

Article

Spanish Universities' Sustainability Performance and Sustainability-Related R&D+I

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Abstract: For its scope and the breadth of its available resources, the university system is one of the keys to implementing and propagating policies, with sustainability policies being among them. Building on sustainability performance in universities, this study aimed to: Identify the procedures deployed by universities to measure sustainability; detect the strengths and weaknesses of the Spanish university system (SUS) sustainability practice; analyse the SUS contributions to sustainability-related Research, Development and Innovation (R&D+I); and assess the efficacy of such practices and procedures as reported in the literature. The indicators of scientific activity were defined by applying scientometric techniques to analyse the journal (Web of Science) and European project (CORDIS) databases, along with reports issued by national institutions. The findings showed that measuring sustainability in the SUS is a very recent endeavour and that one of the strengths is the university community's engagement with the ideal. Nonetheless, high performance is still elusive in most of the items analysed. Whereas universities account for nearly 90 % of the Spanish papers published in the WoS subject category, Green and Sustainable Science and Technology, their contribution to research projects is meagre. A divide still exists in the SUS between policies and results, although the gap has been narrowing in recent years.

Keywords: university policies on sustainability; scientometric indicators; Web of Science; CORDIS; Spanish university system

1. Introduction

Universities as institutions make a significant social, economic, academic, scientific and technological contribution to their local and national environments. These contributions have been widely discussed in the literature [1–5] because universities are considered “the most prominent producers of fundamental knowledge, which has been argued to be one of the main drivers of economic growth” [6]. According to Eurostat [7], 19.6 million students and 1.5 million professors engaged in tertiary education in 2016, whilst public spending on higher education came to 1.2% of European GDP in 2015.

As those figures show, in light of its scope and the breadth of its available resources, the university system is a key agent in implementing and propagating all manner of policies, with sustainability being among them. Higher education institutions (HEIs) are consequently crucial to societal transformation [8].

One of the primary goals of the European Commission document, “Europe’s 2020 Strategy for Smart, Sustainable and Inclusive Growth” is for 40% of the Union’s population between the ages of 30 and 34 to have a post-secondary degree by the target year [9]. Higher education institutions, as knowledge and innovation centres, therefore play a significant role in furthering the migration to sustainable development models. At the same time, they are introducing change in their own processes to adapt to the new scenario, which impacts not only core education but research, institution management and community outreach [10].

As there are many higher education institutions, the world over has become increasingly aware of their impact on the environment. They have made substantial efforts to enhance their understanding of the environmental dimensions of their operations and the implications and impact of higher education activities [11]. HEIs therefore play a catalytic role in societies’ engagement with sustainability. In light of that complex challenge, HEIs must pay greater heed to their internal and external *modi operandi*. This means that HEIs must realise that “the development must meet the needs of the present without compromising the ability of future generations to meet their own needs” [12]. In this line, the concept of a sustainable university is broad and includes consideration of “a sustainable university as a higher education institution, as a whole or as a part, that addresses, involves and promotes, on regional or global level, the minimization of environmental, economics, societal, and health negative effects in the use of their resources in order to fulfill its main functions of teaching, research, outreach and partnership, and stewardship among other as a way to helping society make the transition to sustainable life styles” [13]. Therefore, HEIs need to assume their responsibilities in education (ad hoc courses and curricula), research, on-campus operations and community outreach with greater integrity and transparency. This can be reflected, for instance, in resource allocation planning and commitment to sustainable development.

The push to make sustainability and sustainable development an overarching concern has become particularly prevalent since the last decades of the past century. Leal Filho, Brandli, Becke, Skanavis, Kounani, Sardi, and Raath have described the efforts of 35 universities (on five continents) to implement sustainability policies and procedures [14]. Other authors define a “sustainability or environmental policy” as “one element of HEIs’ sustainability governance documents that also includes plans, strategies, and reports” [15].

