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1 Article

2 Implementing Innovation on Environmental 3 Sustainability at Universities Around the World

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40 **Abstract:** Innovation is known to be an important and influential factor in fostering sustainable
41 development. Yet, there is a paucity of literature on the extent to which universities are successfully
42 implementing innovation in this field. This paper addresses this gap, by examining the role of
43 innovation in the field of environmental sustainability in universities, and by reporting on the
44 results of an international study, in which examples of successful experiences and good practice
45 were identified. The paper outlines the lessons learned from such examples, with the aim of
46 motivating other universities to engage in this rapidly-growing field.

47 **Keywords:** innovation change; experiences; good practice; innovation for sustainable development;
48 higher education

50 1. Introduction

51 To achieve sustainability, innovation needs to be applied to emerging challenges. Innovation is
52 commonly defined as “the implementation of a new or significantly improved product (good or
53 service), or process, a new marketing method, or a new organisational method in business practices
54 workplace organization or external relations.” [1]. Additionally, sustainable innovation reflects
55 innovation that “balances the long-term influences of the process and the output with the needs of
56 people, societies, the economy and the environment” [2].

57 Innovations can not only change societal behaviours and environments, but also ensure that
58 organisations, institutions, communities and society as a whole can become more sustainable [3].
59 According to Dormann and Holliday [4] in a report for the World Business Council for Sustainable
60 Development, innovation is fundamental for creating a sustainable human society and not focusing
61 merely on more efficient approaches. Thus, radical and systemic innovations to products, services,
62 and business models are needed [5,6].

63 Over the last decade, sustainability and the importance of sustainable development has been
64 increasingly acknowledged by academics, policy-makers and industry [e.g 7,8]. This is due, in part,
65 to current global environmental challenges, such as increasing extreme weather events [9], food and
66 water shortages [10], degradation of ecosystems and biodiversity [11], and a widening gap between
67 the rich and poor [12]. These global challenges were also discussed in the Global Environment
68 Outlook GEO-6 [13], which highlights the importance of innovation for transformative change.

69 UNESCO initiatives [14], the Halifax Declaration [15], the Talloires Declaration [16], and
70 Europe’s independent COPERNICUS-CAMPUS [17] are examples of schemes that have shown that
71 higher education institutions (HEIs) have become conscious of their sustainability practices and
72 performance among faculty, students, and the community. Many international strategies,
73 declarations and university commitments offer support to the implementation of sustainability in
74 HEIs [18], but despite several political initiatives and the important role played by higher education
75 for sustainable development, education for sustainable development is not yet very well widespread
76 [19]. A call for greater collaboration in HEIs is thus necessary. Faculty and administrators, together
77 with environmental practitioners, could develop interdisciplinary approaches to curricula, research
78 initiatives, operations, and outreach activities that support an environmentally sustainable future
79 [16].

80 In order to yield the expected benefits, sustainability in higher education requires whole-
81 university approaches [20-22]. Yet its incorporation into HEI practices is often fragmented. More
82 often than not, sustainability finds itself positioned in discipline-based sustainable development
83 courses. Such initiatives are often not multidisciplinary nor transdisciplinary [23] and do not consider
84 sustainable development in institutional policy [20] which could enhance innovation. The education
85 taking place in HEIs is often not yet seen as a catalyst for innovation and social change aiming to
86 create a sustainable society [24]. Yet, HEIs need to include education for sustainable development
87 into broader activities so that they may pursue sustainability and create opportunities for innovation
88 [25]. Innovations taking place at HEIs include emphasising the idea of campus well-being where
89 activities that promote sustainability feature inter- and transdisciplinary approaches [22]. The
90 freedom to design innovative transdisciplinary sustainable development-oriented content in HEIs is
91 limited by elements such as accreditation procedures, institutional conditions that include
92 disciplinary structure, the dependence on specific a few experts, and the financing of courses that
93 mostly considers student interest (and attendance) in some disciplines [20].

94 Sustainability practices can be incorporated into the formal HEI curricula by offering students
95 the opportunity to become leaders for change through the experience of contributing to change, also
96 known as a curriculum and operational innovation [26]. Coursework that requires students to
97 integrate knowledge across the boundaries of disciplines can lead to higher levels of
98 transdisciplinarity and competence development. Initiatives which require students to integrate
99 knowledge across the boundaries of disciplines may include provisions for initiatives within the
100 organisation (e.g. on energy conservation, waste prevention or emissions reductions). Combined,
101 these may feed into the whole institutional approach.

102 The promotion of Education for Sustainable Development (ESD) has been taking place due to
103 critical transition factors beginning with the acceptance of environmental principles, sustainable
104 development perspectives through individual initiatives that policy-makers are aware of, new
105 transdisciplinary programs, networking, and whole-institution approaches that include practical
106 green campus initiatives. Transdisciplinary initiatives, changes in teaching and learning processes
107 and innovation in the content of university curricula may then occur [20].

108 HEIs are often fragmented in their efforts, with little sign of holistic implementation [27] despite
109 the call by UNESCO to move towards whole-university approaches. The shift needed is in
110 organisational culture, including developments in sustainability practices in teaching and learning,
111 research, community engagement [20,22,28] and campus management. Leadership is fundamental to
112 the integration of sustainability in HEIs maintaining consistency, collaboration and systemic
113 approaches to management [29]. However, university management may not appreciate the
114 importance of innovation and sustainability with regard to addressing social and economic
115 inequalities throughout the university [30]. Many universities work towards securing funding that
116 allows for research outputs and they may not take the social and environmental aspects of
117 sustainability into consideration [20]. The latter issue, is the focus of this paper.

