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Castelo Branco**

Escola Superior
de Tecnologia

Towards a Sustainable Campus: Measuring and Enhancing Sustainability at ESTCB

Arunima Rajesh

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Supervisor

Constança Rigueiro

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Composition of the jury

President of the jury

Prof. Adjunto, Rosa Paula da Conceição Luzia

Vowels

Doctor, Maria Constança Simões Rigueiro

Professor Coordinator, Instituto Politécnico de Castelo Branco

Doctor, Fernando Reinaldo Ribeiro

Professor Adjunto, Instituto Politécnico de Castelo Branco

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Abstract

This study assesses the sustainability of the Escola Superior de Tecnologia de Castelo Branco (ESTCB) using the Ecological Footprint (EF) methodology via the EUSTEPs University Footprint Calculator. The EF provides a comprehensive measure of resource consumption across university operations and is more suitable for Higher Education Institutions than Carbon or Environmental Footprint metrics alone.

Data from 2019 to 2023 were collected from institutional records, covering energy use, food services, mobility, procurement, and more. Activities were categorized under direct and indirect university control. Results, expressed in global hectares (gha), highlighted that staff consistently had a higher per capita footprint than students. A significant rise in the 2023 footprint was linked to material acquisitions, particularly furniture.

Key contributors to ESTCB's footprint included staff labour, energy consumption, food provision, and mobility. COVID-19 influenced results in 2020–2021, with reduced activity and emissions. The analysis also revealed data challenges, such as fragmented records and the need for proxy estimates, limiting full precision.

The study concludes that EF analysis offers valuable insights into institutional sustainability. It calls for better data integration, more precise indirect activity tracking, and incorporation of sustainability accounting in university planning.

Keywords

Ecological Footprint, Sustainability, Higher Education, EUSTEPs, ESTCB

Resumo

Este estudo avalia a sustentabilidade da Escola Superior de Tecnologia de Castelo Branco (ESTCB) recorrendo à metodologia Pegada Ecológica (PE) por intermédio da ferramenta EUSTEPs University Footprint Calculator. A PE fornece uma medida abrangente do consumo de recursos nas operações universitárias e revela-se mais adequada para Instituições de Ensino Superior do que as métricas de Pegada de Carbono ou Pegada Ambiental.

Foram recolhidos dados da ESTCB de 2019 a 2023, abrangendo consumo de energia, serviços alimentares, mobilidade, compras e outros. As atividades foram categorizadas como sob controlo direto e indireto da Escola. Os resultados, expressos em hectares globais (gha), evidenciaram que os funcionários apresentaram consistentemente uma pegada per capita maior do que os estudantes. Um aumento significativo da pegada em 2023 foi associado à aquisição de materiais, nomeadamente mobiliário.

As principais ações que contribuem para a Pegada Ecológica da ESTCB são: as atividades inerentes ao Staf, consumo de energia, fornecimento de alimentos e mobilidade. A pandemia de COVID-19 influenciou os resultados em 2020–2021, promovendo a redução das atividades e consequentemente as emissões. A análise também revelou desafios relacionados com a fragmentação dos dados e a necessidade de estimativas por aproximação, o que limita a precisão do cálculo.

O estudo conclui que a análise da Pegada Ecológica oferece insights valiosos sobre a sustentabilidade da Escola. Recomenda-se o desenvolvimento de uma metodologia prática que promova uma melhor integração de dados, rastreamento mais preciso das atividades indiretas e a incorporação da monitorização da sustentabilidade no planeamento e estratégia da ESTCB.

Palavras Chave

Pegada Ecológica, Sustentabilidade, Ensino Superior, EUSTEPs, ESTCB

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List of abbreviations, acronyms and acronyms

EF – Ecological Footprint

HEI – Higher Education Institution

ESTCB – Escola Superior de Tecnologia de Castelo Branco

EUSTEPs – Enhancing Universities' Sustainability Teaching and Practices

GHG – Greenhouse Gas

GRI – Global Reporting Initiative

SDG – Sustainable Development Goals

FTE – Full-Time Equivalent

IPCB – Instituto Politécnico de Castelo Branco

SAT – Sustainability Assessment Tool

STARS – Sustainability Tracking, Assessment & Rating System

INE – Instituto Nacional de Estatística

PEF – Product Environmental Footprint

GHA – Global Hectare

1. Introduction

Sustainability in higher education institutions (HEIs) has gained increasing attention as universities grapple with their ecological responsibilities and societal influence. HEIs are not only knowledge hubs but also significant consumers of resources and generators of environmental impact. To support global efforts toward sustainable development, HEIs must adopt robust frameworks to evaluate, report, and improve their environmental performance.

Despite the growing array of sustainability assessment tools (SATs), many lack the specificity needed for academic institutions, particularly in integrating data into strategic planning. Among available methodologies, the Ecological Footprint (EF) emerges as a comprehensive indicator—encompassing land use, carbon emissions, food, energy, and waste consumption—making it especially suitable for campus-wide assessments.

This study employs the EUSTEPs University Footprint Calculator to evaluate the environmental impact of the Escola Superior de Tecnologia de Castelo Branco (ESTCB) over a five-year period (2019–2023). By quantifying both direct and indirect activities under university control, this research aims to highlight patterns in resource use, identify priority areas for intervention, and ultimately support institutional strategies aligned with the Sustainable Development Goals (SDGs).

2. State of Art

Higher education institutions (HEIs) have generally addressed sustainability in three dimensions: social, environmental and economic. However, given the breadth and diversity of their activities, the best way to assess their performance and designate them as sustainable universities is still under development. It is known that several elements of sustainability should be emphasised by HEIs, including education, research, campus operation, community involvement, and reporting (Husaini *et al.*, 2018). However, there are some difficulties in achieving this and even in integrating it into the strategic plan of HEIs, particularly in the sustainability measures to be used in decision-making by senior management (Lozano *et al.*, 2015).

Sustainability Assessment Tools (SATs) have been used by higher education institutions, enabling strategic planning and sustained development towards sustainable universities (Berzosa *et al.*, 2017; Bashir *et al.*, 2023). As a result, numerous SATs and approaches have emerged, many with a strong focus on campus-based assessment using qualitative, quantitative or mixed methodologies. Examples of well-known SATs include the Sustainability Tracking, Assessment and Rating System (STARS) and the Times Higher Education Impact Rankings. (Rigueiro *et al.*, 2025)

Regarding to quantitative assessments, such as the Carbon Footprint, Ecological Footprint, and Environmental Footprint offer critical tools for measuring the direct and indirect environmental impacts of campus operations (Wiedmann & Minx, 2008; Global Footprint Network, 2023). These indicators not only help institutions benchmark their performance but also guide the design of strategic initiatives for sustainability enhancement. In order to understand these concepts a detailed study was conducted of the same.

Environmental and sustainability reporting, guided by standardized frameworks like the Global Reporting Initiative (GRI), facilitates transparent disclosure of ecological impacts by organizations (GRI, 2021). Although GRI offers a comprehensive and globally recognized approach to sustainability reporting, its use is predominantly seen in the corporate sector, with limited adoption in higher education institutions—despite its clear potential to improve environmental accountability and comparability. To address the gaps where GRI indicators did not align with the specific needs of the academic sector, a tailored framework titled ‘Higher Education Disclosures’ was developed, comprising seven categories uniquely relevant to universities.

The upcoming section studies footprint calculation methods in detail and shortlists the most appropriate method to measure the sustainability of ESTCB.

2.1. Carbon Footprint at Institutions

The carbon footprint measures the total amount of greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organization, event, or

product (GGP, 2004). These emissions primarily consist of carbon dioxide (CO₂) but also include other GHGs like methane (CH₄) and nitrous oxide (N₂O), all expressed as carbon dioxide equivalents (CO₂e) (Alteia, n.d.; Vitality IO, Inc., n.d.). It focuses specifically on the contribution to climate change (Vitality IO, Inc., n.d.).

The primary unit of measurement is tonnes of carbon dioxide equivalent (tCO₂e), or sometimes kilograms (kg) or grams (g) of CO₂e. This unit allows for the comparison of different greenhouse gases based on their Global Warming Potential (GWP) (Leaf Huella de Carbono, 2024; Wikipedia, n.d.). The following section presents a critical review of the relevant literature examined in the context of this study.

(Kiehle, Kopsakangas-Savolainen, Hilli, and Pongrácz, 2023) provide a notable contribution to institutional sustainability efforts through their carbon footprint analysis of the University of Oulu. Their study aimed to quantify the university's carbon emissions for 2019, contribute a case study from a Northern European context, identify methodological limitations in emissions analysis at the organizational level, and illustrate how such assessments can support emissions mitigation and progress toward carbon neutrality.

The central research question posed was how an institution like the University of Oulu could effectively calculate and interpret its carbon footprint to inform reduction strategies and serve as a model for other universities. Participants included university staff and students, whose institutional behaviors and resource consumption informed the emissions calculations.

The authors employed a hybrid methodological approach that integrated Environmentally Extended Input-Output Analysis (EEIOA) with Life-Cycle Assessment (LCA), covering Scope 1 (direct emissions), Scope 2 (indirect emissions from energy), and Scope 3 (other indirect emissions). This comprehensive approach revealed a total of 19,072 t CO₂e emitted in 2019. Major contributors included district heating, fuel use, the university's vehicle fleet, water, and cooling systems. Electricity consumption, however, yielded no emissions due to exclusive reliance on renewable energy. Additional insights included the proximity of most staff and students to campus, which likely minimized commuting-related emissions. Despite these findings, data limitations—such as reliance on financial records and incomplete datasets—posed challenges to accuracy.

The authors suggest prioritizing energy efficiency and refining procurement policies to reduce emissions. They also advocate for improved interdepartmental coordination and transparent data-sharing frameworks to support more reliable institutional carbon accounting in the future.

(Herth and Blok, 2023) conducted an in-depth analysis of the total carbon footprint of TU Delft, aiming to support the university's goal of achieving carbon neutrality by 2030. The study had three core objectives: (1) to quantify both direct and indirect carbon emissions from university operations, (2) to compare commonly

used footprint calculation methodologies, and (3) to identify effective starting points for emission reductions.

The guiding research question asked how TU Delft could comprehensively measure and reduce its carbon emissions to reach carbon neutrality. The study considered the university community as a whole—including staff and students—as the population contributing to institutional emissions, although the exact number of participants was not specified.

Methodologically, the study utilized a hybrid Life Cycle Assessment (LCA) approach, combining process-based LCA with Extended Input-Output (EIO) models. Physical activity data were used where available (for Scopes 1 and 2, flights, commuting, waste, and water), while monetary data from procurement and catering were analyzed using EIO and Hybrid Monetary Ratios (HMR) when physical data were lacking. This dual approach enabled the researchers to provide a detailed and scalable emissions profile.

Findings showed that TU Delft emitted a total of 106 ktCO₂eq in 2018. Notably, Scope 3 emissions dominated the footprint, accounting for 83% of the total. The top five sources of emissions were identified as real estate and construction (18%), natural gas (17%), equipment (13%), information and communication technology (ICT, 8%), and facility services (8%). Conversely, emissions from waste, water, paper products, and financial services were negligible. These results aligned closely with carbon profiles of other technical universities, highlighting systemic patterns within the sector.

The authors recommended that future reduction efforts focus on the most significant contributors—particularly real estate, natural gas use, and equipment procurement. They also emphasized the importance of improving methodological precision, especially in defining emissions boundaries and enhancing data quality. Furthermore, the study advocated for greater supplier transparency and urged universities to formally include Scope 3 emissions in their neutrality targets, positioning academic institutions as leaders in climate mitigation strategies.

2.2. Ecological Footprint at Institutions

The ecological footprint is a more comprehensive indicator that measures humanity's demand on nature. It quantifies the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes and to absorb the waste generated, given prevailing technology and resource management practices (Global Footprint Network, 2023.; Selectra, 2022; Vitality IO, Inc., 2022.). It assesses whether human demand exceeds the Earth's bio capacity (the planet's capacity to regenerate resources and absorb waste) (EUSTEPS, 2022.; Selectra, 2022).

The ecological footprint is typically expressed in global hectares (gha) (Selectra, 2022; EUSTEPS, 2022). One global hectare represents a hectare of land with world-average biological productivity (Global Footprint Network, 2023). Sometimes, it is

also expressed in terms of the number of "planets" needed if everyone lived like the assessed entity (Selectra, 2022). The following section provides a synthesized overview of scholarly literature previously published on this topic.

(Genta *et al.*, 2021) contribute to the growing body of research on university sustainability by applying the consumption-based Ecological Footprint (EF) methodology to assess the environmental impact of an Italian higher education institution—Politecnico di Torino (PoliTO). Their study represents one of the most comprehensive analyses of a university campus in Italy, aimed at informing planning, decision-making, and policy development to reduce ecological and carbon footprints.

Although no specific research questions were explicitly articulated, the study addresses a clear gap in the literature regarding footprint analysis within the higher education sector, particularly in the Italian context. The authors sought to evaluate the full environmental impact of campus activities using EF and Carbon Footprint (CF) methodologies, with a focus on energy use, mobility, waste, water, land use, and food consumption. The research involved institutional data from PoliTO's administrative and academic units as well as a mobility survey, ultimately covering a substantial sample of students, faculty, and staff.

The methodology followed a bottom-up, componential EF approach based on physical flows and institutional records for the year 2016. Key steps included defining consumption categories, collecting localized data, and calculating EF and CF using category-specific equations. Six consumption domains were assessed: energy, water, mobility, land use, waste, and food. This comprehensive approach allowed the authors to quantify environmental impacts at both institutional and per-student levels.

Results indicated that PoliTO's total ecological footprint was 6,200 global hectares (gha), with mobility and energy as the dominant contributors—accounting for 49.3% and 40.1% of the footprint, respectively. The normalized footprint was 0.19 gha per student. Similarly, the carbon footprint totaled 17,341 tCO₂eq, with mobility again emerging as the leading source of emissions (52.7%), followed by energy consumption (40.4%). Other categories such as food, waste, and water contributed marginally to both EF and CF.