Several national and international bodies have echoed these concerns and instituted sustainability-related statements, programmes, tools and systems. The Stockholm Declaration on the Human Environment (1972), the Tbilisi Declaration (1977) and the UNESCO’s Magna Charta of European Universities (1988) constitute clear examples. Some of the most prominent programmes include the UN-supported Sustainable Development Solutions Network, the International Sustainable Campus Network (ISCN), the Association for the Advancement of Sustainability in Higher Education (AASHE) in the United States and the Environmental Association for Universities and Colleges (EAUC) in the United Kingdom. The rise in the number of scientific publications on the subject attests to growing research interest, prompting the Web of Science to establish a new subject category, Green and Sustainable Science and Technology (GSST), that groups journals dealing with ecology, energy, the environment, climate change, energy efficiency and related issues. The definition of the category set out in the WoS database reads: “This category covers resources that focus on basic and applied research on green and sustainable science and technology, including green chemistry; green nanotechnology; green building; renewable and green materials; sustainable processing and engineering; sustainable policy, management and development; environmental and agricultural sustainability; renewable and sustainable energy; and innovative technologies that reduce or eliminate damage to health and the environment” [16].

An analysis of universities’ scientific activity in a given area may be broached from the perspective of their scientific and technological output. Scientometrics and bibliometrics are pivotal to the analysis, measurement and assessment of research activity [17]. Those disciplines frequently deal with the analysis of (researcher, group, institution, discipline or country) research and its impact on the scientific

community. They nonetheless also embrace more innovative pursuits, such as the detection of new research fronts and emerging fields, network analysis and the identification of research niches.

In those endeavours, the information sourced from publications and patents may be supplemented by the analysis of research projects. When implemented under competitive research and development programmes, such projects furnish data apt for weighing basic against applied science and assessing the effort deployed in emerging fields or interdisciplinary or cross-border research, such as is often the case in environmental and socio-economic studies [18].

Further to this interest in sustainability, some authors have explored the field qualitatively [19,20]. Others have adopted a bibliometric approach to examine the development of sustainability science through the analysis of citations [21,22], journal interdisciplinarity [23] or social media repercussions [24,25]. Recent papers have analysed the dynamics and evolution of GSST (considering that it is an approach to sustainable research) [25,26] and others have focused on the specific study by research on higher education for sustainable development [27].

Earlier studies have also analysed scientific activity in related areas using European projects as a source of information to identify university activity and to analyse project content in depth [28]. The present authors developed a model based on project publications to relate research activity to the impact on the academic community as reflected in social networks [29].

As some authors mention, given the increasing interest on the sustainability in higher education, there is a clear need for a systematic review of the literature [30]. Then, HEIs around the world have become engaged in sustainable practices and methodologies. This is reflected in the “growing body of literature has investigated this trend” [31]. However, as is mentioned by several authors there are “a lack of studies analyzing impacts from a more holistic perspective” [4]. The measurement of these impacts also involves considering that “the tools generally lack indicators in research, education and community engagement areas” as was explained by authors as Yáñez, Uruburu, Moreno, and Lumbreras [10].

Against this backdrop, this study has focused on the Spanish case. This country was chosen because Spanish universities, through the Conference of Rectors of Spanish Universities (CRUE), show great interest in sustainability issues. In fact, CRUE had created a working group on environmental quality and sustainable development. Therefore, CRUE has had a very active role. As some authors mention “this working group compiles university experiences and the progress made in the area of environmental management and sustainability, promoting cooperation among universities in these areas” [32]. In addition, the Spanish university system is the third country in Europe in terms of the number of STEM graduates [33]. It is among the first in terms of the number of the adult population with a university education [34], and it is a clear reference also for the Ibero-American region. In this sense, according to data from the Ibero-American Network of Science and Technology Indicators, Spain is the number one country by number of doctors [35]. From the point of view of scientific production, its contribution is also very relevant since 75% of the country’s publications come from the higher education sector [36]. Furthermore, it is the number one Ibero-American country in terms of both the total number of publications and publications per researcher [35].

Considering this scenario, the objectives pursued here are to:

- Identify and analyse sustainability measurement tools for universities;
- Reveal the strengths and weaknesses of the Spanish university system in terms of sustainability procedures;
- Detect the sustainability-related R&D activities in which universities participate (research projects, scientific papers);
- Analyse the relationship between tools and R&D+I activities conducted by universities.

2. Materials and Methods

Considering the importance of the analysis of scientific activity on sustainability in the higher education institutions, this work focuses on the study of reports, scientific papers and research projects. In this line, the methodological framework used is the Information Metric Studies, which allow, through bibliometric techniques, the analysis of publications and projects on the proposed topic.