118 The engagement of all members of the university, especially –but not only – senior
119 administration is crucial in order to ensure top-down and bottom –up support [22,30]. Those
120 managers with a sustainability vision need to also allow innovation to emerge bottom-up.
121 Communication between stakeholders both on and off campus is essential to the success of HEI
122 sustainability initiatives. HEIs that showcase innovative examples of sustainability stimulate
123 innovative potential and become a testing field for change. HEIs should move toward collaborative
124 development of knowledge and initiate dialogue in their respective communities. This collaboration
125 will project the HEI's vision and put forward its ethical position. HEIs can then become an example
126 of sustainability in society [22]. Adjustments to academic priorities, organisational structures,
127 financial and audit systems, advanced strategic integration, staff development, collaborative
128 partnerships and dialogue amongst stakeholders are required for HEIs to become learning
129 organisations that progress sustainability [31]. And that do justice to the environmental potential of
130 sustainability practices.

131 Strategies to advance innovation in sustainability in HEIs as a whole, and on environmental
132 sustainability in particular, have many obstacles and challenges. Some of the main barriers to
133 innovation and sustainability at HEIs are associated with management [30]. Other barriers have been
134 identified as: resistance to change; lack of support from institutional administrators [32]; lack of
135 specific working groups, committees and sustainability offices; cultural and behavioural change; lack
136 of financial resources; lack of engagement between municipalities, companies and universities; lack
137 of reporting and accountability mechanisms; and institutional culture [30].

138 Having other authors focused on eco-social innovation connected to sustainability in higher
139 education and explored how to apply these new forms of learning [33], this paper is interested in
140 examining the role of innovation in the field of environmental sustainability and reports on the results
141 of an international study, in the context of which examples of successful experiences and good
142 practice are identified. The paper outlines the lessons learned from such examples, with the aim of
143 motivating other universities to engage in this rapidly-growing field.
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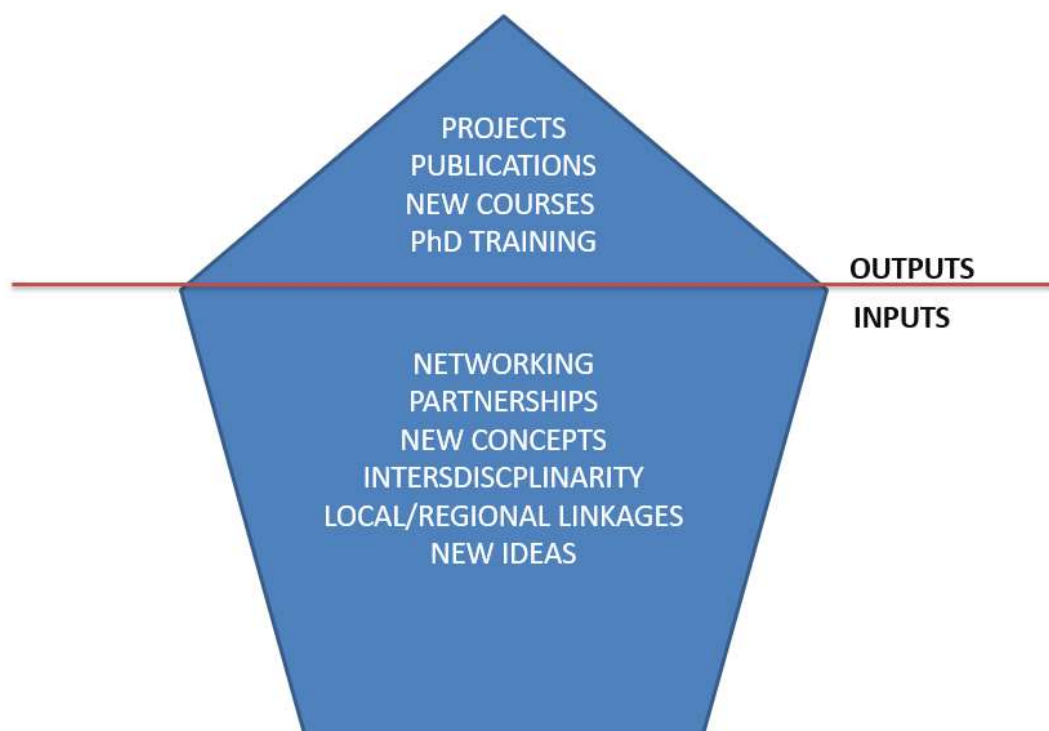
145 **2. State of the art: Innovation and Sustainability at Universities today**

146 Innovation in sustainability must be grounded in research and knowledge generation.
147 Consequently, universities have a role to play in finding solutions to sustainability problems [34].
148 While universities might be aware of how research can contribute to sustainable innovation, the role
149 of the student population in finding social, economic, legislative, and technological innovations to
150 help address what are sometimes known as contemporary ‘wicked problems’, is less understood [2].

151 Innovation in sustainability on campuses can be in respect of operations, education, and/or (the
152 impact of) research. Verhoef and Bossert [35] state that “For many university operations departments,

153 changing to sustainability and/or circularity principles is (very) new and requires (big) changes.”.
 154 The authors highlight that this process may take some time and require innovative efforts, such as
 155 the use of ambitious standards for buildings in order to contribute to CO2 reduction targets and
 156 circular systems, for example.