The authors emphasize the utility of the EF method in supporting campus refurbishment, master planning, and environmental policy development. They also acknowledge methodological limitations, such as the challenges of data completeness and the need for more refined categorization in consumption flows. Nonetheless, the study demonstrates how ecological footprint analysis can provide decision-makers with critical insights and comparative benchmarks, supporting a more sustainable trajectory for the higher education sector.

(Liu, Wang, and Zhao, 2024) address the methodological limitations in traditional Ecological Footprint (EF) calculations as applied to university campuses, presenting

an improved EF assessment method tailored to the specific context of Henan Polytechnic University (HPU). Their work responds to the growing need for accurate sustainability metrics in academic environments, where conventional EF approaches may fall short due to outdated parameters and insufficient granularity.

Focusing on the south campus of HPU as a case study, the authors revised several core components of EF accounting. Enhancements included redefining fossil energy land to account for both forest and pastureland absorption capacities, integrating thermal and hydroelectric power sources in electricity calculations, and utilizing the most recent five-year FAO global productivity statistics to recalibrate yields for agricultural, livestock, and aquatic products. These improvements aimed to more accurately reflect real-world resource use and emissions within a campus context.

The methodology employed a bottom-up, componential approach encompassing all major categories of campus consumption: energy, food, paper, waste, water, and transportation. Data collection drew from institutional offices, field surveys, and utility records for the 2019 pre-pandemic period. The revised EF model yielded a total footprint of 28,358.41 global hectares, or 0.657 gha per capita, with energy consumption accounting for nearly half (49.56%) of the total impact, followed by food (36.33%), paper (5.62%), waste (4.27%), and transportation (4.22%).

Comparison with the unimproved EF model revealed a significant reduction in calculated impacts, attributed to more precise classifications and updated global productivity data. The study underscores the importance of continuous parameter refinement and calls for simplified, scalable EF methods to assist universities with limited data infrastructures. Moreover, the findings serve as a practical foundation for designing EF reduction strategies in support of green campus initiatives.

2.3. Environmental Footprint

The term "environmental footprint" is a broader, overarching concept that can encompass various indicators of environmental impact. However, in a more specific and standardized context, it often refers to the Product Environmental Footprint (PEF). The PEF is a multi-criteria, life cycle-based method for measuring a product's environmental performance from raw material extraction to end-of-life disposal (PlanA.Earth, n.d.). It aims to provide a consistent and transparent method for companies to quantify and communicate the environmental performance of their products, facilitating comparisons and informed decision-making (PlanA.Earth, n.d.).

Unlike the carbon and ecological footprints that often have a single primary unit, the environmental footprint (PEF) is a multi-criteria measure. This means it assesses impacts across various categories, and therefore, it doesn't have a single, overarching unit. Instead, different impact categories have their own units. Impact categories in environmental assessment are typically quantified using specific standardized units. For instance, climate change is measured in kilograms of CO₂

equivalent (kg CO₂e), while water use is expressed in cubic meters (m³). Resource depletion is assessed using kilograms of antimony equivalent (kg Sb eq), and eutrophication potential is represented by kilograms of phosphate equivalent (kg PO₄ eq). Additional categories often include acidification, ecotoxicity, and land use, each with their own corresponding metrics to ensure comprehensive evaluation of environmental impacts. The Environmental Footprint (EF) is less commonly applied in Higher Education Institutions because it requires comprehensive data across a wide range of environmental impact categories—such as acidification, ecotoxicity, and resource depletion—which are often difficult to collect consistently at the institutional level. Additionally, its complexity and the lack of standardized tools tailored to the academic context make it less practical.

2.4. Some Considerations

The Ecological Footprint (EF) offers a more comprehensive method for assessing sustainability in Higher Education Institutions (HEIs) compared to the Carbon Footprint alone, as it encompasses not just greenhouse gas emissions but also broader resource consumption patterns such as land use, food, water, and waste. This holistic approach is particularly well-suited to the complex operational structures of universities, which involve diverse activities beyond energy use, including transportation, procurement, and on-campus services. While Carbon Footprint focuses primarily on climate change-related emissions, Ecological Footprint captures the full spectrum of environmental pressure exerted by institutional practices, making it a more effective tool for sustainability planning and performance tracking in HEIs. The development of the 'Higher Education Disclosures'—a sector-specific reporting framework—further strengthens the application of EF by providing tailored indicators and categories that align with university operations. These disclosures bridge the gap left by general frameworks like the Global Reporting Initiative (GRI), allowing HEIs to systematically report on unique areas of impact and align sustainability metrics with their educational, social, and infrastructural responsibilities.

3. Methodology

3.1. Introduction to EUSTEPs

The EUSTEPs University Footprint Calculator, an open-access digital tool launched in April 2022, represents a notable advancement in assessing sustainability within Higher Education Institutions (HEIs). This Calculator facilitates the standardized monitoring and management of natural resource and ecosystem service consumption by HEIs through Ecological Footprint (EF) Accounting, tailored for this specific sector. It enables institutions to identify key drivers of their ecological impact, optimize resource efficiency, and streamline data collection for sustainability assessments. By prompting institution-wide dialogue, the Calculator supports HEIs in reducing their ecological footprint, thereby contributing to Sustainable Development Goals (SDGs) 11 (Sustainable Cities & Communities), 12 (Responsible Consumption & Production), and 13 (Climate Action). While globally accessible, its country-specific conversion factors are primarily aligned with EU-27 countries and the UK, which may introduce some approximation for non-EU users.

3.2. Hypothesis of Collection of Data

To accurately measure a university's Ecological Footprint (EF) and identify the most important areas for sustainability improvements, it is believed that collecting detailed data from the university's own records will provide a clear, reliable, and useful assessment of its environmental impact.

This includes all activities that the university directly and indirectly manages, i.e., the EUSTEPs University Footprint Calculator, is organized into two main sections: the actions of consumption under the direct control of the University administration and the actions under the indirect control of the University administration. To carry out the assessment of the actions of consumption under the direct control of the University administration data needs to be collected from several key areas. This involves recording how much energy is used every year (like electricity, heating, hot water, and energy from solar panels or other renewable sources), the size of university buildings and outdoor spaces, and information about campus food services—such as how much food is served, how it's produced (for example, organic or local), and the kind of packaging used.

Additional data includes how many hours are spent on cleaning services (or how much is spent on them), how much fuel is used by university-owned vehicles, and how far staff and students travel for work-related reasons, for teaching, research or administrative purposes. It also includes water usage and waste disposal (amounts and types), as well as what the university buys (like furniture, electronics, office supplies, and paper). These areas cover most of the resources the university controls and the waste it produces. (Mancini *et al.*, 2022).

Collecting this detailed information is a key part of the EUSTEPs method, helping ensure the EF calculation truly reflects the university's actual environmental impact.

This data helps uncover how and where the university is using resources and creating waste. By expressing this in global hectares (gha), the EF provides a clear and standardized way to understand the university's demand on nature (Mancini *et al.*, 2022).

3.3. Restrictions

When applying the EUSTEPs methodology to assess a university's Ecological Footprint (EF), one major constraint lies in the fragmentation of data across administrative units. Departments such as facilities management, catering, energy, and transportation often collect data independently, resulting in inconsistent formats and reporting timelines. This disjointed approach impedes the integration of comprehensive datasets, increasing the likelihood of missing or overlapping information. As EUSTEPs pilot studies have shown, coordinating the collection of multiple data streams demands clear governance around data ownership and standardized reporting protocols (Moreno Pires, 2020).

A second limitation arises from the need to translate indirect indicators into required metrics when direct measurements are unavailable. For example, transportation data often records only kilometers travelled by university staff and students, lacking fuel consumption figures. To estimate diesel and gasoline usage, a simplified conversion is often used—assuming 5 L fuel per 100 km for diesel and 7 L per 100 km for gasoline. While pragmatic, this approach introduces substantial variability, as real-world consumption varies widely with vehicle age, maintenance, load, and driving patterns (ICCT, 2021; Wikipedia, 2025).

Thirdly, EUSTEPs relies on physical flow data at granular levels (e.g., liters of fuel), but these are often substituted with proxy variables such as distance travelled. This mismatch fundamentally increases uncertainty: a diesel car's actual fuel usage might deviate significantly from standardized estimates, leading to either underestimation or overestimation of the EF contribution from transportation. Although EUSTEPs allows for such approximations to improve feasibility, it also means that the calculated EF may reflect methodological convenience rather than true resource use, threatening validity (Unit 4 EUSTEPs, 2020).

Lastly, the labour-intensive process of transforming disparate datasets—requiring manual data cleaning, unit conversions, and alignment with EF categories—places a high burden on institutional capacity. Smaller universities or those lacking environmental units may struggle to invest in both manpower and technical expertise, leading to inconsistently implemented assessments. Until data infrastructures are strengthened—with automated collection, standardized formats, and clear stewardship agreements—the precision and comparability of EF calculations across HEIs will remain constrained (Unit 4 EUSTEPs, 2020).

4. Case Study: ESTCB

4.1. Presentation of ESTCB

Higher School of Technology (ESTCB) is one of the six IPCB schools that offers Higher Professional Technical Courses (CTeSP), Bachelor's Degrees, Master's Degrees, Certified Training Courses, Distance Learning Courses and Short Courses in the areas of engineering, electrical engineering and communications, industrial management, IT, renewable energy and civil construction, Figure 1.



Figure 1: Higher School of Technology (ESTCB) – (from Activity Report, 2023)

The ESTCB campus covers a total area of 43,000 m², divided into four interconnected buildings (designated A, B, C and D) of varying heights, forming a harmonious whole that blends into the surrounding landscape. To support sporting activities, the school has a multi-sports field located at the southern end, next to the leisure area of the city of Castelo Branco, Figure 2.

The ESTCB campus borders multi-family buildings and the new city park, Parque Urbano Cruz do Montalvão, to the north, and the leisure and sports area and the Skatepark of the city of Castelo Branco to the south. The leisure area to the south is extensive, with sports facilities such as swimming pools and an athletics track.

The ESTCB spans a total area of ~43,000.00 m² square meters, encompassing a range of physical infrastructures and land uses. This includes 5,937.91 m² designated for teaching and administrative buildings, 1,192.00 m² for canteens and cafeterias, and 2,352.18 m² allocated to parking lots. Internal roadways cover 3,998.72 m², while green spaces such as botanical gardens and forested areas account for 8,563.00 m², reflecting the institution's integration of natural environments.

Notably, the ESTCB reports no allocated area for dormitories or water-related zones such as wetlands, lakes, or rivers, indicating that these features are not present on campus.



Figure 2: Plan View of ESTCB - (Ortet, 2023)

4.2. Data Collection

This section introduces the initial steps and basic data gathered to calculate the ecological footprint of ESTCB over five years—2019 through 2023. ESTCB is a Portuguese school located on a single campus in Castelo Branco city. For the calculation of ecological footprint of activities under the direct control of the university, important yearly information was collected to understand the university's resource use and activities as presented in Table 1.

INFORMAÇÃO GERAL	DESIGNAÇÃO DESIGNATION	UNIDADE UNIT	FONTE / DESIGNAÇÃO DO SERVIÇO DA FONTE / SOURCE / DESIGNATION FROM ESTCB SOURCE	ANO YEAR				
				2019	2020	2021	2022	2023
	Ano civil de referência para todos os dados <i>Calendar year of data</i>	ano year	ESTCB	2019	2020	2021	2022	2023
	País <i>Country</i>	nome name	ESTCB	Portugal				
	Nome da Instituição de Ensino Superior - IES <i>Name of the Higher Education institution - HEI</i>	nome name	ESTCB	ESTCB				
	Se a IES é uni ou multicampus? <i>Is the HEI a single or multi-campus university?</i>	opções options	ESTCB	Uni-campus				
	Se é uma IES com vários campi, estão todos localizados na mesma cidade ou em cidades diferentes? <i>If a multi-campus university, are all campuses located in the same city or in different cities?</i>	opções options	ESTCB	Única Cidade				
	Número de publicações anual, em revistas especializadas (sem peer-review). <i>Number of annual publications in peer-review journals</i>	n.º	Scopus	50	53	52	57	55
	Número de diplomas atribuídos no ano de referência <i>Number of annual graduations attributed in the reference year</i>	n.º	Direção	112	118	163	110	118
	Financiamento total recebido para investigação no ano de referência <i>Total funds received for research in the year of reference</i>	euros	RA ESTCB/Site do PCB e outros sites	264.059.73	203.346.15	527837.59	695505.35	879008.12

Table 1: General Information of ESTCB

For example, ESTCB published 50 academic papers in 2019, 53 in 2020, 52 in 2021, 57 in 2022, and 55 in 2023. These values were determined through an analysis of the Scopus database, examining the publication output of each faculty member at the school. The number of students graduating annually was 112 in 2019, 118 in 2020, 163 in 2021, 110 in 2022, and 118 in 2023, based on data provided by ESTCB's academic services. Regarding research funding, ESTCB received €264,059.73 in 2019, €203,346.15 in 2020, €527,837.59 in 2021,

€698,505.85 in 2022, and €879,006.12 in 2023. These funding values were compiled through an analysis of the ESTCB Activity Reports from 2019 to 2023, a review of individual project websites, consultations with project coordinators and faculty members, and data from the IPCB website concerning ongoing research activities.

Information regarding the total number of actively enrolled students in each reference year, the average number of ECTS credits completed annually by full-time students, and the number of contracted staff (both academic and non-academic) is drawn from the ESTCB Activity Reports for the years 2019 to 2023. The Full-Time Equivalent (FTE) for staff was calculated based on a standard full-time workload of 1,920 hours per year—defined as 240 working days at 8 hours per day. This standard is in accordance with data provided by INE – Instituto Nacional de Estatística, as referenced in Table 2.