Information for this study was sourced from the following:

- Scientific publications and reports on sustainability measurement tools in universities;
- Sustainability reports authored by national bodies in Spain;
 - ‘Evaluación de las políticas universitarias de sostenibilidad como facilitadoras para el desarrollo de los campus de excelencia internacional’ [assessment of university sustainability policies in furthering the international campus of excellence programme] (2010) and;
 - ‘Diagnóstico de la sostenibilidad ambiental en las universidades españolas’ [diagnosis of environmental sustainability in Spanish universities] (2017);
- The Clarivate Analytics Web of Science is an international multidisciplinary database that has been indexing the most prominent scientific journals in science, technology, humanities and sociology since 1945, from which information was collected on Spanish university papers on sustainability.
- The CORDIS project database is the primary source of results from EU-funded projects since 1990 that carries information on the EU’s framework programmes by call, country, subject and type of result: <https://cordis.europa.eu/projects/es>).

The study was broken down into the following stages:

1. A literature review of sustainability measurement in universities: Scientific publications and reports on sustainability measurement tools in universities were consulted and analysed considering the most frequent tools, dimensions and indicators included. A classification of the dimensions in categories was also carried out. The results are presented in Section 3.1.
2. An analysis of the Spanish data and identification of the strengths and weaknesses: Sustainability reports authored by national bodies were analysed. The results obtained in two surveys (2010 and 2017) were considered and the results are presented in Section 3.2.
3. The information retrieval in the subject category, Green and Sustainable Science and Technology, from Web of Science database. The following search strategy was used: “WC = Green and Sustainable Science and Technology AND CU = Spain”. No cuts have been made by type of document or date when collecting all the publications in journals included in this subject.
4. The obtention of the main bibliometric indicators: Output by country, institution, discipline and year. By identifying production by institution, it has been possible to detect documents from Spanish universities and calculate the contribution of the higher education system. The activity index has been calculated to measure the intensity of the production related to sustainability, both in Spain and in the higher education system and in each of the Spanish universities. The results are presented in Section 3.3.
5. The identification of European projects on related subjects in CORDIS database. The selection of the Seventh Framework Programme projects because they are the most numerous and the call has already been completed. The obtention of information on the participation by Spanish institutions. The results are presented in Section 3.4.

3. Results

The findings are set out below.

3.1. Sustainability Measurement in Universities

Integrating sustainability in universities entails creating tools that enable institutions to assess their engagement with the economic, social and environmental dimensions of sustainability and to continually improve their performance in those realms. Measuring sustainability remains a complex and challenging process for higher education institutions, however, especially institutions in the early stages of their sustainable development programmes [37].

The three resources used to analyse and measure sustainability in universities were accounts; narratives such as reports and similar; and indicators [38]. The proliferation in recent decades of papers of the many tools in place attests to the interest in such measurements. Some of the most popular publications analyzing and comparing sustainability assessment tools were published by authors such as Shriberg [39]; Alshuwaikhat and Abubakar [40]; Yarime & Tanaka [41]; Sayed, Kamal and Asmuss [42]; Gómez, Sáez-Navarrete, Lioi, and Marzuca [37]; Salvioni, Franzoni, and Cassano [43]; Berzosa, Bernaldo and Fernández-Sanchez [44]; Findler, Schönherr, Lozano and Stacherl [45] or Parvez and Agrawal [46]. Then, the tools have been described in the international literature to quantify sustainability-related activities in higher education institutions. According to Alghamdi [47], the ones most commonly used include the following:

- Sustainability Assessment Questionnaire (SAQ) (2001)
- Graphical Assessment of Sustainability in University (GASU) (2006)
- Sustainable University Model (SUM) (2006)
- University Environmental Management System (UEMS) (2008)
- Assessment Instrument for Sustainability in Higher Education (AISHE) (2009)
- Benchmarking Indicator Questions – Alternative University Appraisal (BIQ-AUA) (2009)
- Unit-based Sustainability Assessment Tool (USAT) (2009)
- The Green Plan (2012)
- Sustainable Campus Assessment System (SCAS) (2014)
- Adaptable Model for Assessing Sustainability in Higher Education (AMAS) (2014)
- Sustainability Tracking, Assessment and Rating System (STARS) (2014)
- Green Metric – UI's GreenMetric World University Ranking (GM) (2014)

Some of the most prominent features (dimensions and indicators) of the afore mentioned 12 tools are set out in Table 1. The links and references consulted to extract the information are shown in the table.