157 Living Labs, another approach to innovation, are well suited for ‘wicked’ multi-stakeholder
 158 problems or solutions. They build on three corner stones: learning integral element in the projects,
 159 involvement of users, and innovation as a goal. A systematic organisational and management
 160 approach to urban Living Labs was recently published by Steen and van Bueren [36] and for
 161 household-related Living Labs by Keyson et al. [37]. At a university campus, the unique possibility
 162 exists to have researchers deploy their findings on their own premises, and for students to be both
 163 experimenters and users of the services provided, thus enriching their learning. Combining research,
 164 education and campus operations in the form of Living Labs has been discussed in various
 165 international sustainable university workshops (e.g. ISCN, 2017, HSDS, 2017). Approaches
 166 employing Living Labs at universities are also emerging, leading to frameworks for Living Labs for
 167 sustainability on campuses [38] and successful examples, amongst others at Delft University of
 168 Technology [39], at the Eidgenössische Technische Hochschule Zürich [40] and at the European
 169 School of Sustainability Science and Research (ESSSR) in Hamburg. A recent book produced by a
 170 team led by ESSSR also handles this topic [41] and explores the connection with the Sustainable
 171 Development Goals. ESSSR pay a special emphasis to innovation and Figure 1 explores the various
 172 innovation dimensions of its works.
 173



174
 175 **Figure 1 - Innovation dimensions of ESSSR's works**
 176

177 Universities have a responsibility to not only drive innovation, but also role model the use of
 178 innovative technologies that promote sustainability as a whole, and environmental sustainability in
 179 particular. Their role as education institutions allows universities to teach students about the
 180 importance of sustainability [42,43] and modern and socially relevant themes such as climate change
 181 mitigation tools and techniques [44], while providing opportunities for students to explore
 182 innovative solutions to environmental degradation [45]. Thus, by making use of sustainable
 183 innovations, universities can potentially instil values that are grounded in environmental
 184 sustainability at local, national and international levels [46]. Given many decision makers in

185 communities, organisations and politics are university graduates this is significant and can have
186 flow-on effects for sustainability as students graduate and work across sectors [47].

187 Finally, many universities also own large estates where the potential for environmental
188 improvements are significant. The potential alone for carbon savings is significant, estimated at 0.7
189 Gton/yr equivalent to approx. 1.5% of global CO₂ emissions in a recent publication [35,48]. In
190 addition, innovative solutions implemented by one university and then shared with the sector might
191 have the potential to contribute to carbon savings and other positive impacts on social, environmental
192 and economic sustainability. The Green Gown Awards in the UK are such an example. They started
193 in the UK in 2004 and moved to Europe in 2006 and Australasia in 2010. They involve universities
194 competing for awards linking campus and curriculum innovations and through the award process,
195 they promote examples of good sustainable practices [49].

196 3. Methodology: a survey of Innovation and Sustainability at Universities

197 3.1. Survey design

198 In order to address the research question: “to which extent are universities using innovation as
199 a tool to implement sustainability?” and fill in the research gap on specific information about the
200 implementation of innovation and sustainability at universities around the world, a questionnaire
201 survey was undertaken. The aim of the survey was to understand whether and how universities
202 innovate with regards to environmental issues. This was based on the assumption and definition
203 given above that innovation in relation to sustainable development is strongly linked to improved
204 products, processes and services. When it comes to the context of universities, the focus of our study,
205 the survey aimed to portray the opinions and realities at different institutions with regard to their
206 outlook of innovation and sustainability in addition to associated attitudes, practices and beliefs. The
207 first list of items was reviewed by the authors to minimize redundancies and similar items and to
208 ensure that all important questions were added. The questionnaire survey was pre-tested by a panel
209 of academics within sustainability areas at different universities, as already performed by other
210 studies [50]. The survey instrument was composed of 20 questions (fifteen closed questions and five
211 open questions) and structured in a way that it could gather information on the universities’
212 experiences. Table 1 presents the topics and issues covered in the questionnaire.

213 **Table 1.** Summary of the topics and issues covered by the questionnaire survey.

Area	Topic	Assessed issues	Options
General	Sociodemographic characteristics of the respondent and university	Country, Region, Role	--
	University’s participation in awareness-raising activities	My university participates in awareness-raising activities and assists with distributing information and advice.	
Sustainability	Environmental sustainability team and Environmental sustainability policy	My university has an environmental sustainability team who raise awareness of environmental sustainability across the organisation.	
	Importance given to programme development to achieve the commitments of its environmental sustainability policy and plan	My university has an environmental sustainability policy.	Strongly disagree, Disagree, Don't know, Agree, Strongly agree
	Actions planned to demonstrate the commitment to reduce the university’s environmental footprint and	My university participates in program development and in implementing ideas to achieve the commitments of its environmental sustainability policy and plan.	
	Actions planned to demonstrate the commitment to reduce the university’s environmental footprint and	My university has planned its actions for the next three years to demonstrate its commitment to reducing the university’s environmental footprint and seeking to continually improve its environmental performance.	