POPULAÇÃO DA UNIVERSIDADE UNIVERSITY POPULATION	DESIGNAÇÃO DESIGNATION	UNIDADE UNIT	FUNTE / DESIGNAÇÃO DO SERVIÇO DA ESTCB SOURCE / DESIGNATION FROM ESTCB SERVICE	ANO YEAR				
				2019	2020	2021	2022	2023
				Número total de estudantes matriculados ATIVOS no ano de referência Total number of students enrolled ACTIVE in the reference year	ciclos ciclos + OUTRAS FORMAÇÕES (*)	n.º	RA ESTCB + Borjato ECO-AP	549
Número médio de ECTS por Estudante inscrito em regime integral no ano de referência Average ECTS for a full-time student in one academic		n.º	RA ESTCB + Borjato ECO-AP	40	40	40	40	40
Número de STAFF - trabalhadores (docentes e não docentes) contratados na ano de referência, em EI (tempo inteiro + tempo parcial). Number of STAFF (teachers and non-teachers) contracted for the reference year, in FTE (full-time + part-time)		n.º	RA ESTCB + Borjato ECO-AP	91	88	86	93	97
Define o EI - Equivalente a Tempo Inteiro (integral na sua 1/3 - quarta hora trabalha um membro do STAFF - trabalhadores (docente e não docente), contratado a tempo inteiro num ano (240 dias de trabalho x 8 h por dia = 1 920 horas anuais, por pessoa). Define FTE - Full Time Equivalent/ full time in your HEI - how many hours a STAFF member (teachers and non-teachers), contracted full time in a year (we counted it based on: 240 days in a year * 8 hours, per day = 1920 hours per year, per person) works.		horas hours	INE - Instituto Nacional de Estatística + Campus Sustentável + Borjato ECO-AP	1,920	1,920	1,920	1,920	1,920

Table 2: University Population of ESTCB

Table 3 presents the data on ESTCB’s annual energy consumption, covering electricity, heating, and hot water, along with energy production from the University's renewable energy sources. The data was gathered from utility bills for each reference year, with annual totals calculated based on the sum of those bills. All calculations followed the unit standards defined by the reporting tool. Notably, in 2023, ESTCB began supplementing its electricity needs with self-generated power from alternative energy sources, reducing its dependence on the national grid.

SERVIÇOS DE INFRAESTRUTURAS UTILIZAÇÃO DE ENERGIA	INFRAESTRUTURAS ENERGY USE	Consumo anual de eletricidade (inclui energia ativa + energia reativa) Annual electricity consumption (includes active energy + reactive energy)	kWh	Serviços Centrais + Borjato ECO-AP	2019	2020	2021	2022	2023
					277.754,00	217881,00	207585,00	244088,00	241490,00
	Gás natural (metano) Natural gas (methane)	m3	Serviços Centrais + Borjato ECO-AP	9325,92	4184,74	4048,11	5597,84	2995,1	
	GPL (gás propano) LPG (propane)	litros	-	0	0	0	0	0	
	Combustíveis derivados do petróleo, para aquecimento de edifícios Heating fuel	litros	-	0	0	0	0	0	
	Biocombustíveis	litros	-	0	0	0	0	0	
	Biomassa	ton	-	0	0	0	0	0	
	Biomassa	tons	-	0	0	0	0	0	
	Existe algum sistema de produção de eletricidade instalado na Universidade? Does your University generate any of its own electricity?	sim ou não yes or no	Serviços Centrais + Borjato ECO-AP	no	no	no	no	yes	
	Painéis solares/ fotovoltaicos (PV) Solar panel (photovoltaic) - PV	kWh	Serviços Centrais + Borjato ECO-AP	0	0	0	0	24290,70	
	Eólica Wind	kWh	-	0	0	0	0	0	
	Geotérmica Geothermal	kWh	-	0	0	0	0	0	
	Hidroelétrica Hydroelectric	kWh	-	0	0	0	0	0	
	Consumo Consumption	kWh	-	0	0	0	0	0	

Table 3: Description of Energy Use

Table 4 outlines the University's buildings and recreational areas. This section details the total physical surface area of built structures on campus, measured in square meters (m²). For ESTCB, the surface area measurements were obtained using Google Earth to ensure accurate calculations of the built environment.

SERVIÇOS DE INFRAESTRUTURAS INFRASTRUCTURES EDIFÍCIOS E ÁREAS RECREATIVAS BUILDINGS AND RECREATIONAL AREA	Toda a Universidade Whole University						
	m ²	ESTCB	43,000	43,000	43,000	43,000	43,000
Ensino e Administração Teaching & administrative buildings	m ²		5,937.91	5,937.91	5,937.91	5,937.91	5,937.91
Residência Dormitories	m ²		0.00	0.00	0.00	0.00	0.00
Cantinas e bares Canteens e cafeterias	m ²		1,192.00	1,192.00	1,192.00	1,192.00	1,192.00
Parques de estacionamento Parking lots	m ²		2,352.18	2,352.18	2,352.18	2,352.18	2,352.18
Estradas ou arruamentos Roads	m ²		3,998.72	3,998.72	3,998.72	3,998.72	3,998.72
Áreas verdes (jardim, floresta, quinta/hortas, culturas) Green areas (botanical garden, forest, farm, crops)	m ²		29,519.19	29,519.19	29,519.19	29,519.19	29,519.19
Áreas azuis (zonas húmidas, lagos, rios) Blue areas (wetlands, lakes, rivers)	m ²		0.00	0.00	0.00	0.00	0.00
Outras Other (?)	m ²		0	0	0	0	0

Table 4: Buildings and Recreational Areas of ESTCB

Table 5 presents data on food services provided by a third-party company subcontracted by IPCB to supply meals on the university premises. The estimates refer exclusively to meals served in the campus canteen. While ESTCB also operates a bar, no data could be obtained from that facility. The number of meals served was estimated in consultation with the Director of ESTCB.

ALIMENTAÇÃO FOOD	DESIGNAÇÃO DESIGNATION	UNIDADE UNIT	FONTE / DESIGNAÇÃO DO SERVIÇO SOURCE / DESIGNATION FROM SERVICE	ANO YEAR				
				2019	2020	2021	2022	2023
STAFF - Trabalhadores (docentes e não docentes) e ESTUDANTES STAFF (teachers and non-teachers) and STUDENTS	ton tons	RA ESTCB		25	28	29	30	30
DESPERDÍCIO E REAPROVEITAMENTO DE ALIMENTOS FOOD WASTE and REUSE	ton tons	Evaluation of Menus in Public University		4	4	4	5	5
SERVIÇOS DE INFRAESTRUTURAS COMMITTEES ACTIONS SERVIÇOS DE LIMPEZA CLEANING SERVICES	Número total de horas anuais, com os serviços de limpeza dos edifícios da ESTCB Total number of hours per year dedicated to cleaning ESTCB buildings	hours hours	RA ESTCB	704	528	528	880	1,056
	Número total de custos anuais, com os serviços de limpeza da ESTCB Total number of annual cost for ESTCB cleaning services	euros	RA ESTCB	50,400.00	37,800.00	37,800.00	63,000.00	75,600.00

Table 5: Food Supplied and Served in ESTCB Canteen and Cleaning Services

For the calculations, consistent assumptions were applied, based on sources such as (Aires C. *et al.*, 2021). Each meal was estimated to weigh 800 grams, with an average food waste of 15% per meal. It was also assumed that approximately 25% of the total on-campus population dines at the canteen. Out of 800 grams of food, 250 grams is soup which is assumed to be vegetables, principal food is meat assumed to be 400 grams approximate, fruits are assumed to be 100 grams and bread is assumed to be 40 grams. For a full year calculation, five days a week were considered working in eleven months of a year.

Cleaning services, which are directly managed by IPCB, were calculated using data provided in the Activity Reports and verified through consultation with the Director of ESTCB.

It was also necessary to gather information on the travel activities of the ESTCB community—including staff and students—for purposes such as teaching, research, studying, and administrative work. These travel expenses are fully covered by IPCB, either through direct payment or full reimbursement.

SERVIÇOS DE INFRAESTRUTURAS COMUNITARIAS ACTIONS	CONSUMO DE ÁGUA E PRODUÇÃO DE RESÍDUOS WATER AND WASTE CONSUMPTION						
	Consumo anual de água na Universidade Annual water consumption at University	m ³	Serviços centrais + Barômetro ECO AP	3,244.00	1,731.00	1,784.00	2,860.00
Produção anual de águas residuais na Universidade (80% a 100% do consumo de água) cerca de 90 % Annual wastewater production at University (80% to 100% of water consumption) around 90 %	m ³	Serviços centrais + Barômetro ECO AP	2,919.60	1,557.90	1,605.60	2,574.00	2,268.90
Produção anual das seguintes frações de RESÍDUOS, com base na fatura do consumo de água potável (considerando que a densidade = 250 kg/m ³) Annual production of the following fractions of WASTE based on the invoice for drinking water consumption (assuming density = 250 kg/m ³)	Plástico/Metal Plastic/Metal	ton tons					
	Papel Paper	ton tons					
	Vidro Glass/can	ton tons					
	Orgânico Organic	ton tons					
	Indiferenciado Undifferentiated	ton tons					
Resíduos de Equipamentos Eléctricos e Electrónica - REEE Waste Electrical and Electronic Equipment- WEEE	ton tons		0	0	0	0	0

Table 7: Data Regarding Wastewater and Waste

Data was also gathered on the use of ESTCB funds for the purchase of specific categories of materials and equipment during the reference year, as illustrated in Table 8. The required data includes the total amount spent in each category, expressed in the national currency:

- **Furniture and furnishings:** This includes items such as desks, chairs, closets, filing cabinets, whiteboards, blackboards, shelves, bookcases, dormitory furnishings, and similar equipment.
- **Electronic equipment:** This category covers laptops, computers, tablets, printers, scanners, cameras, and other electronic devices.
- **Newspapers, books, and stationery:** This includes all printed and paper materials acquired for research, study, teaching, or administrative use, along with common desk supplies such as pens, pencils, highlighters, erasers, staplers, adhesive tape, clips, notebooks, and various binders. Notably, this category excludes white/virgin paper used for printing and writing.

In addition, two material categories require reporting based on quantity rather than expenditure:

- **Reams of A4 paper:** The total number of A4 paper reams (29.7 x 21 cm) purchased during the reference year.
- **Reams of A3 paper:** The total number of A3 paper reams (29.7 x 42 cm) purchased during the reference year. However, data for this final item was not available and could not be collected.

AÇÕES COMUNITARIAS COMUNITARIAS ACTIONS	MATERIAIS E EQUIPAMENTOS MATERIALS AND EQUIPMENTS							
	Mobiliário e complementos Furniture and furnishings	euro	Serviços centrais + Barômetro ECO AP	0,00	0,00	0,00	0,00	7,200.00
Costo anual de aquisição das seguintes materiais e equipamentos pela Universidade Annual acquisition cost of the following materials and equipments at the University								
Equipamento eletrónico (ex: computador portátil, impressoras) Electronic equipment (e.g., laptops, printers)	euro	Serviços centrais + Barômetro ECO AP	90,000.00	0,00	0,00	38,000.00	85,000.00	
Publicações, livros e artigos de papelaria Newspapers, books, and stationery	euro	Serviços centrais + Barômetro ECO AP	2000 *	2000 *	2000 *	2000 *	2000 *	
PAPEL	# Resma de papel A4 # of reams of A4 paper	n.º reamas n.º of reams	Serviços centrais + Barômetro ECO AP	110	32	70	93	108
	# Resma de papel A3 # of reams of A3 paper	n.º reamas n.º of reams	Serviços centrais + Barômetro ECO AP	0	0	0	0	0

Table 8: Data on Materials and Equipment Purchased for the Use of ESTCB's Population

This information was difficult to extract, despite the existence of purchase templates. As a result, the values were estimated using the data available in the Activity Reports. However, the way this information is presented in the reports is not structured in a manner that supports this type of compilation effectively.

For the calculation of ecological footprint of activities under the indirect control of the university, the tool gave two calculation methods- Tier 1 and Tier 2.

- **Tier 1 (Default):** This is the automatic option when there is no specific data available. It estimates the university's impact by taking a portion of each person's everyday consumption (like home energy, commuting, and off-campus food) based on how much time staff and students spend at the university versus at home.
- **Tier 2 (Specific Data):** This method is used when there is detailed data available from a good sample of staff and students collected via survey.

In the calculations in this paper, the default calculation, Tier 1, was opted for calculation of ecological footprint under indirect control of the university.

5. Results and Discussions

Results are presented in global hectares (gha)—a standardized unit that represents the average productivity of all biologically productive land and sea areas on Earth. This allows us to compare human demand on nature with the planet's ecological capacity to regenerate those resources and absorb waste, particularly carbon emissions.

Using the Ecological Footprint as a key indicator, the tool reveals whether our lifestyle is within the planet's limits. When the Ecological Footprint surpasses a region's biocapacity, it signals an ecological deficit—meaning that the area is depleting natural capital faster than it can be replenished. The EUSTEPs tool thus provides critical insight into sustainability performance, highlighting areas where action is needed to reduce consumption and align with the Earth's regenerative capacity.

After the calculation of results to get an overview of ecological footprint over the years, comparison of overall ecological footprint of activities under the direct and indirect control of the university was performed.

The results represent land use in terms of:

- **Cropland:**
The area required to grow crops for food, feed, and fiber.
- **Grazing Land:**
The area needed to raise livestock for meat, dairy, and other animal products.
- **Forest Products:**
The area of forests needed to produce timber, paper, and other wood-based products.
- **Fishing Grounds:**
The area of marine and freshwater ecosystems needed to support fish and other aquatic resources.
- **Built-up Land:**
The area covered by infrastructure, such as buildings, roads, and other human-made structures.
- **Carbon:**
The area of forest land that would be needed to absorb the carbon dioxide emissions from burning fossil fuels.

5.1 Total Ecological Footprint of Activities Over the Years 2019-2023 Under Direct and Indirect Control of the University

The University's Total Ecological Footprint, measured in global hectares (gha), represents the total amount of natural resources and ecosystem services needed to sustain all its operations and activities during a specific year. Analyzing the total ecological footprint over multiple years offers a university a powerful tool for enhancing its sustainability efforts. Firstly, it provides a clear **baseline and trend indicator**, allowing the university to see if its overall environmental impact is increasing, decreasing, or remaining stable. This trend analysis helps in identifying periods of significant change and understanding the effectiveness of past sustainability initiatives. Secondly, by comparing the total footprint with operational changes, such as new building constructions, shifts in energy sources, changes in purchasing policies, or increased research activity, the university can pinpoint **key drivers of its environmental impact**.