These tools differ in typology, the number of indicators and methodology for determining the integration of sustainability in university activities. By way of example of the details for some of these tools, the parameters addressed (and their relative weights) in sustainability tracking, assessment and rating systems (STARS) include academic courses (AC) (28%), engagement (EN) (20%), operations (OP) (35%), planning and administration (PA) (15%), innovation and leadership (IN) (2%). The academic dimension covers indicators associated with research and projects, with three sub-sections: support for research, research and scholarship and open access to research, further broken down into items.

Sustainability assessment questionnaires (SAQs), in turn, comprise eight dimensions: curriculum, research and scholarship, operations, faculty and staff, development and reviews, outreach and services, student opportunities, and administration, mission and planning. They are designed to stimulate discussion and further assessment by campus representatives knowledgeable of and responsible for the activities specified and include a specific dimension for assessing research on sustainability.

Green Metrics, another tool, encompasses dimensions such as education (ED) (18%), (setting and infrastructure (SI) (15%), energy and climate change (EC) (21%), waste (WS) (18%), water (WR) (10%) and transportation (TR) (18%). The education dimension covers research and project indicators and more specifically, total research funds (in USD) dedicated to environmental and sustainability research and the number of scholarly papers published on the environment and sustainability.

Table 1. Tools for measuring sustainability in universities: Key features.

Tools	Dimensions	Indicators	References/Link
SAQ	Curriculum. Research and scholarship. Operations. Faculty and Staff. Development and Reviews. Outreach and services. Student Opportunities. Administration, mission and planning.	35	(SAQ 2001) http://ulsf.org/sustainability-assessment-questionnaire/ .
GASU	Economic. Environmental. Social. Education (curriculum and research).	59	Lozano, R. (2006)
SUM	Education. Research. Outreach and partnership. Sustainability on campus.	23	Velazquez, L., Munguia, N., Platt, A., & Taddei, J. (2006).
UEMS	University EMS (environmental management and improvement. Green campus). Public participation and social responsibility. Sustainability teaching and research.	27	Alshuwaikhat, H.M., & Abubakar, I. (2008)
AISHE	Operation. Education. Research. Society. Identity.	30	Roorda, N. (2004).
BIQ-AUA	Governance. Education. Research. Outreach. Teaching and research community service.	30	Gómez <i>et al.</i> (2015)
USAT	Operations and management. Student involvement. Policy and written statements.	75	PSPE (2012)
THE GREEN PLAN	Strategy and governance. Teaching and training. Research. Environmental management. Social policy and regional presence.	44	Green Plan (2010),
SCAS	Management. Education and research. Environment. Local community. Special reporting. Institutional commitment. Example setting.	48	Alghamdi, N., den Heijer, A., & de Jonge, H. (2017)
AMAS	Advancing sustainability (education, research and public engagement).	25	Gómez <i>et al.</i> (2015)
STARS 2.0	Academic courses. Engagement. Operations. Planning and administration. Innovation.	74	(STARS 2014) https://reports.aashe.org/accounts/login/?next=/tool/
GM	Setting and infrastructure. Energy and climate change. Waste. Water. Transportation. Education	33	(GM 2019) http://greenmetric.ui.ac.id

In short, sustainability measurement in universities embraces a variety of realms, some internal and others external to the university community, as reflected in the diversity of parameters defined in these tools and the number of indicators applied to each.

These 12 tools consider indicators that can be grouped within each of the categories (curricula and competences, research, campus operations, community outreach, university and governance, sustainable assessment and reporting) that have been collected in the model for sustainable development in universities by authors as Alonso-Almeida *et al* [48] and Lozano *et al* [49,50]. However, as mentioned above, each tool uses different indicators and weights for each dimension (Table 2).

Table 2. Categories and dimensions of tools.

Categories	Dimensions
Curricula and competences	Curriculum. Education. Sustainability teaching. Teaching and training.
Research	Academic courses Research and scholarship
Campus operations	Operations. Sustainability on campus. Green campus. Setting and infrastructure. Energy and climate change. Waste. Water. Transportation.
Community outreach	Development and Reviews. Outreach and services. Outreach and partnership. Public participation and social responsibility. Local community. Social policy and regional presence. Public engagement Society.
University and governance	Administration, mission and planning. Student Opportunities. Economic. Identity. Faculty and Staff. Governance. Strategy and governance. Management. Policy and written statements. Institutional commitment. Economic. Environmental. Social. Innovation.
Sustainable assessment and reporting	Special reporting

The research dimension is explicitly included in all tools, except STARTs and GM which include it in academics and education, respectively. However, the sustainability research dimension uses a small number of indicators compared to the total of the indicators of each tool, mainly related to the number of publications, number of projects, funding support, institutional support, staff (teachers and/or students) involved in this type of research. Some examples are: In the GM tool of 33 indicators, there are only two focusing on sustainability research (number of academic publications and funds); and in the SAQ tool that has 35 indicators and only three are related to research (projects and professors focused on this subject, as well as the presence of multidisciplinary or interdisciplinary structures for research on sustainability issues).