	to improve the environmental performance		
	Promotion of waste, energy and water management and the benefits of active travel	My university promotes improved waste, energy and water management and the benefits of active travel.	
	Carbon reduction targets at the university	My university contributes in its operation to achieve the carbon reduction targets set by the government	
	Education of students about the impact of climate change	My university educates its students about the impact of climate change on the discipline chosen by the student.	
	Scope of last/current project of innovation and the objectives involved in the project	What scale is the scope of your current or last project/programme? What objectives were involved in this project?	university-wide, faculty, department, support services, other new buildings, renovations, mobility, services, other
Innovation	Innovation implemented in the program and how the innovation was managed	What kind of innovation was implemented? How did you manage / organise innovation?	Technological, organisational, educational, financial, other living lab tools, TRL's, R&D management, adoption theories, other
	Standards used to reach a better performance	Which standards were used to come to new / better performance?	BREEM, WELL, ISO14000, in house standard, other
	Open questions	Description of the most successful project/program on innovation and sustainability, their nature, innovative aspects, benefits, challenges/problems and publication of results.	--

214

215 The online survey was carried out from 28th September to 4th December 2017 using
216 SurveyMonkey.

217

218 3.2. Sampling

219 The survey was disseminated via a web link through email to the following groups, based on
220 Leal Filho et al. [50]: rectors and office managers of a wide range of universities, including those
221 which participated in the Green Sustainability Metrics 2016; authors of publications on the subject
222 "sustainability at universities" in the Web of Science between 2007–2016; participants in the World
223 Symposium on Sustainable Development at Universities, held in September 2016 at the
224 Massachusetts Institute Technology in the United States of America; Rectors of Brazilian federal
225 public universities; Rectors of Portuguese public universities; Representative of Universities (rector,
226 sustainability office manager, researcher/teacher) participating in the Inter-University Program for
227 Sustainable Development Research (IUSDRP); Representatives of the Universities participating in the
228 Copernicus Alliance; Rectors and Managers of the Sustainability Office of the Universities
229 participating in the Association, for the Advancement of Sustainability in Higher Education
230 (AACHE). Approximately 1.000 persons were contacted, in 40 countries (distributed approximately
231 as follows: 40% of them in Europe, 30% in Asia/Oceania, 15% in Africa, 10% in South America and
232 5% in North America). Responses were obtained from 73 universities in 17 countries, spread among
233 all continents. The **validity** of the data is assured since it derived from bona fine academic institutions
234 and supplied by well-informed sources. The **reliability** of data is also assured, since those who
235 replied are very familiar with the concept of sustainability and have an understanding of the

236 emphasis to this topic in their own institutions. The same data can be verified in a few years' time,
 237 which is also a characteristic of valid studies.

238 There are two main limitations with this approach: firstly, the answers derive from people who
 239 are motivated and knowledgeable enough to reply, so many others were not included. Secondly, only
 240 17 countries took part and the spread of the responses does not allow conclusions to be drawn about
 241 the implications of the work to different geographical regions. On the other hand, a study on
 242 innovation on matters related to sustainable development in 17 countries is so far unparalleled in the
 243 literature, hence adding a degree of innovation and new insights into this key topic.
 244

245 3.3. Data analysis

246 A total of 73 responses were received and analysed. The numerical data collected were analysed
 247 using SPSS 23® in order to perform descriptive statistics. The five open ended questions were
 248 analysed through content analysis [51], allowing (i) development of a classification of the answers in
 249 unit categories, and (ii) integration of categories and their meaning, to provide data interpretations.
 250

251 4. Results and discussion

252 Most of the questionnaire's respondents were from European universities (47%). North
 253 American, South American, African and Asian universities were represented by 10 to 16% of the
 254 respondents and Australasian were only 1%. Figure 2 shows the countries represented on the study.
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 256
 257



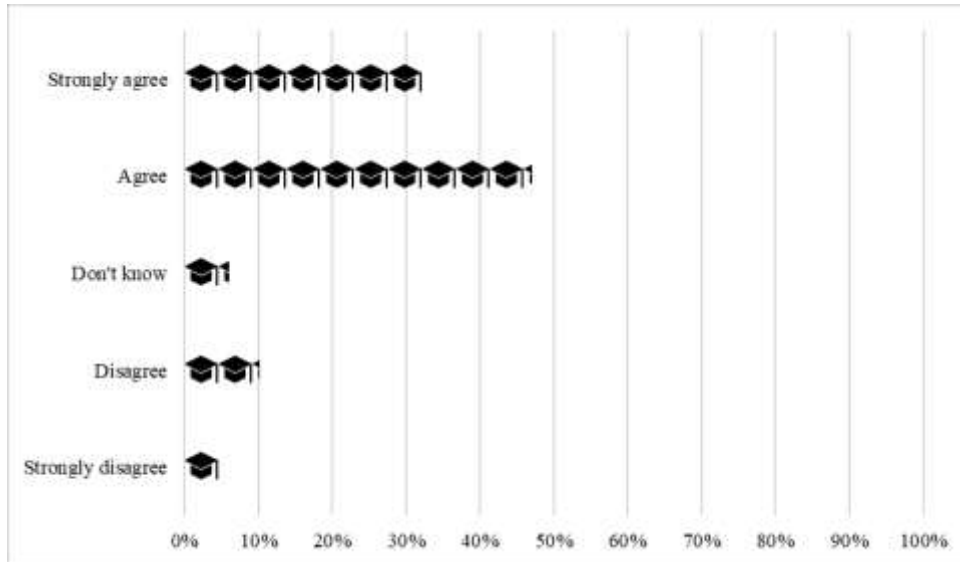
258
 259 **Figure 2- Countries represented on the study**
 260