The Figure 3, below, illustrates the ecological footprint attributed to activities under direct and indirect control over a five-year period from 2019 to 2023. The blue bars represent the ecological footprint under "Direct Control," while the red bars represent the footprint under "Indirect Control."

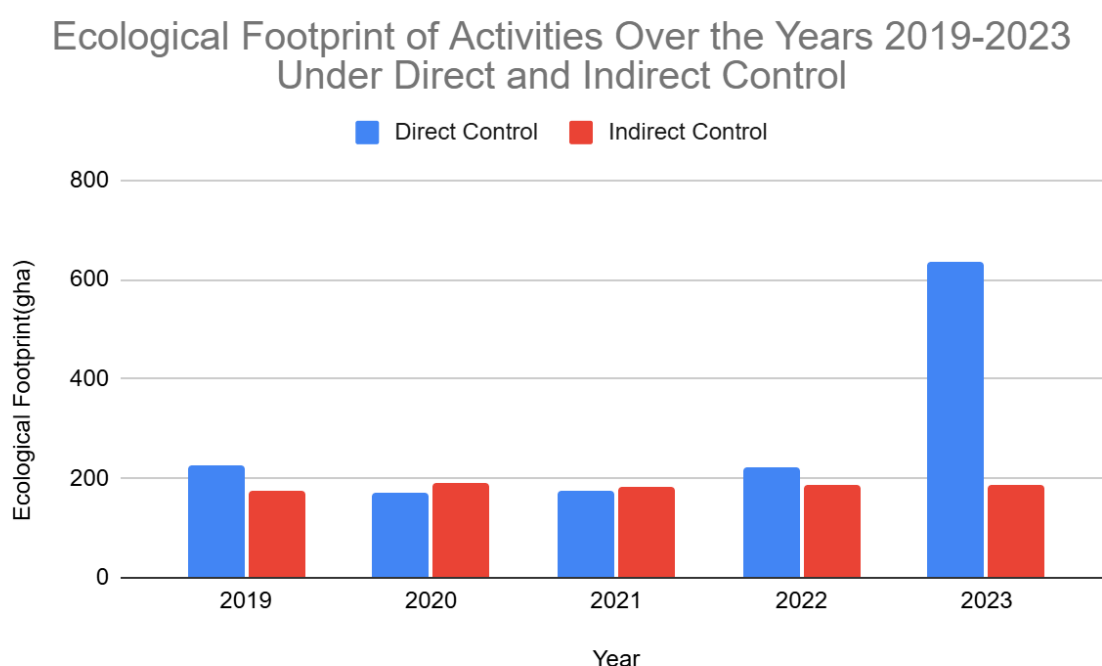


Figure 3: Ecological Footprint of Activities Over the Years 2019-2023 Under Direct and Indirect Control

The most striking feature of the chart is the substantial increase in the ecological footprint under direct control in 2023, while the indirect control footprint shows relative consistency across all five years. This suggests a significant change in directly controlled activities or their intensity in 2023, leading to a much larger

environmental impact compared to previous years and compared to indirectly controlled activities. This increase in value in 2023 is assumed to be due to availability of data on “Furnitures and Furnishings” under direct control of university in “Material and Equipments” subsection. This can be established on deeper analysis in the upcoming sections. Other reasons for increased value of ecological footprint under direct control compared to indirect control in 2019 and 2023 but not in 2020, 2021 and 2022 might be due to COVID which restricted mobility and full functioning of the university.

5.2 Total Ecological Footprint per Student and Staff Over the Years

The “Footprint per student” and “Footprint per staff” metrics measure the natural resources and ecosystem services consumed by the University on an individual basis, specifically for students (those receiving education) and staff (those providing it). These per-person results are especially useful for tracking the environmental intensity of a University's operations over time, because they account for changes in the total number of students and staff, which would otherwise make direct comparisons of the overall ecological footprint less meaningful.

Figure 4 illustrates the ecological footprint in global hectares (gha) per individual, specifically differentiating between students and staff, over a five-year period from 2019 to 2023. The blue bars represent the “Footprint per Student,” while the red bars represent the “Footprint per Staff.”

Throughout all five years (2019-2023), the “Footprint per Staff” is significantly higher than the “Footprint per Student.” This suggests that, on an individual basis, staff members have a considerably larger ecological impact than students. There is an increase in footprint of staff as well as students in 2023 where the increase is quite substantial in case of staff. This again might be due to available data on “Acquisition of Furniture and Furnishings” under direct control of the university in the “Material and Equipment” subsection. The availability and addition of this value increased the footprint generated per staff a lot more than it did per student indicating that the tool assumes staff to impact use of furniture and furnishings acquired by the university much more than it does students.

Footprint per Student and Footprint per Staff Over the Years 2019-2023

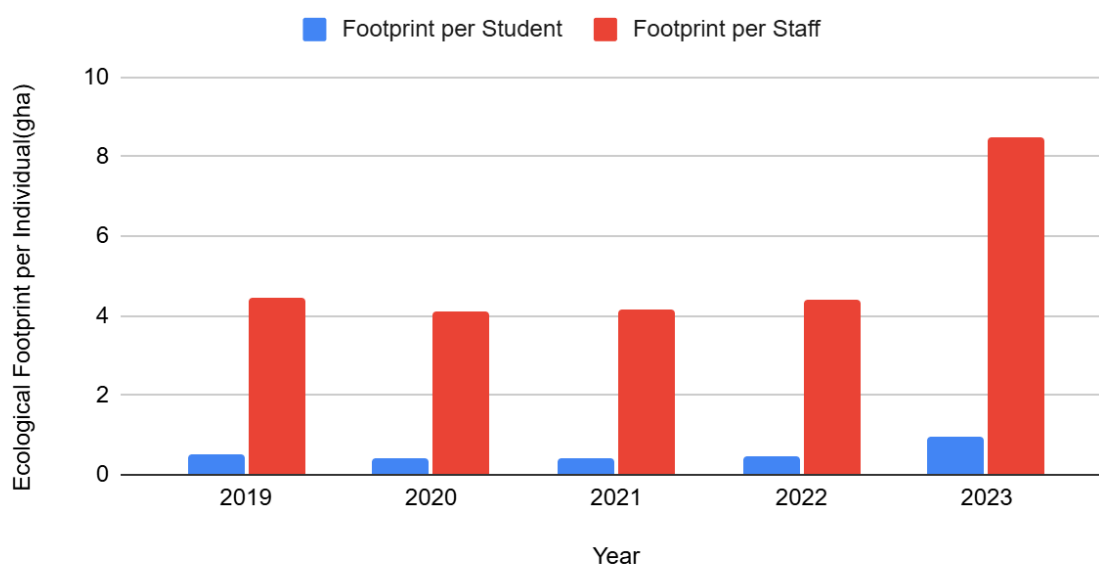


Figure 4: Footprint per Student and Footprint per Staff Over the Years 2019-2023

5.3 Total Ecological Footprint per Number of Graduations Over the Years

The "Footprint per number of graduations" metric quantifies the natural resources and ecosystem services a university expends for each student who graduates. Tracking this annually helps the university assess its efficiency in resource and ecosystem service utilization throughout the educational process.

Figure 5 displays the total ecological footprint per graduation in global hectares (gha) across a five-year span from 2019 to 2023. Each blue bar represents the ecological footprint associated with each graduation event in a given year.

The most notable trend in this chart is the substantial increase in the "Footprint per Number of Graduations" in 2023. This again might be due to available data on "Acquisition of Furniture and Furnishings" under direct control of the university in the "Material and Equipment" subsection. The tool is assuming that the availability of this data in 2023 increases the footprint generated that year by almost double. This shows the importance of acquisition of materials and equipment used by students as well as staff in the overall ecological footprint of the university and how it impacts footprint per graduation in a year.

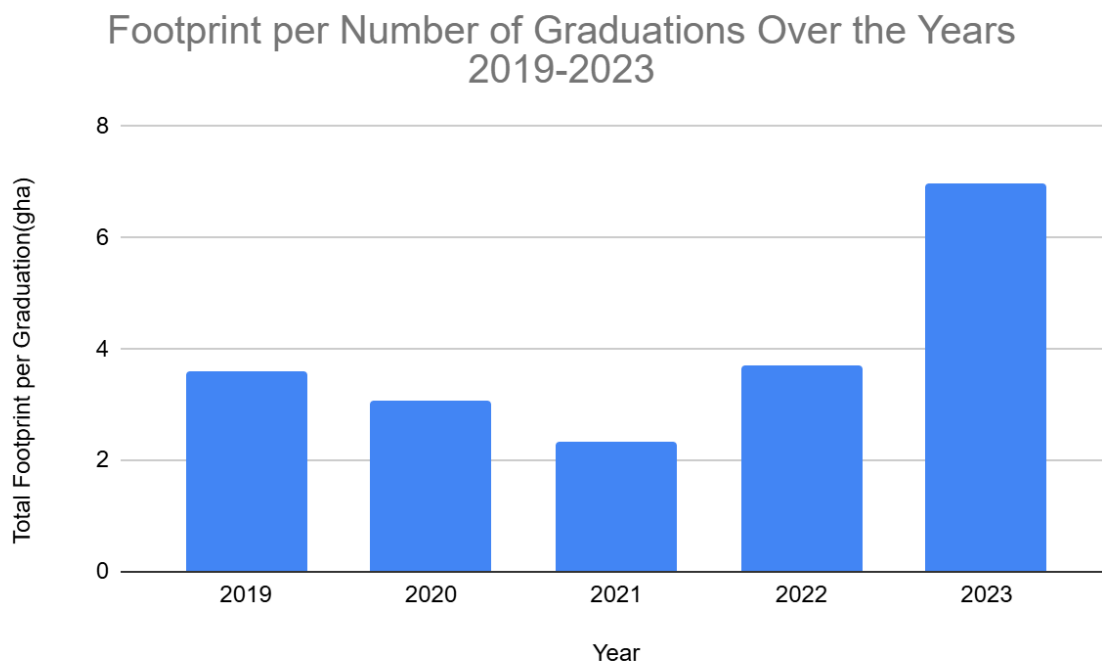


Figure 5: Footprint per Number of Graduations Over the Years 2019-2023

5.4 Total Ecological Footprint per Number of Publications Over the Years

The "Footprint per number of publications" metric measures the natural resources and ecosystem services a university uses to produce a single peer-reviewed journal article in a given year. By tracking this annually, universities can gauge the efficiency with which their staff utilize natural resources and ecosystem services in their research leading to peer-reviewed publications.

The figure 6 illustrates the total ecological footprint per publication in global hectares (gha) across a five-year period from 2019 to 2023. Each blue bar represents the ecological footprint associated with each publication in a given year.

A €7,000 furniture acquisition in 2023 contributed significantly to the total ecological footprint because it involves resource extraction, manufacturing, and transportation, all of which have environmental costs. When this increased total footprint is divided by the number of publications, which may not have increased commensurately, the "Footprint per Publication" metric can show a disproportionate surge. The lack of similar large acquisitions in other years makes this particular purchase a plausible explanation for the distinct spike observed in the data.

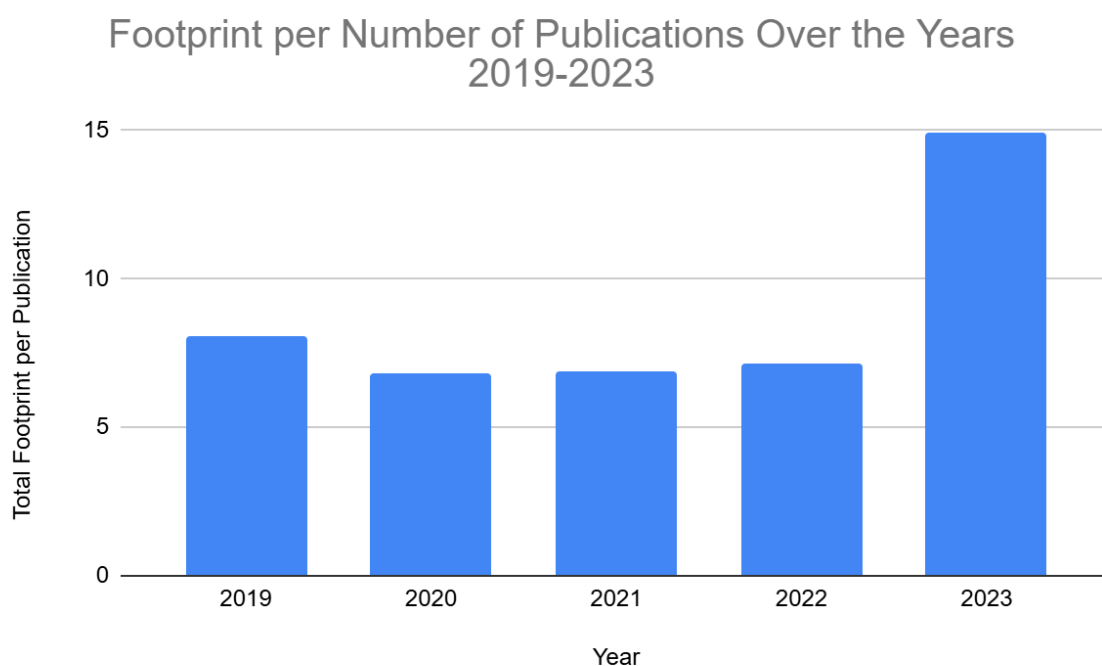


Figure 6: Footprint per Number of Publications Over the Years 2019-2023

5.5 Total Ecological Footprint per Thousand Euro of Funds Received Over the Years

The "Footprint per thousand euro of funds received" metric quantifies the natural resources and ecosystem services consumed by the University for every thousand euros of research funds it receives. Annually tracking this result helps the University understand the environmental intensity of the activities for which it has secured financial support.

