pascual:** Methodology, Writing – review & editing, Investigation. **A. Erauskin:** Methodology, Writing – review & editing, Investigation. **I. Etxano:** Writing – review & editing, Investigation. **U. Tamayo:** Writing – review & editing, Investigation. **M. García:** Investigation. **O. Akizu-Gardoki:** Investigation. **I. León:** Investigation. **C. Marieta:** Investigation. **G. Zulueta:** Investigation. **I. Barrio:** Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

To the Sustainability Directorate and the Educational Advisory Service, both belonging to the Vice-Chancellor's Office for Innovation, Social Commitment and Social Action of the University of the Basque Country UPV/EHU, in the context of the Campus Bizia Lab programme (2017/18, 18/19 and 19/20 calls) for the financing of the EHU-Aztarna project.

This research has also been supported by 'Ekopol: Iraunkortasunerako Bideak' research group, recognised by the Basque Government (IT-1365-19) and the University of the Basque Country UPV/EHU (GIC-18/22).

References

Althaus, H.J., Classen, M., 2005. Life cycle inventories of metals and methodological aspects of inventorying material resources in ecoinvent. Int. J. Life Cycle Assess. 10, 43–49. https://doi.org/10.1065/lca2004.11.181.5.

Alvarez, S., Blanquer, M., Rubio, A., 2014. Carbon footprint using the compound method based on financial accounts. The case of the school of forestry engineering. Tech. Univ. Madrid. J. Clean. Prod. 66, 224–232. https://doi.org/10.1016/j.jclepro.2013.11.050.

Amador, F., Padrel Oliveira, C., 2013. Integrating sustainability into the university: past, present, and future. In: Sustainability Assessment Tools in Higher Education Institutions: Mapping Trends and Good Practices Around the World. Springer International Publishing, pp. 65–78. https://doi.org/10.1007/978-3-319-02375-5_4.

Benoît, C., Traverso, M., Neugebauer, S., Ekener, E., Schaubroeck, T., Russo Garrido, S., Berger, M., Valdivia, S., Lehmann, A., Finkbeiner, M., Arcese, G., 2020. Guidelines for Social Life Cycle Assessment of Products and Organisations 2020.

Beusen, A.H.W., Bouwman, A.F., Van Beek, L.P.H., Mogollón, J.M., Middelburg, J.J., 2016. Global riverine N and P transport to ocean increased during the 20th century despite increased retention along the aquatic continuum. Biogeosciences 13, 2441–2451. https://doi.org/10.5194/bg-13-2441-2016.

Beton, A., Des Abbayes, C., Iyama, S., Stobbe, L., Gallehr, S., Scheidt, L.G., 2008. Impacts of Information and Communication Technologies on Energy Efficiency.

BOE, 2011. Ley 22/2011, de 28 de julio, de residuos y suelos contaminados [WWW Document]. URL. https://www.boe.es/diario_boe/txt.php?id=BOE-A-2011-13046, 6.1.20.

BOPV, 2019. LEY 4/2019, de 21 de febrero, de Sostenibilidad Energética de la Comunidad Autónoma Vasca [WWW Document]. URL. http://www.euskadi.eus/bopv2/datos/2019/02/1901087a.pdf, 6.1.20.

Bueno, G., de Blas, M., Pérez-Iribarren, E., Zuazo, I., Torre-Pascual, E., Erauskin, A., Etxano, I., Tamayo, U., García, M., Akizu-Gardoki, O., León, I., Marieta, C., Saez de Cámara, E., Zulueta, G., Barrio, I., 2021. Dataset on the Environmental and Social Footprint of the University of the Basque Country UPV/EHU. Data Br. Manuscript submitted for publication.

Caeiro, S., Azeiteiro, U.M., Filho, W.L., Jabbour, C., 2013. Sustainability assessment tools in higher education institutions: mapping trends and good practices around the world. In: Sustainability Assessment Tools in Higher Education Institutions: Mapping Trends and Good Practices Around the World. Springer International Publishing. https://doi.org/10.1007/978-3-319-02375-5.

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M., Palmer, T.M., 2015. Accelerated modern human-induced species losses: entering the sixth mass extinction. Sci. Adv. 1, e1400253 https://doi.org/10.1126/sciadv.1400253.

Cho, Y., Ko, Y.M., 2018. Energy efficiency of data center operating practices: server clustering, powering on/off, and bang-bang control. Networks 71, 107–119. https://doi.org/10.1002/net.21752.