261 The respondents were mostly lecturers (37%) and researchers (26%), a few were sustainability
 262 officers (16%), and minor proportion was of operation managers (3%), university board members
 263 (3%) and procurement officers (1%). A minor number of students (4%) also responded the
 264 questionnaire, as well as "other respondents" (10%).
 265

266 4.1. Sustainability

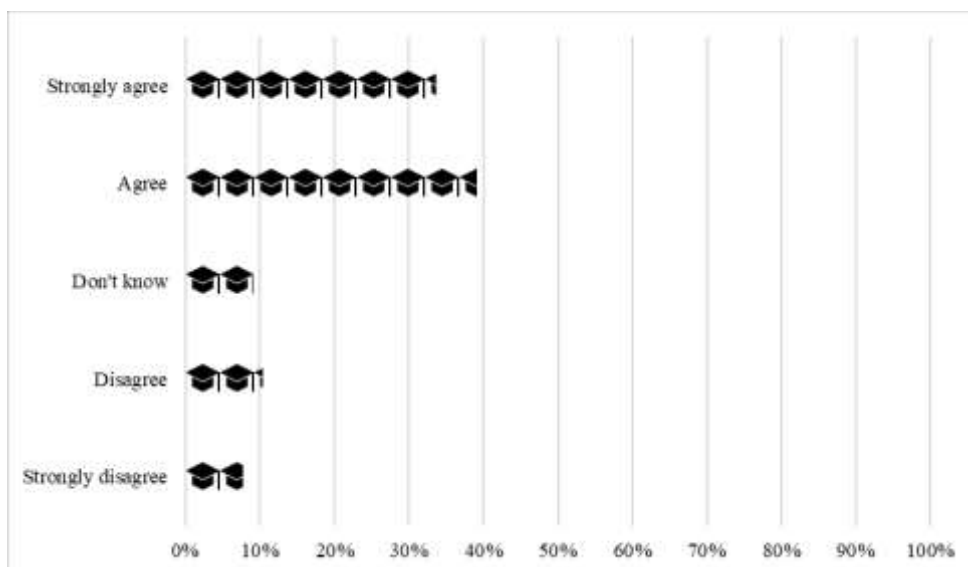
267 4.1.1. University involvement

268 Seeking information relating to university involvement towards sustainability and innovation,
 269 we asked whether the university promotes awareness-raising activities and assists with distributing
 270 information and advice. The majority of respondents (79%) strongly agree or agree with this
 271 statement, which may contribute to the innovation and sustainability at the universities, which may
 272 happen through varied approaches, including the use of social media [52] and research and teaching
 273 in inter- and transdisciplinary approaches [53]. Figure 3 presents all answers for this question.
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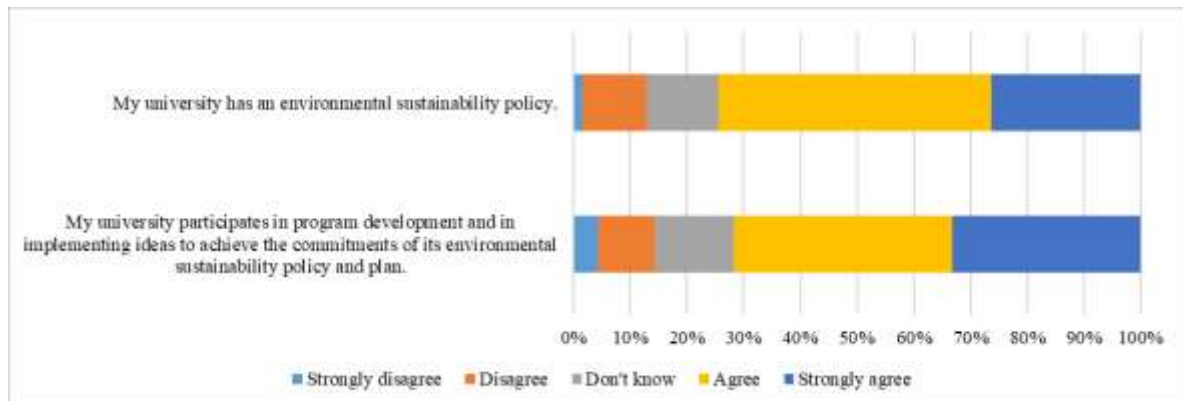
275
 276 **Figure 3.** Comparison between university responses in relation to promotion of awareness-raising
 277 activities (percentage of respondents, N = 73)

278 One next step to raise awareness of environmental sustainability across the organization is to
 279 have an environmental sustainability team. 73% of respondents strongly agree or agree that their
 280 university has such a team, contributing to the university involvement. Figure 4 presents all answers
 281 for this question. One example of innovative approach related to sustainability team is the Green
 282 Office Model [54] which empowers not only staff, but also students and academics.
 283



284
 285 **Figure 4.** Comparison between university responses in relation to environmental sustainability team
 286 (percentage of respondents, N = 73)

287 Communication is an important part of university involvement for innovation and
 288 sustainability. The inclusion of such topics in the environmental sustainability policy drives the
 289 strategy, which roots sustainability in the core of the university. In this matter, 75% of the respondents
 290 strongly agree or agree that the university has an environmental sustainability policy, while 72%
 291 strongly agree or agree that the university participates in program development and in implementing
 292 ideas to achieve the commitments of its environmental sustainability policy and plan. These two
 293 questions refer to communication of environmental sustainability and innovation, and Figure 5
 294 shows their outcome. It is important to highlight, however, that these policies cannot be totally
 295 regarded as preconditions for universities to engage on sustainability issues [55], but they may
 296 support the process of management of resources and support innovation.
 297