3.2. Sustainability in Spanish Universities

The Spanish university system presently comprises 83 institutions (50 public and 33 private). Together they account for 27% of total national R&D spending and employing 36.8% of the personnel engaging in research [33]. The intensity of their activity is attested to by the findings, for Spanish universities author 75% of the country's scientific publications listed in international databases, such as the Web of Science.

Most Spanish universities conduct some manner of sustainability-related activity (administration, education, research), although they only began to address this issue in the nineteen nineties, somewhat later than countries, such as America and other parts of Europe. Those initial endeavours around university sustainability in Spain were induced by inter-university projects and attendance at meetings or seminars on the subject. Against that backdrop, in 2002 the Conference of Spanish University Vice-Chancellors (Spanish initials, CRUE) created a working group on environmental quality and sustainable development to further pro-sustainability action in Spanish universities. In July 2008, the group was restructured into the Sectoral Commission on Environmental Quality, Sustainable Development and Risk Prevention in Universities (Spanish initials, CADEP) [51]. In 2009, the commission was renamed CRUE-Sustainability. At least 68 universities have participated in some of its events. In June 2007, the University of Santiago de Compostela hosted a standing seminar for university environmental action entitled "Indicators and Sustainability in Universities". The conclusions included a proposal to create a technical working group to establish a system for assessing sustainability performance in Spanish universities. That project envisaged the definition of system of indicators to assess the universities' sustainability policies, compile models for implementing those policies and identify good practice in connection with international campus of excellence projects. The result was a system of indicators for assessing university sustainability agreed to and tested by most of Spain's university system. On an initiative authored by several universities, that led 2 years later to the creation of the CRUE Sectoral Commission-Sustainability to compile the experience of higher education institutions on environmental management, progress in heightening environmental awareness in the university community and risk prevention. It was also intended to further cooperation and exchange in these areas and establish good practice.

Those commissions and working groups organised a series of sustainability-related activities in Spanish universities and authored reports on the subject. In 2010, a questionnaire was circulated among all higher education institutions, to which 30 public (62% of the Spanish University System) and one private university responded. The findings were written up in a report [52] diagnosing university sustainability policy in Spain and defining the realms and indicators to be used to measure Spanish universities' contribution to sustainability. Those indicators afford an assessment framework for the progress made in sustainability policies, rendering progress more visible for the university community and society at large. The 31 universities responding to the questionnaire were consulted about the structure of the report. All were visited to discuss their inquiries and suggestions and obtain a first-hand view of sustainability programmes in the Spanish university system. The report revealed that the universities analysed engaged most intensely in areas such as environmental awareness, waste management and sustainability courses and least in green procurement, water management, social

responsibility and environmental impact assessment. The follow-up on that first report (2010–2011) included the review of the tool used by the CADEP-CRUE working groups and the one employed by the group on university sustainability assessment (GESU) from November 2014 to April 2015. The outcome was a new document entitled “Sistema de evaluación ambiental de la Universidad Española- GESU-CRUE v3”, Spanish university environmental assessment system-GESU-CRUE v3.

A second version of the questionnaire formulated in 2017 and responded to by 33 universities spawned the report “Diagnóstico de la sostenibilidad ambiental en las universidades españolas” (diagnosis of environmental sustainability in Spanish universities). One of its major conclusions was that the universities studied had made environmental improvements in terms of organisation, with the highest mean scores reported for environmental policy, awareness and engagement. Nearly all the respondent institutions had environmental policy officers and had attained a degree of engagement deemed as acceptable by the university community. Education and research, areas where implementation was essentially nil, scored the lowest. The findings on green campus management showed that universities had made a substantial effort in controlling environmental parameters such as water, energy, waste and biodiversity, although the implementation of improvements in those areas was scantily systematised. The difficulties were also observed in the adoption of measures to enhance green procurement. Many universities had developed plans for improving sustainable transportation, although most were still in the initial phases [51].