Ciroth, A., 2007. ICT for environment in life cycle applications openLCA - a new open source software for Life Cycle Assessment. Int. J. Life Cycle Assess. 12, 209–210. https://doi.org/10.1065/lca2007.06.337.

Ciroth, A., Eisfeldt, F., 2016. PSILCA - a product social impact life cycle assessment database, database version 1. https://www.openlca.org/wp-content/uploads/2016/08/PSILCA_documentation_v1.1.pdf.

CNMC, 2017. GDO/DE/001/17 - RESUMEN DE LOS RESULTADOS DEL SISTEMA DE GARANTÍA DE ORIGEN Y ETIQUETADO DE LA ELECTRICIDAD RELATIVOS A LA ENERGÍA PRODUCIDA EN EL AÑO 2016. CNMC [WWW Document]. https://www.cnmc.es/expedientes/gdode00117, 6.1.20.

Doumpos, M., Figueira, J.R., Greco, S., Zopounidis, C. (Eds.), 2019. New Perspectives in Multiple Criteria Decision Making, Multiple Criteria Decision Making. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-11482-4.

EAUC-Scotland, 2016. Summary Report on Scottish Further and Higher Education Carbon Emissions 2014-15.

Eisfeldt, F., 2017. Soca v.1 Add-On – Adding Social Impact Information to Ecoinvent.

Erauskin-Tolosa, A., Etxano, I., Bueno, G., Tamayo, U., García, M., de Blas, M., Pérez-Iribarren, E., Zuazo, I., Torre-Pascual, E., Akizu-Gardoki, O., 2021. Social organisational LCA for the academic activity of the University of the Basque Country UPV/EHU. Int. J. Life Cycle Assess.. In press.

EUSTAT, 2020. Survey on the population in relation to activity [WWW Document]. URL. https://en.eustat.eus/estadisticas/tema_57/opt_1/temas.html, 5.14.20.

EVE, 2017. Euskadi energia 2016 - EVE [WWW Document]. URL. https://www.eve.eus/Publicaciones/Datos-Energeticos/Euskadi-Energia-2016.aspx?lang=es-ES, 5.18.21.

Figueira, J.R., Greco, S., Ehrogott, M., 2016. Multiple Criteria Decision Analysis, International Series in Operations Research & Management Science. Springer New York, New York, NY. https://doi.org/10.1007/978-1-4939-3094-4.

Finkbeiner, M., Wiedemann, M., Saur, K., 1998. A comprehensive approach towards product and organisation related Environmental Management tools: life Cycle Assessment (iso 14040) and environmental management systems (iso 14001). Int. J. Life Cycle Assess. 3, 169–178. https://doi.org/10.1007/BF02978825.

Forin, S., Martínez-Blanco, J., Finkbeiner, M., 2019. Facts and figures from road testing the guidance on organizational life cycle assessment. Int. J. Life Cycle Assess. 24, 866–880. https://doi.org/10.1007/s11367-018-1533-x.

Gao, T., Wang, X.C., Chen, R., Ngo, H.H., Guo, W., 2015. Disability adjusted life year (DALY): a useful tool for quantitative assessment of environmental pollution. Sci. Total Environ. 511, 268–287.

Goldstein, B., Birkved, M., Quitzau, M.B., Hauschild, M., 2013. Quantification of urban metabolism through coupling with the life cycle assessment framework: concept development and case study. Environ. Res. Lett. 8, 035024 https://doi.org/10.1088/1748-9326/8/3/03502410.1016/j.scitotenv.2014.11.048.

Gómez, N., Cadarso, M.Á., Monsalve, F., 2016. Carbon footprint of a university in a multiregional model: the case of the University of Castilla-La Mancha. J. Clean. Prod. 138, 119–130. https://doi.org/10.1016/j.jclepro.2016.06.009.

Gu, Y., Wang, H., Xu, J., Wang, Y., Wang, X., Robinson, Z.P., Li, F., Wu, J., Tan, J., Zhi, X., 2019. Quantification of interlinked environmental footprints on a sustainable university campus: a nexus analysis perspective. Appl. Energy 246, 65–76. https://doi.org/10.1016/j.apenergy.2019.04.015.

Guinée, J., Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, A., 2001. Life Cycle Assessment: an Operational Guide to the ISO Standards. Final Report.

Huijbregts, M., Steinmann, Z., Elshout, P., Stam, G., Verones, F., Vieira, M., Hollander, A., Zijp, M., van Zelm, R., 2017. ReCiPe 2016 A harmonized life cycle impact assessment method at midpoint and endpoint level Report I: Characterization. Rijksinstituut voor Volksgezondheid en Milieu RIVM.