298

299

300

Figure 5. Comparison between university responses in relation to environmental Sustainability Policy (percentage of respondents, N = 73)

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302 4.1.2. Operations

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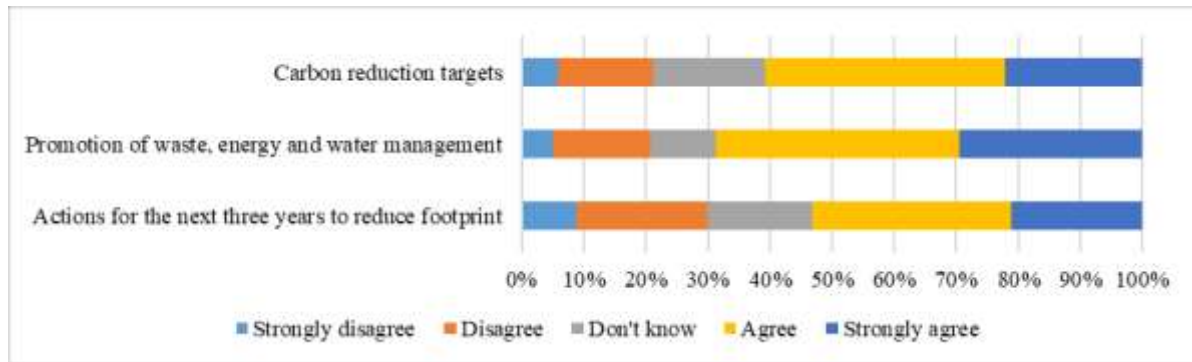
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Working for environmental sustainability is commonly related to the operations on campus. In this sense, three questions were proposed in order to identify how the university is working with campus operations for sustainability. 69% of responses (strongly agree or agree) indicate that the university promotes improved waste, energy and water management and the benefits of active travel; 61% of all responses (strongly agree or agree) informed that the university contributes in its operation to achieve the carbon reduction targets set by the government. These results show that the universities are aware of the importance of investing in campus operations in the short term and reinforce the attention paid by many universities especially in issues related to energy, waste, water and climate action [56,57]. In the longer term, 53% of responses (strongly agree or agree) indicated that the university has planned its actions for the next three years to demonstrate its commitment to reducing the university's environmental footprint and seeking to continually improve its environmental performance. Even though this last result is lower than the first two, it still shows a good direction in favour of sustainability. All results of these questions are shown in Figure 6.



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Figure 6. Comparison between universities responses in relation to campus operations (percentage of respondents, N = 73)

320

4.1.3. Student involvement

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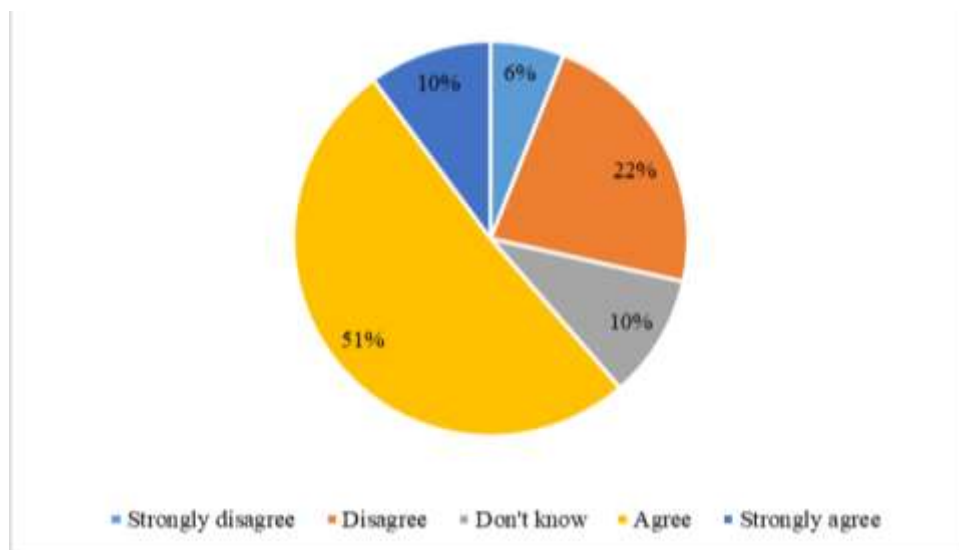
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As the university promotes sustainability through internal communication and campus operations, students want to be involved and participate in sustainability practices, which highlights the importance of the campus as a living laboratory [38]. In order to verify this topic, the respondents were asked if the university educates its students about the impact of climate change on the discipline chosen by the student. Although 61% answered they strongly agree or agree with this question, still 22% disagree with it. It shows that the student involvement is lacking attention regarding environmental sustainability. Figure 7 presents these results.



330

331

332

Figure 7. Comparison between universities responses in relation to student's involvement (percentage of respondents, N = 73)

333

4.2. Innovation

334

335

336

The development of projects and/or programmes with specific sustainability aims and outcomes represents a way to influence the university, their students and operations towards sustainability and innovation.