Figure 7 illustrates the total ecological footprint in global hectares (gha) generated per 1000 Euros of funds over a five-year period from 2019 to 2023. Each blue bar represents the ecological footprint associated with every 1000 Euros of funds in a given year.

Footprint per 1000 Euro of Fund Over the Years 2019-2023

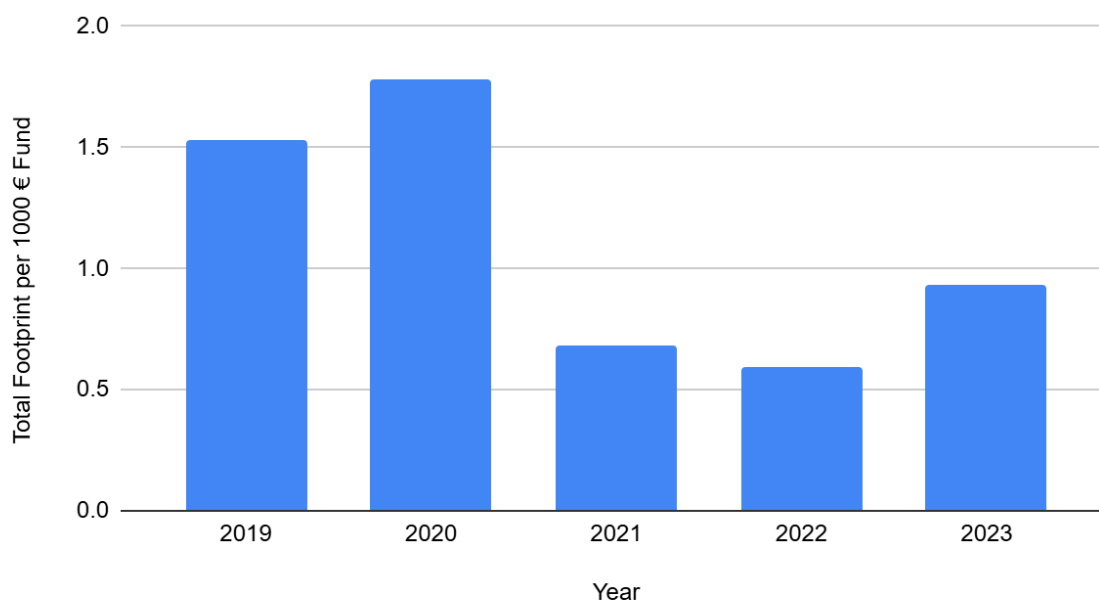


Figure 7: Footprint per 1000 Euro of Fund Over the Years 2019-2023

The funds received in the years were €264,059.73, €203,346.15, €527,837.59, €695505,35 and €879008,12 respectively for the years 2019, 2020, 2021, 2022 and 2023. The analysis reveals a fluctuating but generally improving trend in the university's environmental efficiency per unit of fund received, with 2020 being the least efficient and 2022 being the most efficient. The sharp decrease in "Footprint per 1000 Euro" from 2020 to 2022, coinciding with a substantial increase in funds, suggests a period where the university managed to scale its operations with increasing financial resources without a proportional increase in environmental burden. This occurring in the years 2020 to 2022 might be due to the COVID pandemic. However, the uptick in 2023, despite the highest funding level, warrants further investigation. This time, the campus was functioning fully after the COVID drop. It indicates that the additional activities or investments made with the increased funds in 2023, a part of which was invested in the acquisition of new furniture, might have been more resource-intensive, affecting the overall environmental efficiency per euro received.

5.6 Total Ecological Footprint of All Divisions Under Direct Control in the University Over the Years.

The total ecological footprint of the direct control is a component of the total ecological footprint of the university. It represents a portion of the total natural resources and ecosystem services required by the University for its operations and activities conducted in the year of reference that are specifically under its direct control.

Figure 8 represents the total ecological footprint under direct control of the university in the year 2019.

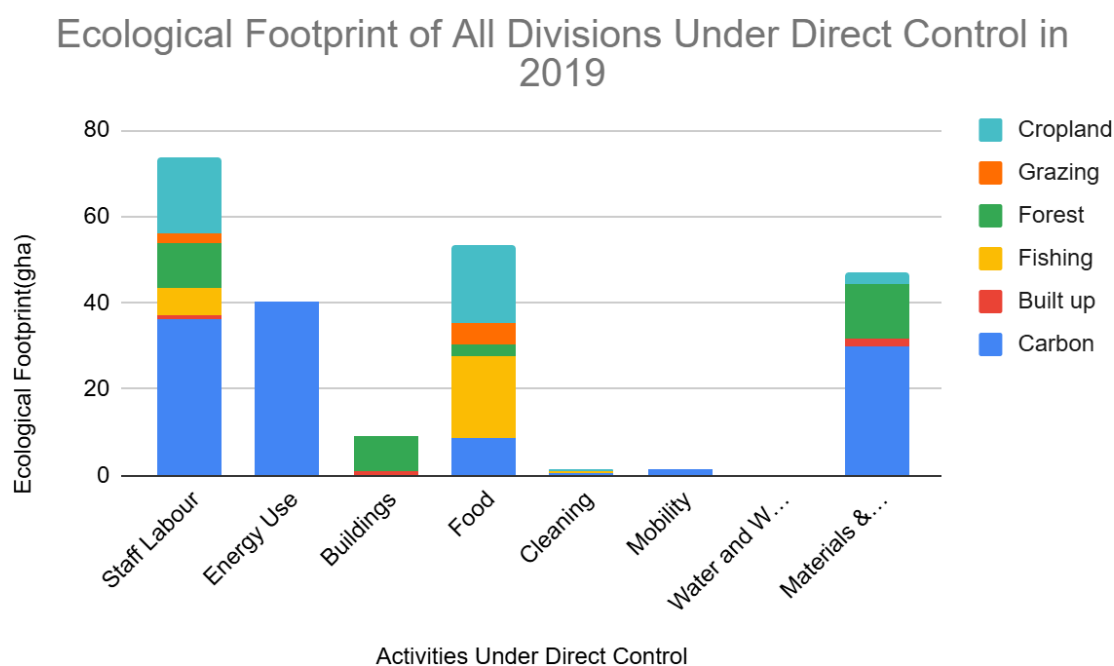


Figure 8: Ecological Footprint of All Divisions Under Direct Control in 2019

The most significant contributors to the overall ecological footprint under direct control are "Staff Labour," "Energy Use," "Food," and "Materials & Equipment." Among these, "Staff Labour" and "Energy Use" stand out as particularly dominant. "Staff Labour" shows a substantial footprint spread across several bioproductive categories, with a notable portion stemming from the carbon footprint. Similarly, "Energy Use" is almost entirely dominated by its carbon footprint component. "Food" also contributes considerably, with its footprint distributed across various categories including carbon, built-up land, fishing, forest, grazing, and cropland. "Materials & Equipment" likewise represents a substantial portion of the total footprint, with its carbon component being the most prominent.

Figure 9 represents the total ecological footprint under direct control of the university in the year 2020.

Similar to the previous year, "Staff Labour," "Energy Use," and "Food" remain the most significant contributors to the overall ecological footprint under direct control. "Staff Labour" continues to show a substantial footprint, largely driven by its carbon component but also including contributions from cropland, grazing, forest, fishing, and built-up land. "Energy Use" also maintains a considerable footprint, almost exclusively dominated by its carbon component. "Food" continues to be a major contributor, with notable portions from carbon, built-up land, fishing, forest, grazing, and cropland. It is more compared to last year because the number of students are increasing which leads to an increase in food consumption and provision as well.

Ecological Footprint of All Divisions Under Direct Control in 2020

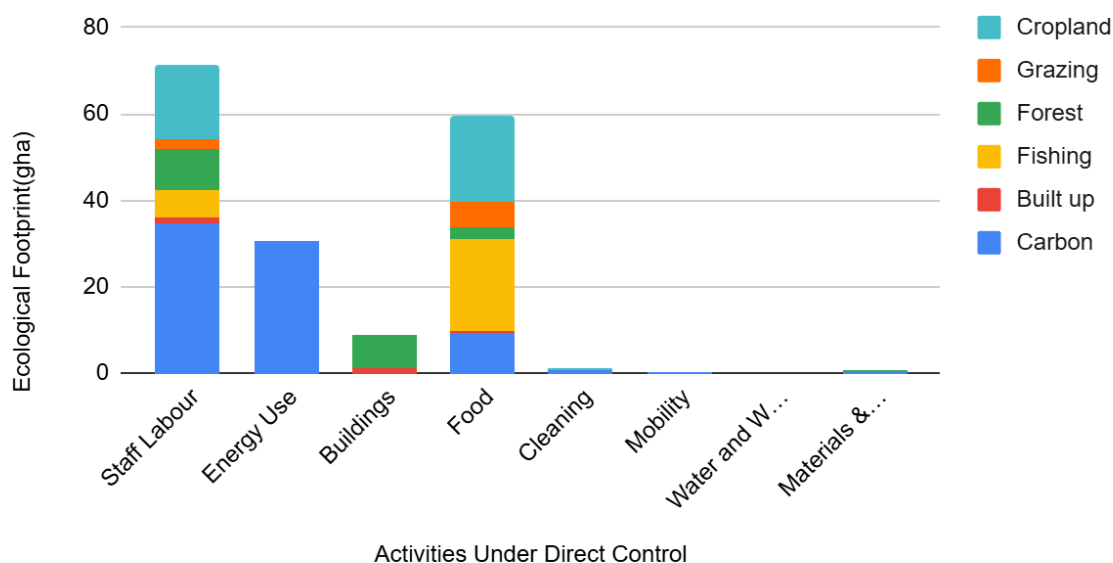


Figure 9: Ecological Footprint of All Divisions Under Direct Control in 2020

Figure 10 represents the total ecological footprint under direct control of the university in the year 2021.

Ecological Footprint of All Divisions Under Direct Control in 2021

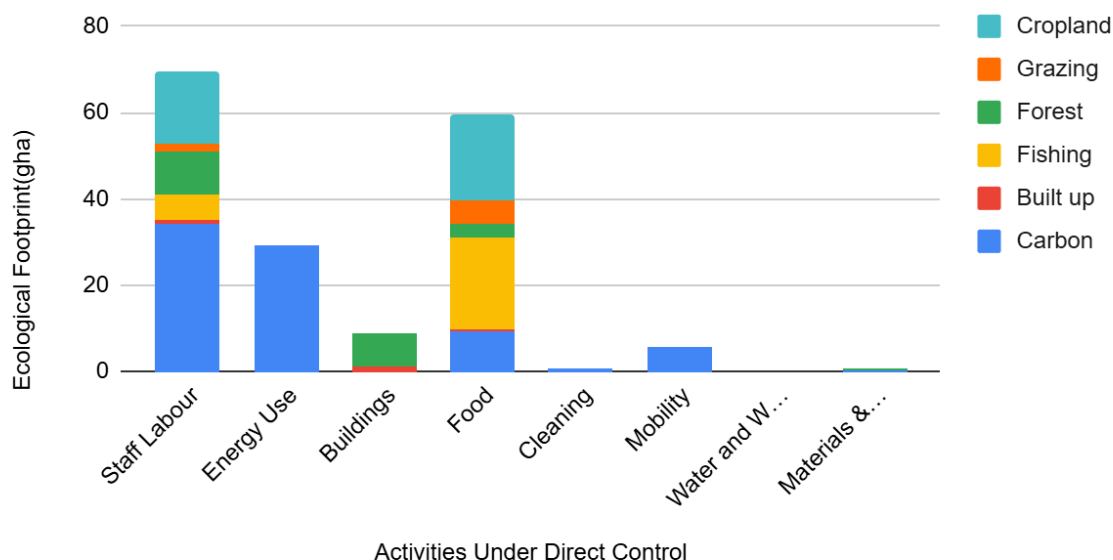


Figure 10: Ecological Footprint of All Divisions Under Direct Control in 2021

"Staff Labour," "Energy Use," and "Food" continue to be the primary drivers of the university's ecological footprint under direct control. "Staff Labour" demonstrates a significant footprint, with its carbon component being the most substantial, followed by contributions from cropland, grazing, forest, fishing, and built-up land. "Energy

"Energy Use" maintains a considerable impact, almost entirely attributable to its carbon footprint. "Food" also remains a major contributor, exhibiting a diverse footprint across carbon, built-up land, fishing, forest, grazing, and cropland.

Figure 11 represents the total ecological footprint under direct control of the university in the year 2022.

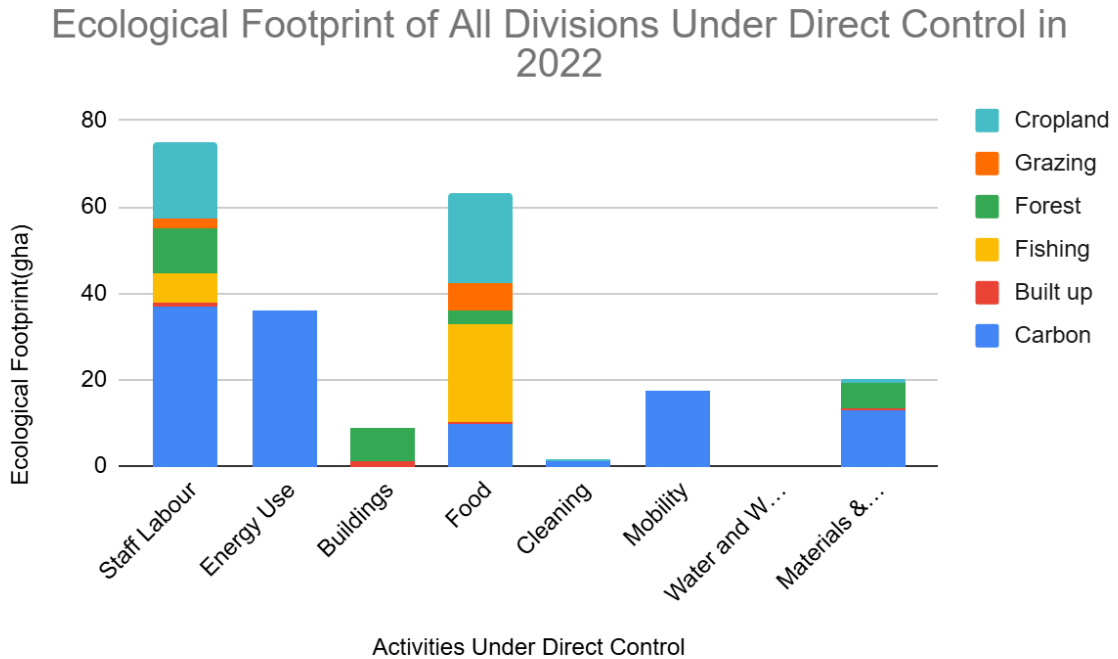


Figure 11: Ecological Footprint of All Divisions Under Direct Control in 2022

Similar to prior years, "Staff Labour," "Energy Use," and "Food" remain the most significant contributors to the direct control ecological footprint. "Staff Labour" continues to show a substantial impact, primarily driven by its carbon component, but also encompassing contributions from cropland, grazing, forest, fishing, and built-up land. "Energy Use" maintains a considerable footprint, almost exclusively attributed to its carbon component. "Food" is also a major contributor, with a notable portion of its footprint coming from carbon, fishing, built-up land, forest, grazing, and cropland.