Ihobe, 2018. GUÍA METODOLÓGICA PARA LA APLICACIÓN DE LA HUELLA AMBIENTAL CORPORATIVA.

Ihobe, 2004. Ekoscan standard [WWW document]. URL. https://www.ihobe.eus/Publicaciones/Ficha.aspx?IdMenu=97801056-CD1F-4503-BAFA-F54FA80D9A44&Cod=B9D45C36-0C9A-4A7E-86FC-DF4BF059D7A5&Idioma=en-GB, 6.1.20.

Ihobe, 2020. Greenhouse gas emissions inventory of the Basque Country 2018. Executive summary [WWW Document]. URL. https://www.euskadi.eus/contenidos/documentacion/inventarios_gei/es_pub/adjuntos/2018.pdf, 5.18.21.

INGARTEK, 2018. Diagnóstico de movilidad de la UPV/EHU - sostenibilidad - UPV/EHU.

ISO, 2014. ISO/TS 14072:2014 Environmental Management — Life Cycle Assessment — Requirements and Guidelines for Organizational Life Cycle Assessment.

ISO, 2006a. ISO 14040: environmental management—life cycle assessment—principles and framework.

ISO, 2006b. ISO 14044: Environmental Management—Life Cycle Assessment—Requirements and Guidelines.

Lang, T., Kennedy, C., 2016. Assessing the global operational footprint of higher education with environmentally extended global multiregional input-output models. J. Ind. Ecol. 20, 462–471. https://doi.org/10.1111/jiec.12396.

Larsen, H.N., Pettersen, J., Solli, C., Hertwich, E.G., 2013. Investigating the carbon footprint of a university - the case of NTNU. In: Journal of Cleaner Production. Elsevier Ltd, pp. 39–47. https://doi.org/10.1016/j.jclepro.2011.10.007.

Leach, A.M., Majidi, A.N., Galloway, J.N., Greene, A.J., 2013. Toward institutional sustainability: a nitrogen footprint model for a university. Sustain. J. Rec. 6, 211–219. https://doi.org/10.1089/SUS.2013.9852.

Lee, C., Martin, R.V., Van Donkelaar, A., Lee, H., Dickerson, R.R., Hains, J.C., Krotkov, N., Richter, A., Vinnikov, K., Schwab, J.J., 2011. SO2 emissions and lifetimes: estimates from inverse modeling using in situ and global, space-based (SCIAMACHY and OMI) observations. J. Geophys. Res. Atmos. 116, 6304. https://doi.org/10.1029/2010JD014758.

Liang, X., Ng, E.L., Lam, S.K., Castner, E.A., Leach, A.M., Gu, B., Healey, G., Galloway, J. N., Chen, D., 2018. The nitrogen footprint for an Australian university: institutional change for corporate sustainability. J. Clean. Prod. 197, 534–541. https://doi.org/10.1016/j.jclepro.2018.06.050.

Lo-Iacono-Ferreira, V.G., Torregrosa-López, J.I., Capuz-Rizo, S.F., 2017. Organizational life cycle assessment: suitability for higher education institutions with environmental management systems. Int. J. Life Cycle Assess. 22, 1928–1943. https://doi.org/10.1007/s11367-017-1289-8.

Lopes Silva, D.A., De Oliveira, J.A., Saavedra, Y.M.B., Ometto, A.R., Rieradevall I Pons, J., Gabarrell Durany, X., 2015. Combined MFA and LCA approach to evaluate the metabolism of service polygons: a case study on a university campus. Resour. Conserv. Recycl. 94, 157–168. https://doi.org/10.1016/j.resconrec.2014.11.001.

Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F.J., Waas, T., Lambrechts, W., Lukman, R., Hugé, J., 2015. A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey. J. Clean. Prod. 108, 1–18. https://doi.org/10.1016/J.JCLEPRO.2014.09.048.

Manzardo, A., Loss, A., Mazzi, A., Scipioni, A., 2016. Organization life-cycle assessment (OLCA): methodological issues and case studies in the beverage-packaging sector. In: Environmental Footprints and Eco-Design of Products and Processes. Springer, pp. 47–73. https://doi.org/10.1007/978-981-287-913-4_3.

Martínez-Blanco, J., Finkbeiner, M., 2018. Organisational LCA. In: Life Cycle Assessment. Springer International Publishing, Cham, pp. 481–498. https://doi.org/10.1007/978-3-319-56475-3_20.