337

338

339

340

341

Regarding the current or last project/programme in which the respondents were involved, most of these were implemented at the university-wide level (45%) and faculty level (10%), while fewer were at the departmental and support services' level (16% and 12%, respectively). Still, nearly one-fifth of the respondents (17%) were involved in projects/programmes identified as "other" level, mainly involving links to society (local administration, private sector, community and social

342 networks outside the university campuses). This is in line with the key points presented by Müller-
343 Christ et al. [22], regarding the importance of universities having society-wide dialogue with other
344 key players and think beyond their physical boundaries to provide transferable models for the
345 surrounding community.

346 The main issues involved in these projects/programmes were services and new buildings (31%
347 and 18%, respectively), while renovations of existing buildings and mobility issues accounted for a
348 lesser importance (9% and 6%, respectively). The greatest proportion of objectives in these
349 projects/programmes (37%) was identified as “other”. These innovations were mostly of an
350 educational (34%), technological (29%) and organisational nature (19%). Some of the implemented
351 innovations were also identified as financial (4%) and of “other” categories (13%).

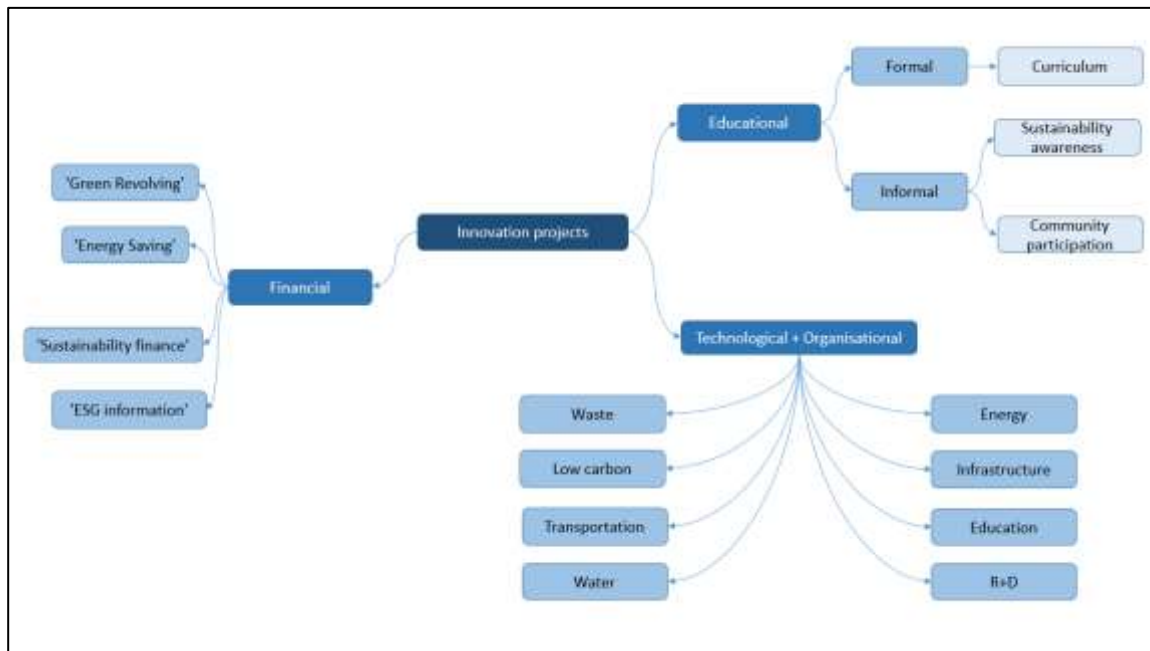
352 Specifically, the innovative aspects which were implemented via these projects / programmes
353 were identified as living lab tools (13%), adoption of theory (18%), research and development
354 management (15%) and technology readiness levels (TRL's) (2%). However, most of the innovative
355 aspects were not identified through the questionnaire (53%), which suggests that innovation can be
356 practiced, but may not be perceived as such.

357 Standards used in the projects/programmes to attain new or better performances and promote
358 innovation were mainly “in house standards” (35%) and ISO 14000 (18%); BREEAM and WELL
359 standards were also identified in fewer cases (8% and 3%, respectively). In most cases, however, the
360 project/programme standards were identified as “Other” by the respondents (43%).

361 Descriptions of the most successful innovation and sustainability project/program that
362 respondents were currently implementing (open-ended questions), enabled a more in-depth
363 understanding of these projects, their nature, and their innovative aspects.

364 Educational projects were subdivided into formal education at university (18%, mainly relating
365 to curriculum) and informal education, i.e. sustainability awareness and community participation
366 projects (13% and 6%, respectively). This latter category appeared with a strong emphasis, on projects
367 involving local schools, museums, tourism organisations, local administration or business/private
368 sector (on issues such as Waste, Energy, Water, Resources, Low Carbon, Transport and Mobility).
369 Also, projects within the categories Research and Development and Environmental Management
370 Research (mostly related to Waste, Energy resources and Low Carbon, but also to a lesser extent
371 related to Food Waste, Water and Risk) were identified as the most successful ones (10% and 13% of
372 the respondents, respectively).