Figure 12 represents the total ecological footprint under direct control of the university in the year 2023.

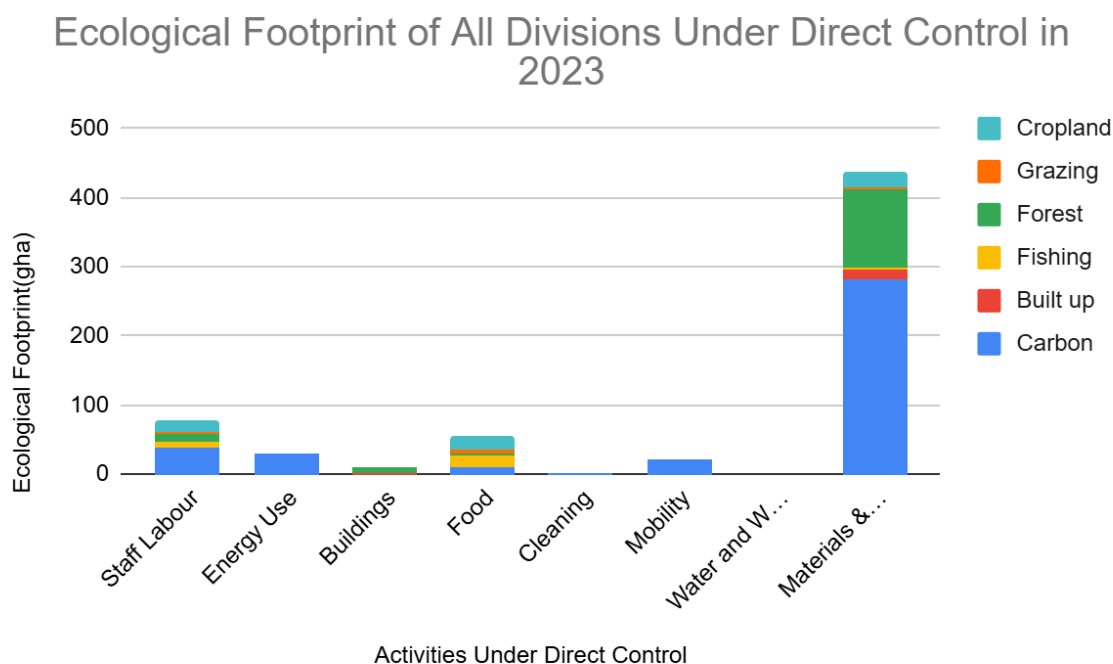


Figure 12: Ecological Footprint of All Divisions Under Direct Control in 2023

The most striking observation in 2023 is the overwhelming dominance of "Materials & Equipment" as the primary contributor to the university's direct ecological footprint. Its impact far surpasses all other categories combined, driven almost entirely by its carbon footprint, but also showing contributions from forest, grazing, and cropland. This is a dramatic shift compared to previous years where "Staff Labour" and "Energy Use" were the top contributors.

While "Materials & Equipment" takes the lead, "Staff Labour" and "Energy Use" still contribute, though their overall magnitudes appear significantly smaller relative to "Materials & Equipment." "Staff Labour" continues to show a multifaceted footprint across several bio-productive areas, with carbon being notable. "Energy Use" remains primarily a carbon footprint contributor. "Food" also continues to contribute, showing various bio productive components, but its overall footprint is considerably smaller than that of "Materials & Equipment." This is due to the acquisition of furniture in 2023 which significantly increased the overall ecological footprint.

The coming sections will closely analyse the trend over the years in each activity under the direct control and indirect control of the university.

5.7 Total Ecological Footprint of Staff Over the Years

Figure 13 illustrates the breakdown of the ecological footprint attributed specifically to staff over a five-year period, categorized by different types of bioproductive areas: Carbon, Built up, Fishing, Forest, Grazing, and Cropland. Each colored line represents the contribution of one of these bioproductive categories to the staff's overall ecological footprint in global hectares (gha) over the years.

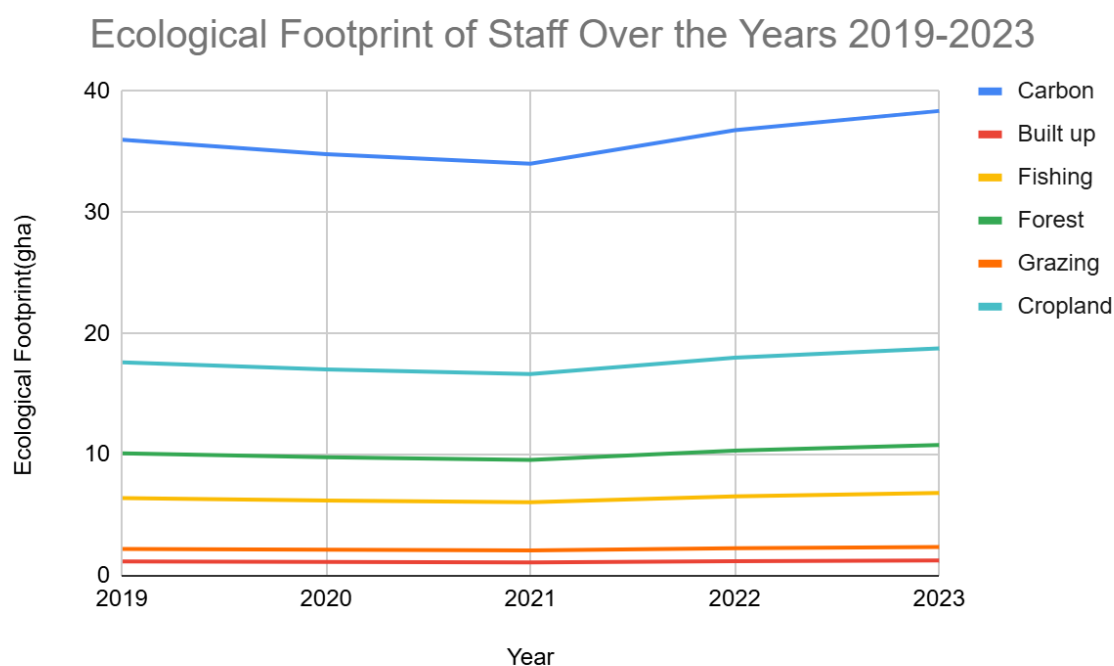


Figure 13: Ecological Footprint of Staff Over the Years 2019-2023

The graph suggests a slight dip around 2021, followed by an increasing trend towards 2023 in all components except “built up” and “grazing” which stays uniform throughout. This overall increase in the later years is primarily driven by the rising carbon footprint which is due to a number of factors, the primary one being acquisition of furniture and increasing energy consumption and mobility. Data shows acquisition of furniture in 2023 which contributes to the increased value. The decreased value in 2021 might be due to lack of mobility and least energy consumption compared to all years. 2019 does not see an acquisition of furniture but mobility is quite high and so is energy consumption at an all-time high. Staff is the prominent user of all these facilities and in turn resources, hence the graph shows a dip in 2021 and a rise in 2023.

5.8 Total Ecological Footprint of Energy Consumption Over the Years

Figure 14 illustrates the ecological footprint specifically from the university's energy consumption, broken down by different types of bioproductive areas, over a five-year period from 2019 to 2023. The vertical axis represents the ecological footprint in global hectares (gha), and the horizontal axis represents the year.

Ecological Footprint of Energy Consumption Over the Years 2019-2023

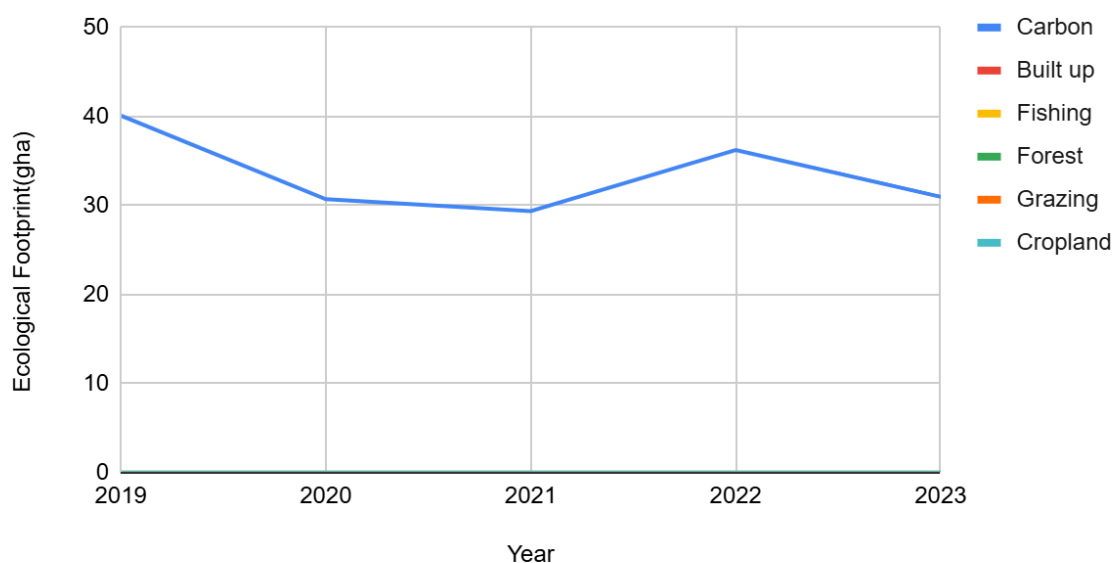


Figure 14: Ecological Footprint of Energy Consumption Over the Years 2019-2023

The carbon footprint associated with energy consumption exhibits a dynamic pattern over the five-year period, initially high in 2019 before noticeably decreasing into 2020 and continuing its decline to reach its lowest point in 2021. This trend then reverses with a significant increase from 2021 to 2022, followed by a slight decrease from 2022 to 2023.

The decline in the carbon footprint from 2019 to 2021 corresponds directly to the decreased consumption of both electricity and methane during these years due to COVID. Both energy sources contribute to carbon emissions, so reductions in their use would lead to a lower footprint.

The subsequent increase in the carbon footprint from 2021 to 2022 aligns with the rise in electricity consumption in 2022, even though methane use continued to fall. This indicates that the increased electricity demand was the dominant factor influencing the carbon footprint in that year.

The slight decrease in the carbon footprint from 2022 to 2023 is particularly insightful. While electricity consumption saw only a minor dip, the methane consumption underwent a substantial reduction in 2023. Furthermore, the university began to produce its own solar energy in 2023. These factors—a significant drop in methane use and the introduction of clean, internally generated solar power—likely worked together to reduce the net carbon emissions from energy, resulting in the observed slight decline in the energy consumption footprint despite relatively high electricity usage. This suggests a positive shift in the energy mix towards lower-carbon sources.

5.9 Total Ecological Footprint of Buildings Over the Years

Figure 15 depicts the ecological footprint specifically attributed to the university's buildings across a five-year period, broken down by different bioproductive areas.

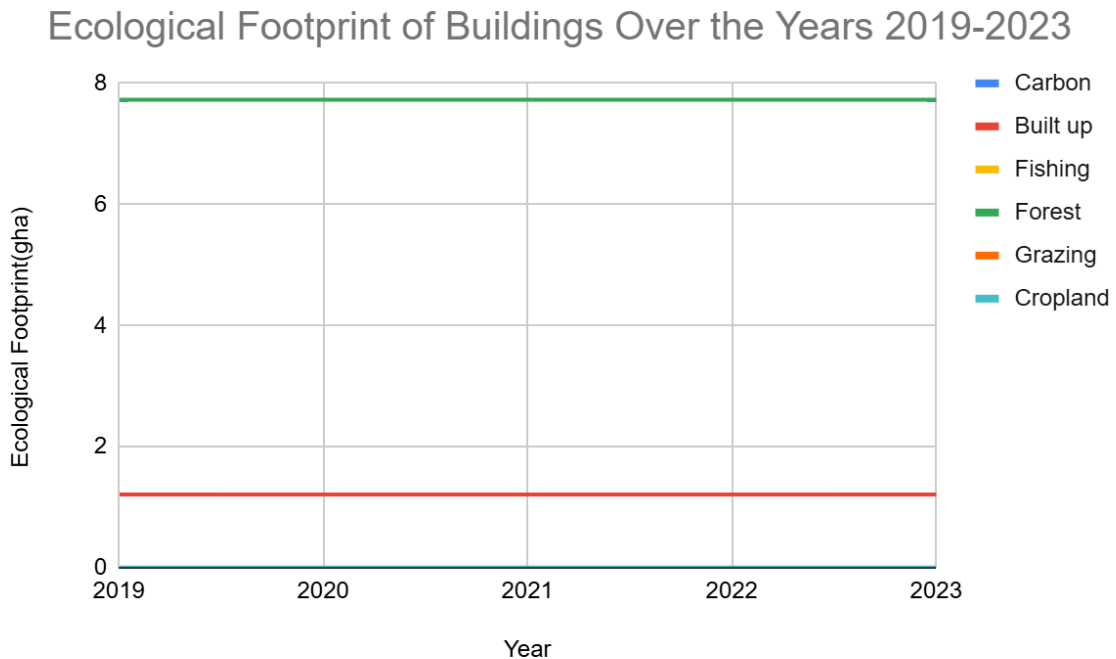


Figure 15: Ecological Footprint of Buildings Over the Years 2019-2023

As observed, the contributions from "Forest" and "Built up" consistently maintain a steady level throughout all five years, while other categories like Carbon, Fishing, Grazing, and Cropland show negligible or zero impact. This unchanging pattern directly reflects that the physical area occupied by the university's buildings has remained constant over the years, leading to no variation in their associated ecological footprint contributions. The high value of forest land is due to the predominant green area around the university.