Martínez-Blanco, J., Finkbeiner, M., Inaba, A., 2015a. Guidance on Organizational Life Cycle Assessment.

Martínez-Blanco, J., Forin, S., Finkbeiner, M., Inaba, A., 2017. Road Testing Organizational Life Cycle Assessment Around the World. Applications, Experiences and Lessons Learned.

Martínez-Blanco, J., Inaba, A., Finkbeiner, M., 2016. Life Cycle Assessment of Organizations. Springer, Dordrecht, pp. 333–394. https://doi.org/10.1007/978-94-017-7610-3_8.

Martínez-Blanco, J., Inaba, A., Finkbeiner, M., 2015b. Scoping organizational LCA—challenges and solutions. Int. J. Life Cycle Assess. 20, 829–841. https://doi.org/10.1007/s11367-015-0883-x.

Martínez-Blanco, J., Lehmann, A., Chang, Y.J., Finkbeiner, M., 2015c. Social organizational LCA (SOLCA)—a new approach for implementing social LCA. Int. J. Life Cycle Assess. 20, 1586–1599. https://doi.org/10.1007/s11367-015-0960-1.

Martinez, S., Delgado, M., del, M., Martinez Marin, R., Alvarez, S., 2019. Organization environmental footprint through input-output analysis: a case study in the construction sector. J. Ind. Ecol. 23 https://doi.org/10.1111/jiec.12827, 879–892.

Mazzi, A., 2019. Introduction. Life cycle thinking. In: Life Cycle Sustainability Assessment for Decision-Making: Methodologies and Case Studies. Elsevier, pp. 1–19. https://doi.org/10.1016/B978-0-12-818355-7.00001-4.

Moltesen, A., Bonou, A., Wangel, A., Bozhilova-Kisheva, K.P., 2018. Social life cycle assessment: an introduction. In: Life Cycle Assessment. Springer International Publishing, Cham, pp. 401–422. https://doi.org/10.1007/978-3-319-56475-3_16.

Montzka, S.A., Dutton, G.S., Portmann, R.W., Chipperfield, M.P., Davis, S., Feng, W., Manning, A.J., Ray, E., Rigby, M., Hall, B.D., Siso, C., Nance, J.D., Krummel, P.B., Mühle, J., Young, D., O'Doherty, S., Salameh, P.K., Harth, C.M., Prinn, R.G., Weiss, R.F., Elkins, J.W., Walter-Terrinoni, H., Theodoridi, C., 2021. A decline in global CFC-11 emissions during 2018−2019. Nature 590, 428–432. https://doi.org/10.1038/s41586-021-03260-5.

Moreau, V., Weidema, B.P., 2015. The computational structure of environmental life cycle costing. Int. J. Life Cycle Assess. 20, 1359–1363. https://doi.org/10.1007/s11367-015-0952-1.

Nehdi, M., Tariq, A., 2007. Stabilization of sulphidic mine tailings for prevention of metal release and acid drainage using cementitious materials: a review. J. Environ. Eng. Sci. https://doi.org/10.1139/S06-060.

Neppach, S., Nunes, K.R.A., Schebek, L., 2017. Organizational environmental footprint in German construction companies. J. Clean. Prod. 142, 78–86. https://doi.org/10.1016/j.jclepro.2016.05.065.

Norgate, T., Haque, N., 2012. Using life cycle assessment to evaluate some environmental impacts of gold production. J. Clean. Prod. 29 (30), 53–63. https://doi.org/10.1016/j.jclepro.2012.01.042.

Ozawa-Meida, L., Brockway, P., Letten, K., Davies, J., Fleming, P., 2013. Measuring carbon performance in a UK University through a consumption-based carbon footprint: de Montfort University case study. J. Clean. Prod. 56, 185–198. https://doi.org/10.1016/j.jclepro.2011.09.028.

Pelletier, N., Allacker, K., Manfredi, S., Chomkhamsri, K., Maia de Souza, D., 2012. Organisation Environmental Footprint (OEF) Guide.

Pelletier, N., Allacker, K., Pant, R., Manfredi, S., 2014. The European Commission Organisation Environmental Footprint method: comparison with other methods, and rationales for key requirements. Int. J. Life Cycle Assess. 19, 387–404. https://doi.org/10.1007/s11367-013-0609-x.

Resta, B., Gaiardelli, P., Pinto, R., Dotti, S., 2016. Enhancing environmental management in the textile sector: an Organisational-Life Cycle Assessment approach. J. Clean. Prod. 135, 620–632. https://doi.org/10.1016/j.jclepro.2016.06.135.