373 Projects on Financial innovation were related to dedicated funds such as “Green revolving” and
374 “Energy saving”, or to “Sustainable finance and ESG information”. It was also noticeable that the
375 Organisational and Technological Programmes mentioned were mostly complex and transversal to
376 various sustainability aspects of the university campuses, such as waste (e.g. “implementation of
377 institutional and standardised waste reduction strategies, covering technological, behavioural and
378 organisational issues”), water (e.g. “WaterHub that purifies over 40% of the university waste water”),
379 energy (e.g. Energy neutral buildings), low carbon (e.g. low to zero carbon emissions),
380 infrastructures (e.g. Green buildings) transport, research and development (R&D) and education
381 (formal and informal). Some of these sustainability aspects were certified by a variety of standards.
382 On one organisational programme, the aim was the development of collaborative communities in the
383 university management: “a collaborative management system for the university should allow
384 transversal issues as innovation, sustainability, equity, inclusion or so to be developed and
385 implemented easier in the whole university” (...); “this is focusing at the (invisible) core of a
386 sustainable organisation.” An overview of the main projects related to innovation are in Figure 8.
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Figure 8. Overview of innovation projects based on universities responses

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When asked which benefits were obtained from these most successful project/programme, the most evident dimensions reported were, again, increased awareness on environmental and sustainability issues (18%) and training on environmental and sustainability issues (13%), which endorses the answers obtained in relation to university and student's involvement [42,43]. The importance of societal networking and of community engagement (external and internal to campus, with governance issues included) were also pointed as major benefits (17% and 6%, respectively). Innovative research on sustainability topics and natural resources conservation, low carbon emissions, and waste reduction were informed as project benefits by, respectively, 11%, 5% and 4% of the respondents. Although the respondents indicated previously that universities promote waste, energy and water management (72%), innovation is still not so strongly applied in practice. Financial benefits were identified, such as operational cost reduction and institutional marketing and student enrolment (11%). Social benefits of the involved communities (e.g. charities, NGOs) were reported by a few respondents (4%), which may indicate the potential for contributing to sustainability at local, national and international levels [46] is not being sufficiently realised.

Most problems found in the implementation of these successful projects were of motivational nature (37%; mainly due to cultural differences, participation on a voluntary basis, and time constraints of individuals, either for students, university staff or other partners) and of financial (30%) and governance and organisational nature (20%; mainly due to communication between organs and decision instances, as well as other staff at faculty or department; and also bureaucratic procedure hinders), aligned with the findings presented by Ávila et al. [30]. These challenges are to a greater or lesser extent connected to barriers to organisational change towards sustainable development in higher education, which include lack of explicit funding flows between organisations [58] and departmentalism, conservative management, stakeholders' involvement and lack of interdisciplinary [59]. Technological and R&D limitations were reported by a minority (7%) and also a minority reported no limitations in the implementation of their projects (7%).

Finally, 69% of the respondents stated that they have published their project results in peer reviewed scientific journals, but 31% did not do so (some expressing that their project had just started). This suggests that projects related to sustainability and innovation are mainly focused on research for publication, and not necessary only related to benefits to the university. In this way, more support for research in sustainability and innovation could bring higher benefits for the university without it having to have a specific organisation (i.e. a centre) to act in these fields.

422 5. Conclusions

423 This paper has analysed some examples of how innovation in a sustainable development context
424 is being practiced in a group of universities from different countries, in addition to presenting some
425 factors that tend to contribute to the relation between innovation and sustainability in HEIs.

426 The innovative nature of this study lies on the fact that it tried to relate perceptions on the role
427 of innovation as it related to sustainable development, with the ways sustainability is practiced. One
428 limitation of the study is that it refers to responses obtained from a set of 73 universities and, as such,
429 it cannot be regarded as comprehensive. However, bearing in mind that the sample encompassed
430 higher education institutions from European universities, North America, South America, Africa and
431 Asia/Australasia, it enables a profile to be built, of the extent to which innovation and sustainability
432 are perceived across the sample.

433 The study presented a diversity of innovation projects in connection to institutional attitudes,
434 practices and beliefs. This explains, for instance, why many universities have systematically designed
435 and implemented sustainability policies, whereas others do not. Also, innovative aspects
436 implemented by means of specific projects / programmes take place by means of living lab tools (e.g.
437 green offices demonstrating sustainability in practice), the adoption of theories such as organisational
438 programme identified in one of the surveyed universities, whose aim was the development of
439 collaborative communities in the university management), by means of research (including research
440 on sustainability innovation per se) or by deploying project management technology readiness
441 levels (TRL's) as the European School of Sustainability Science and Research -which led the research-
442 does.

443 The study has a limitation in the sense that the answers derive only from people who are
444 motivated and knowledgeable enough to reply. Also, with 17 countries only, it does not allow
445 definitive conclusions about the implications of the work to different geographical regions. On the
446 other hand, the sample is robust enough to allow a profile to be built, on the extent to which
447 innovation on matters related to sustainable development are perceived and being pursued,
448 providing new insights into this key topic.

449 The implications of this paper are two-fold. Firstly, it shows that in order to become more
450 conspicuous, innovation should be more often applied with a view to handling sustainability
451 challenges. This means going over and above and tackling issues related to motivational, financial
452 and organisational nature. In this sense, more beneficial outcomes can be reached, as increased
453 awareness on environmental and sustainability issues, which may be led to actual changes in
454 attitudes and behaviours.

455 Secondly, innovation needs to be perceived as creating value for stakeholders, so that they may
456 become more aware of its potential. It has become clear from the study, that the potential for
457 improvements is significant and that universities should endeavour to take greater advantage of
458 innovation not only with a view to pursuing sustainability objectives, but to also ensure that their
459 surrounding communities and society can become more sustainable. Here, systemic innovation can
460 play an important role.

461

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