5.10 Total Ecological Footprint of Food Provision Over the Years

Figure 16 illustrates the ecological footprint attributed specifically to the university's food provision over a five-year period.

Ecological Footprint of Food Provision Over the Years 2019-2023

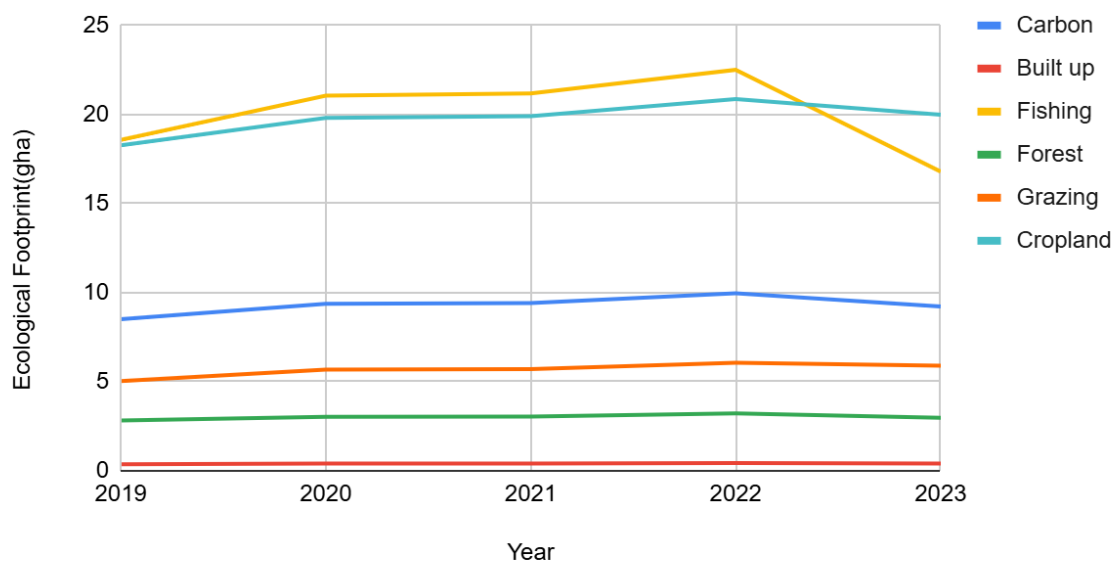


Figure 16: Ecological Footprint of Food Provision Over the Years 2019-2023

The graph highlights that the ecological footprint of food provision is primarily shaped by the consumption of resources from cropland and fishing, with carbon emissions also playing a significant role. The university's food footprint generally increased over the observed period, reaching its highest point in 2022 before showing a minor reduction in 2023. The results do not go hand in hand with values as there is no decrease in any food item for the trend graph to dip in 2023.

5.11 Total Ecological Footprint of Cleaning Services Over the Years

Figure 17 illustrates the ecological footprint specifically attributed to cleaning services. The vertical axis represents the ecological footprint in global hectares (gha), and the horizontal axis represents the year.

The ecological footprint of cleaning services, driven mainly by carbon and cropland, shows an initial decrease from 2019 to 2021, followed by a clear upward trend from 2021 to 2023, indicating an increased environmental impact from cleaning services in the latter part of the period. This increase is largely driven by the rising carbon and cropland components. This is due to majority of funds allocated for cleaning services in 2023 compared to other years. 2020 and 2021 saw least amount of hours dedicated to cleaning and this is reflected in the ecological footprint trend along the years as well.

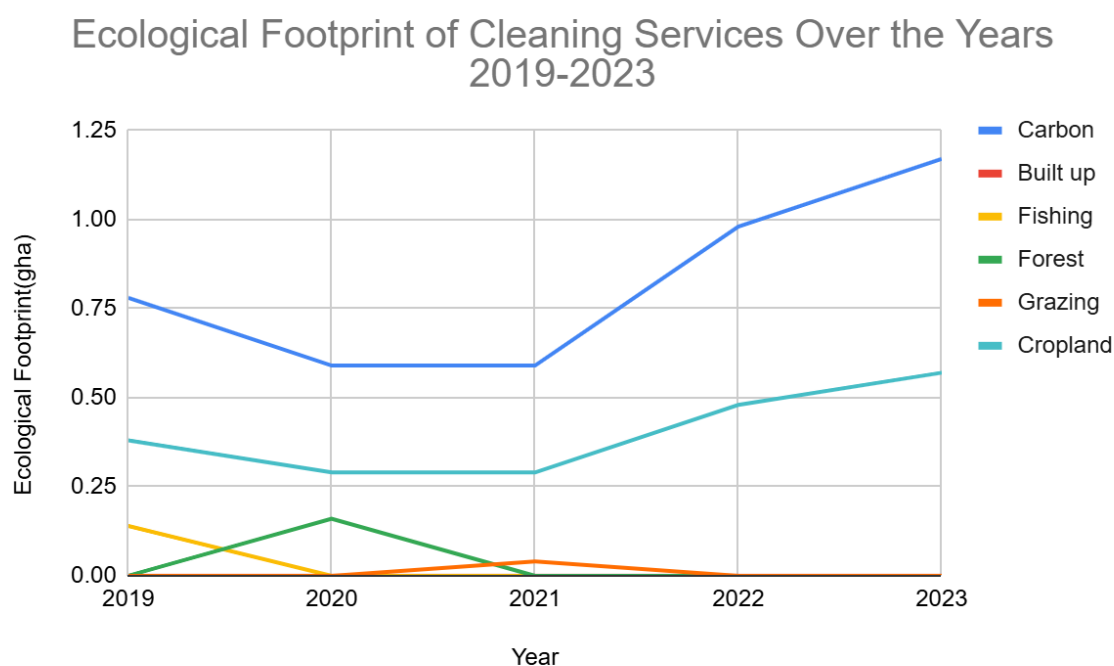


Figure 17: Ecological Footprint of Cleaning Services Over the Years 2019-2023

5.12 Total Ecological Footprint of Mobility Over the Years

Figure 18 shows the ecological footprint specifically generated by mobility, broken down by different types of bioproductive areas, over a five-year period. The vertical axis represents the ecological footprint in global hectares (gha), and the horizontal axis represents the year.

The graph clearly shows that Carbon (blue line) is overwhelmingly the dominant component of the mobility footprint across all years, with all other bio productive categories (Built up, Fishing, Forest, Grazing, Cropland) consistently remaining at or very near zero. This signifies that the environmental impact of mobility is almost exclusively tied to greenhouse gas emissions from fuel consumption.

Observing the trend of this dominant carbon footprint, it starts at a moderate level in 2019, then experiences a significant drop to near zero in 2020. Following this low point, the carbon footprint from mobility shows a sharp and continuous increase from 2020 through 2023, reaching its highest point by far in the final year of the period. This dynamic pattern can be understood in light of the provided context: while university-owned vehicle fuel consumption was highest in 2019, the lack of comprehensive data for other staff and student travel means the full picture for that year is incomplete. The sharp decline in 2020 can be attributed to the impact of COVID-19, which significantly reduced overall travel. The subsequent dramatic increase in the mobility footprint in 2022 and especially 2023, despite lower university-owned vehicle fuel consumption, is explained by the availability of comprehensive data for these later years, which includes significant contributions from personal vehicle use and flights by staff and students. The peak in 2023 specifically indicates that travel via personally owned vehicles and flights became

the maximum contributor to the mobility footprint in that year, reflecting a return to and even exceeding pre-pandemic travel patterns, and highlighting a growing challenge in managing the university's indirect travel-related emissions.

Ecological Footprint of Mobility Over the Years 2019-2023

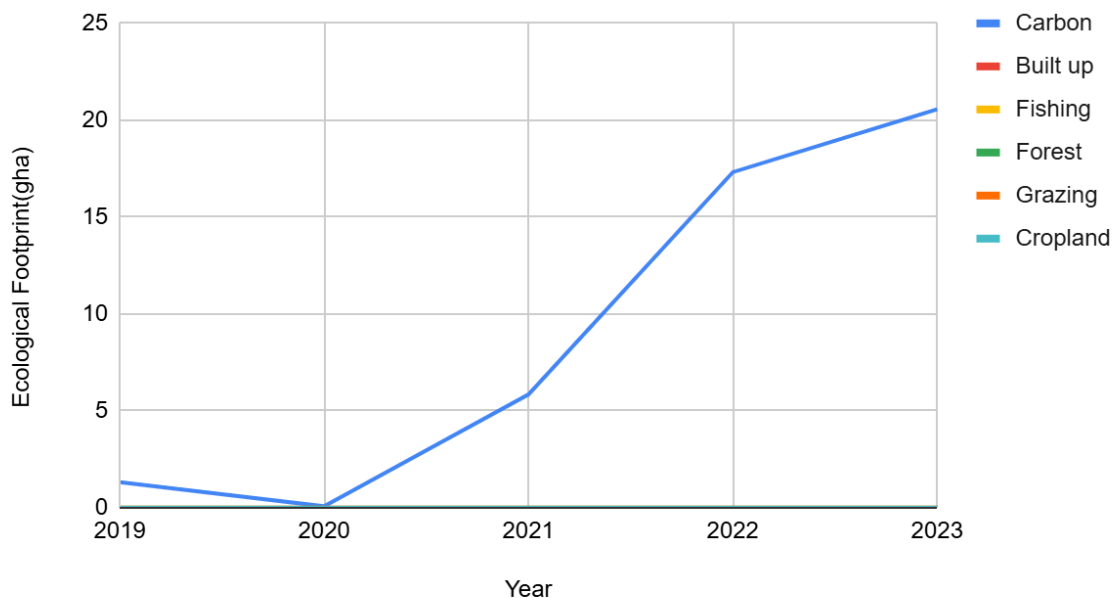


Figure 18: Ecological Footprint of Mobility Over the Years 2019-2023

5.13 Total Ecological Footprint of Water and Wastewater Over the Years

Even though data is available on water consumption of the university, due to lack of information on wastewater and waste generation the tool calculated zero ecological footprint for all five years.

5.14 Total Ecological Footprint of Materials and Equipment Over the Years

Figure 19 is a line graph illustrating the environmental impact associated with the university's materials and equipment consumption from 2019 to 2023.

Ecological Footprint of Material and Equipment Over the Years 2019-2023

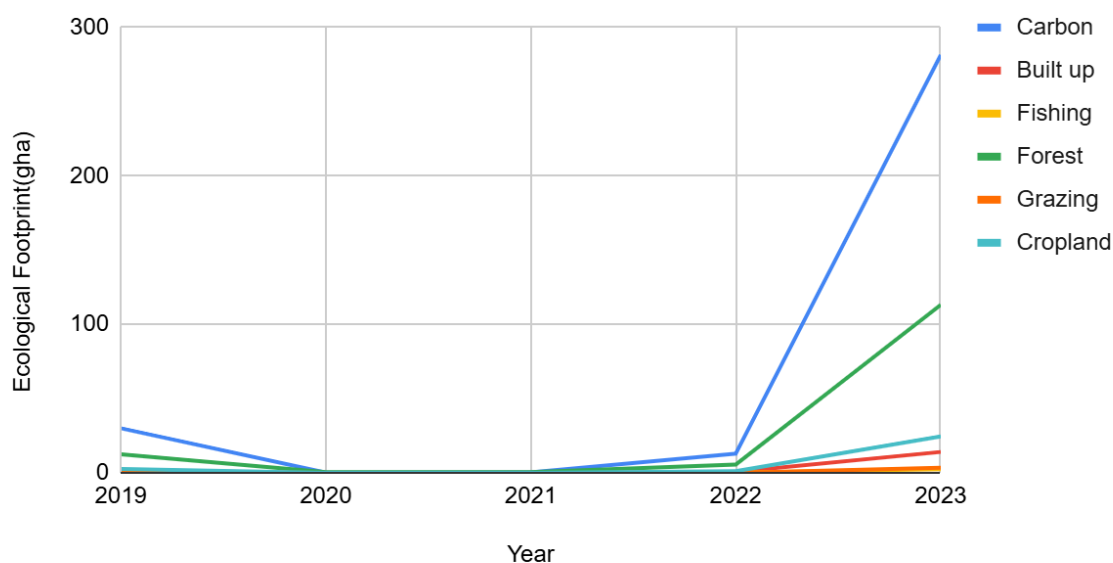


Figure 19: Ecological Footprint of Materials and Equipment Over the Years 2019-2023

A key observation from the graph is the overwhelming dominance of the "Carbon" footprint (blue line) in shaping the overall trend, indicating that greenhouse gas emissions are the primary environmental consequence of materials and equipment use. The "Forest" component (green line) also shows a significant, albeit smaller, contribution, particularly in certain years. Conversely, "Built up," "Fishing," "Grazing," and "Cropland" consistently register negligible or zero impact throughout the period. The carbon footprint for materials and equipment shows a drastic decline from 2019 to 2020 and 2021, becoming almost negligible, before undergoing a dramatic and unprecedented surge from 2021 to 2023, reaching its highest point by a substantial margin in 2023. The forest footprint mirrors this rise in 2023, though on a smaller scale.