Sáez de Cámara, E., Fernández, I., Castillo-Eguskitza, N., 2021. A holistic approach to integrate and evaluate sustainable development in higher education. The case study of the university of the Basque Country. Sustainability 13, 392. https://doi.org/10.3390/su13010392.

Schulte, R.F., Tuck, C.A., 2020. 2016 Minerals Yearbook - FERROALLOYS.

Shehabi, A., Smith, S., Sartor, D., Brown, R., Herrlin, M., Koomey, J., Masanet, E., Horner, N., Azevedo, I., Lintner, W., 2016. United States Data Center Energy Usage Report. United States), Berkeley, CA. https://doi.org/10.2172/1372902.

Shields, R., 2019. The sustainability of international higher education: student mobility and global climate change. J. Clean. Prod. 217, 594–602. https://doi.org/10.1016/j.jclepro.2019.01.291.

Sinha, P., Schew, W.A., Sawant, A., Kolwaite, K.J., Strode, S.A., 2010. Greenhouse gas emissions from U.S. institutions of higher education. J. Air Waste Manag. Assoc. 60, 568–573. https://doi.org/10.3155/1047-3289.60.5.568.

Sippel, M., Meyer, D., Scholliers, N., 2018. What about greenhouse gas emissions from students? An analysis of lifestyle and carbon footprints at the University of Applied Science in Konstanz, Germany. Carbon Manag. 9, 201–211. https://doi.org/10.1080/17583004.2018.1440851.

Steubing, B., Wernet, G., Reinhard, J., Bauer, C., Moreno-Ruiz, E., 2016. The ecoinvent database version 3 (part II): analyzing LCA results and comparison to version 2. Int. J. Life Cycle Assess. 21, 1269–1281. https://doi.org/10.1007/s11367-016-1109-6.

Toniolo, S., Mazzi, A., Mazzarotto, G., Scipioni, A., 2019. International standards with a life cycle perspective: which dimension of sustainability is addressed? Int. J. Life Cycle Assess. 24, 1765–1777. https://doi.org/10.1007/s11367-019-01606-w.

Townsend, J., Barrett, J., 2015. Exploring the applications of carbon footprinting towards sustainability at a UK university: reporting and decision making. J. Clean. Prod. 107, 164–176. https://doi.org/10.1016/j.jclepro.2013.11.004.

Ullah, I., Din, I. ud, Habiba, U., Noreen, U., Hussain, M., 2020. Carbon footprint as an environmental sustainability indicator for a higher education institution. Int. J. Glob. Warming 20, 277. https://doi.org/10.1504/ijgw.2020.107147.

UN, 2015. General Assembly Resolution A/RES/70/1. Transforming Our World, the 2030 Agenda for Sustainable Development.

UNEP/SETAC, 2015. Guidance on Organizational Life Cycle Assessment. Life-Cycle Initiative. Paris, France.

UPV/EHU, 2020a. Localization - UPV/EHU [WWW document]. URL. https://www.ehu.eus/es/ikastegien-kokapena, 5.8.20.

UPV/EHU, 2020b. UPV/EHU in figures | UPV/EHU zenbakitan [WWW Document]. URL. http://www.ehu.eus/zenbakitan/en/node/1.html, 5.8.20.

UPV/EHU, 2020c. Presupuestos - portal de Transparencia - UPV/EHU [WWW document]. URL. https://www.ehu.eus/es/web/gardentasun-ataria/aurrekontuak, 5.14.20.

UPV/EHU, 2019. EHUagenda 2030 for Sustainable Development.

Van Oers, L., Guinée, J.B., Heijungs, R., 2020. Abiotic resource depletion potentials (ADPs) for elements revisited-updating ultimate reserve estimates and introducing time series for production data. Int. J. Life Cycle Assess. 25, 294–308. https://doi.org/10.1007/s11367-019-01683-x.

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. Int. J. Life Cycle Assess. 21, 1218–1230. https://doi.org/10.1007/s11367-016-1087-8.

Zuazo, I., Torre-Pascual, E., Bueno, G., Tamayo, U., Saez de Cámara, E., de Blas, M., Pérez-Iribarren, E., Erauskin, A., Etxano, I., García, M., Akizu-Gardoki, O., León, I., Marieta, C., Zulueta, G., Barrio, I., 2021. The Environmental Footprint of the Mobility Needs of the University of the Basque Country UPV/EHUManuscript on Preparation.