The dynamic pattern observed in the graph, particularly the sharp increase in 2023, can be better understood when considering the specific consumption data. The substantial peak in the ecological footprint of materials and equipment in 2023 aligns with the €7,000 worth of furniture acquisition in that year, suggesting that this significant purchase contributed overwhelmingly to the environmental impact within this category. While no specific data on furniture acquisitions is available for other years, its singular mention for 2023 indicates a unique contribution. Interestingly, despite maximum euros being spent on electronic equipment in 2019 and a close second in 2023, these expenditures do not cause a proportionally high ecological footprint on the graph; this suggests that the environmental intensity per euro spent on electronic equipment may be comparatively lower than for other material categories, such as furniture. Conversely, the usage of A4 paper directly correlates with the "Forest" component, with maximum reams used in 2019 and a close second

in 2023, which is reflected in the noticeable "Forest" footprint visible in both of those years, especially the significant rise in 2023. This combined context highlights that the ecological footprint of materials and equipment is not simply a function of monetary spending but is highly dependent on the type and intensity of materials acquired, with large, material-intensive purchases like furniture or high paper consumption having a disproportionate environmental effect.

5.15 Total Ecological Footprint of All Divisions Under Indirect Control Over the Years

As mentioned, tier 1 was chosen to calculate this and the tool used default values for the results.

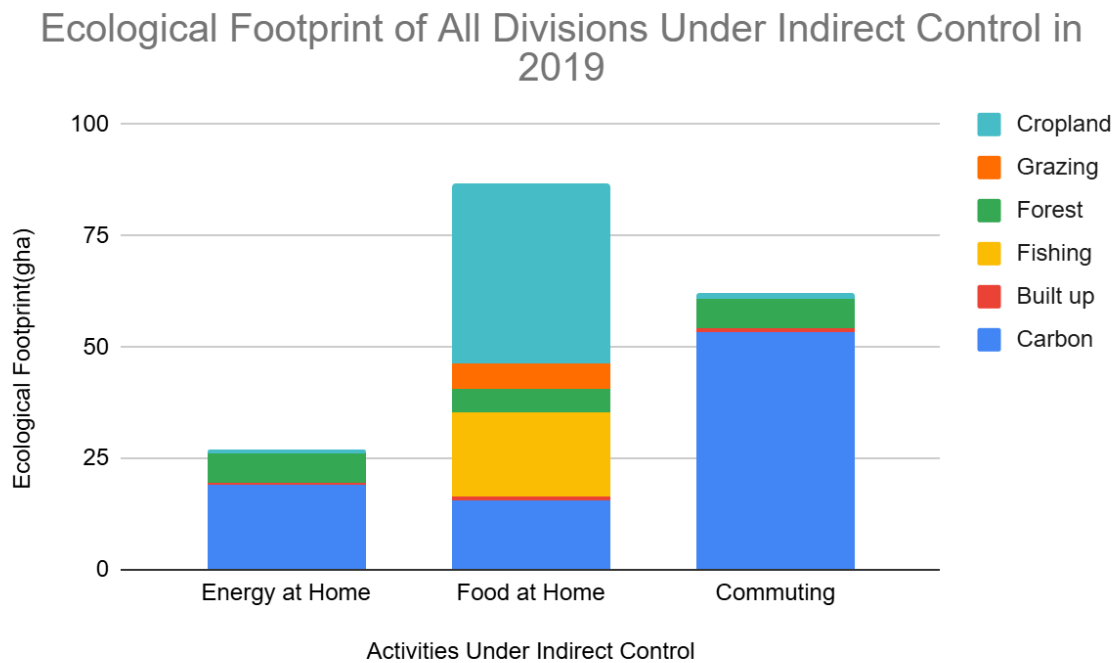


Figure 20: Ecological Footprint of All Divisions Under Indirect Control in 2019

Ecological Footprint of All Divisions Under Indirect Control in 2020

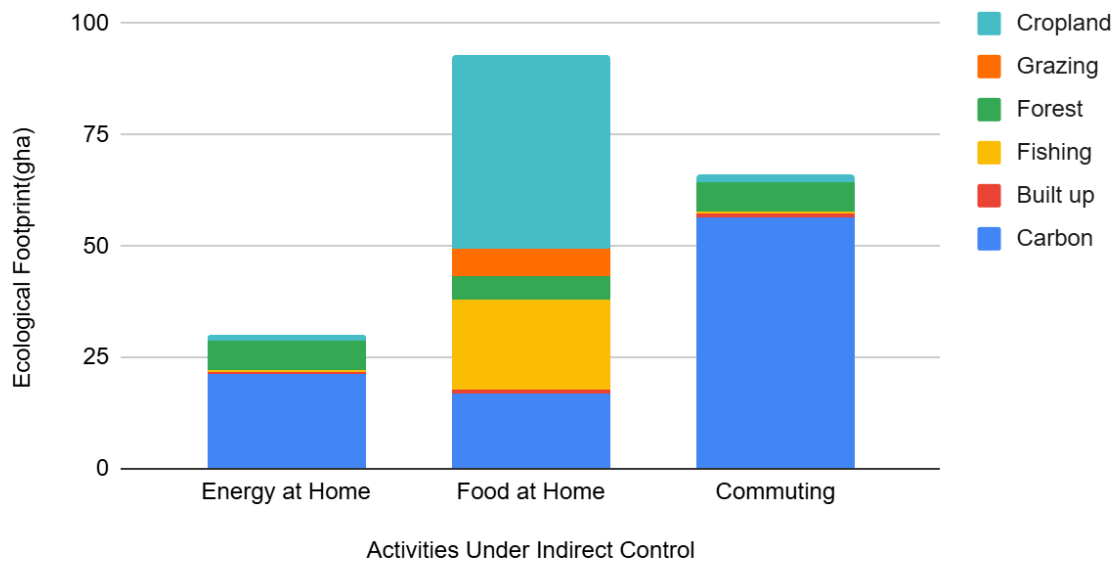


Figure 21: Ecological Footprint of All Divisions Under Indirect Control in 2020

Ecological Footprint of All Divisions Under Indirect Control in 2021

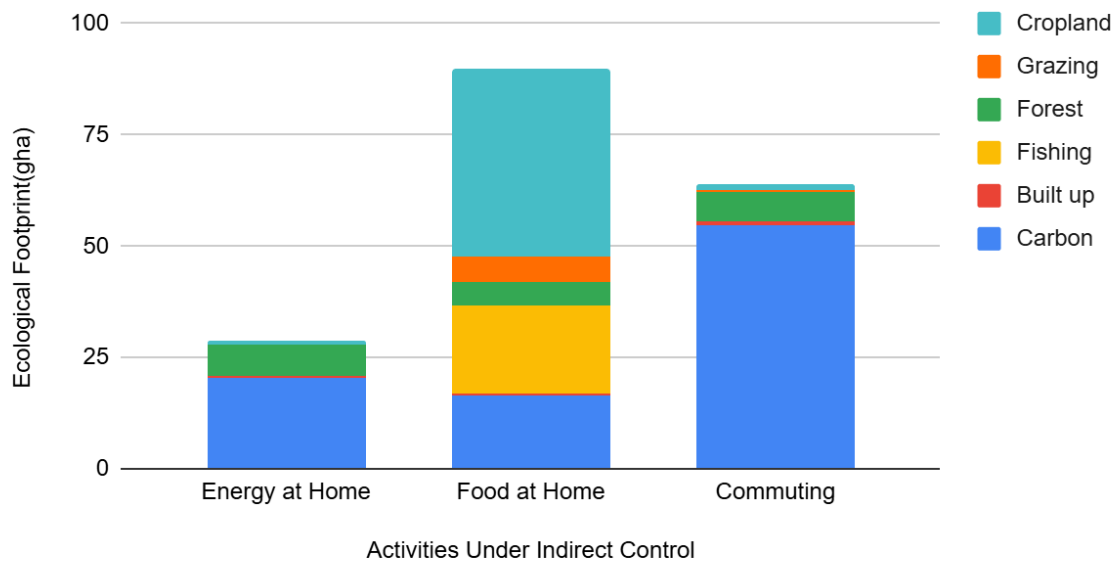


Figure 22: Ecological Footprint of All Divisions Under Indirect Control in 2021

Ecological Footprint of All Divisions Under Indirect Control in 2022

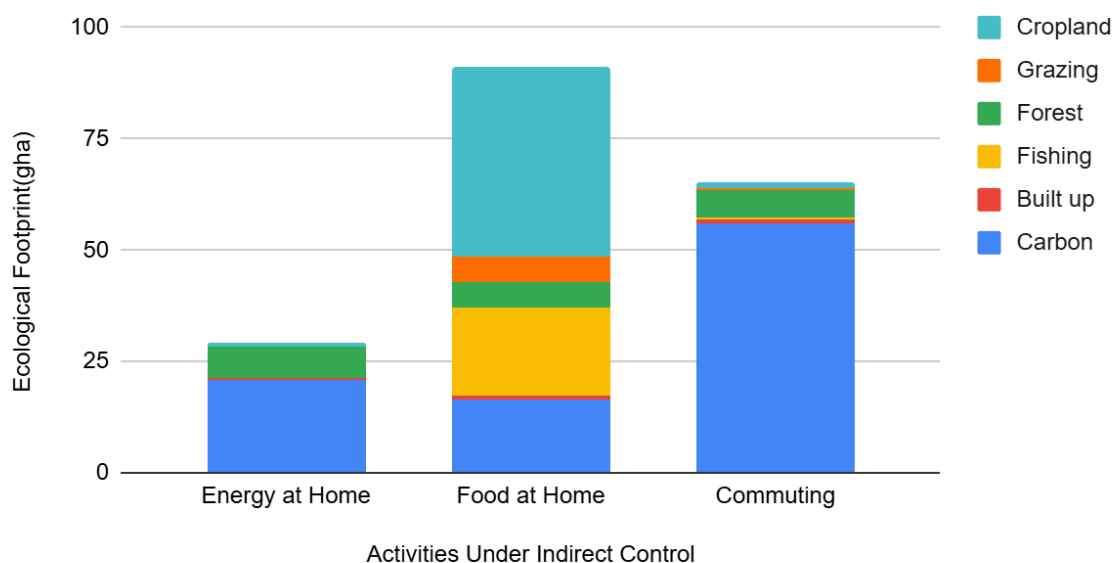


Figure 23: Ecological Footprint of All Divisions Under Indirect Control in 2022

Ecological Footprint of All Divisions Under Indirect Control in 2023

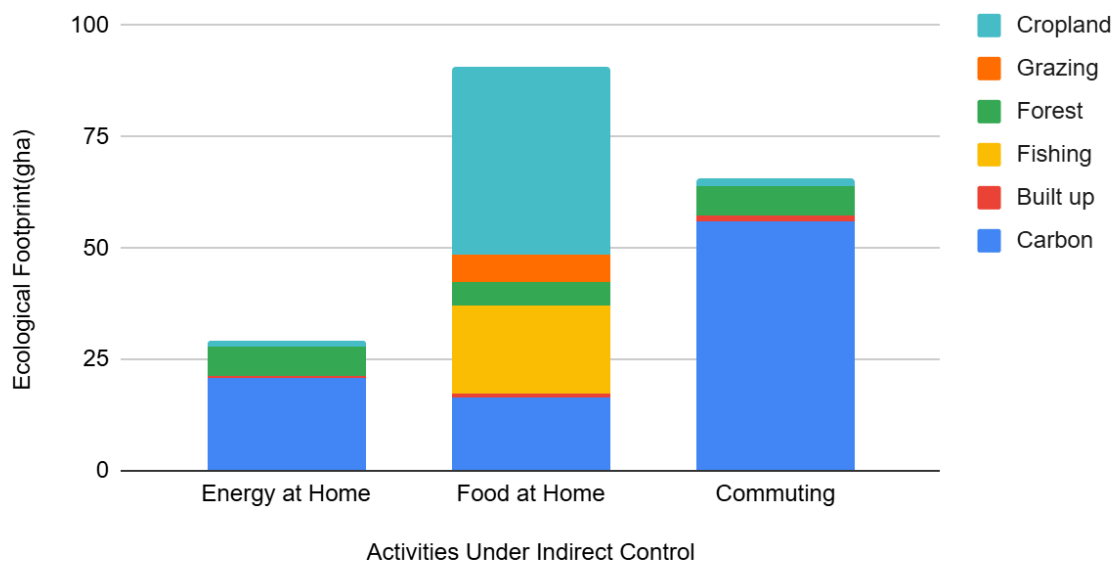


Figure 24: Ecological Footprint of All Divisions Under Indirect Control in 2023

No prominent change observed in ecological footprint of activities under Indirect Control over the years.

6. Conclusion and Future Work

The assessment of ESTCB's sustainability performance using the Ecological Footprint methodology revealed meaningful insights into its operational impacts. Key contributors to the university's footprint included staff activities, energy consumption, and food provision, with a notable spike in 2023 due to furniture acquisition. Per capita footprint values highlighted the relatively higher impact of staff compared to students, and Scope 3 emissions emerged as a growing concern.

Despite challenges in data integration and completeness, the EUSTEPs tool enabled a systematic evaluation of sustainability performance, demonstrating the potential for academic institutions to monitor and reduce their environmental footprint using practical, scalable methodologies. These results emphasize the importance of targeted interventions, especially in procurement and mobility, and advocate for integrating footprint metrics into institutional decision-making.

Future research and institutional efforts should focus on the following:

1. **Data Infrastructure Improvement:** Developing centralized and standardized data collection systems across departments will enhance the reliability of EF assessments.
2. **Tier 2 Method Implementation:** Conducting comprehensive staff and student surveys can enable use of Tier 2 methodologies for more precise calculations of indirect activities.
3. **Waste and Water Data Enhancement:** Since current records on waste generation and water use are limited, efforts must be made to access utility bills, implement internal tracking mechanisms, and include all relevant categories.
4. **Qualitative Integration:** Complementing quantitative EF data with qualitative assessments can offer a more holistic view of institutional sustainability culture and behaviors.
5. **Tool Localization:** Adapting EUSTEPs conversion factors for regional contexts outside the EU would improve accuracy and global applicability.

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