According to the results of the two surveys (Figure 1), the universities listed in the 2017 report scored higher in sustainability policy, water management and environmental impact assessment than the institutions included in the 2010 report. In En relación a los demás aspectos analizados, cabe destacar que una de las fortalezas de las universidades que se recoge en los dos informes es la implicación de la comunidad universitaria, en este ámbito se incluyen: another vein, one of the strengths recorded in both reports was university community engagement, including cursos, jornadas, noticias, congresos, difusión de actividades de la sociedad en general, etc. courses, seminars, press releases, congresses and dissemination of activities to society at large. The 2010 and 2017 reports also revealed considerable room for improvement in connection with environmental impact assessment, social responsibility, green procurement, education and research.

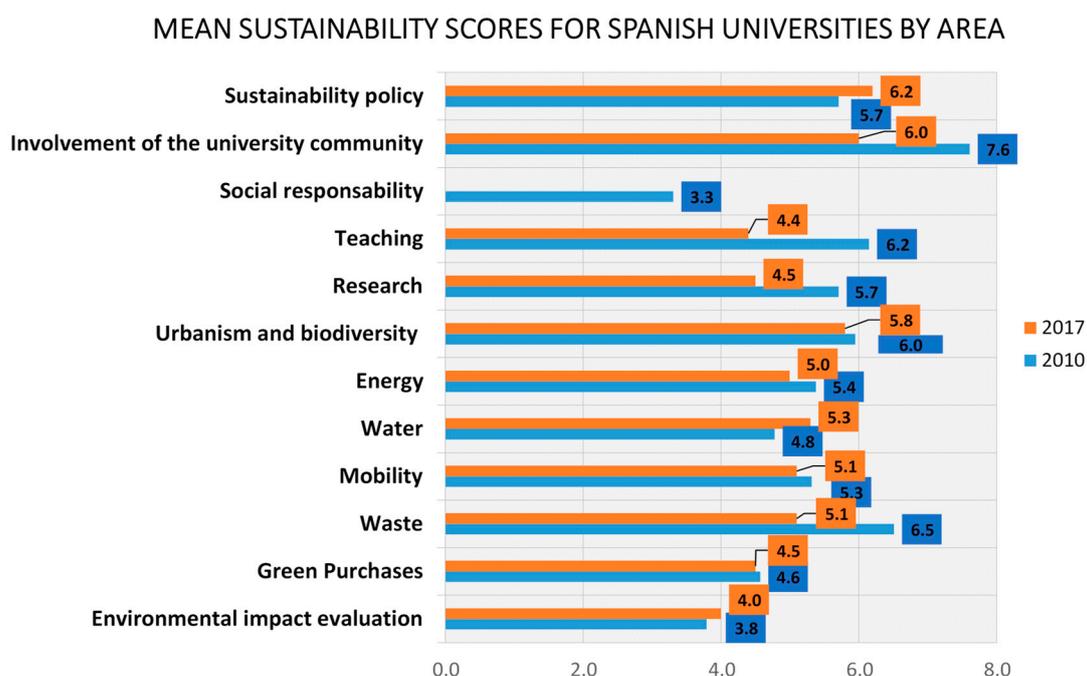


Figure 1. Conference of Rectors of Spanish Universities (CRUE) report findings, 2010 and 2017.

The differences between the two reports were not significant due to most of the areas considered maintain very similar results. With the exception of the involvement of the university community, teaching and research which, although they have reduced their scores (even some by 1.8 points) continue to be above the average of the scores. These differences are related to the improvement adjustment of the report, which led to modify some aspects of the questionnaire and simplify the total of questions (from 176 to 140) but keeping most of the questions the same as in the 2010 version so that the information can be comparable. In the case of the social responsibility aspect in the 2017 report, no data is available because it was not considered.

In short, in the results of the 2010 and 2017 reports, Spanish universities stand out in the score of sustainable policies and the involvement of the university community, but they must improve in the other areas that correspond to the effective implementation of sustainability, as well as in the monitoring and evaluation of the environmental impact generated by HEIs.

3.3. Publications on Sustainability

The Web of Science database lists 79,014 papers in Green and Sustainable Science and Technology, GSST (through 2018). Considering the whole period analysed, the average annual increase was 17.3%.

Although documents dated as early as 1994 were listed, the number of publications was higher in the last 5 years. As can be seen in Figure 2, a 66% of production is concentrated between 2014 and 2018. It is important to note that the decrease in the number of documents in 2018 is due to the updating of the database.

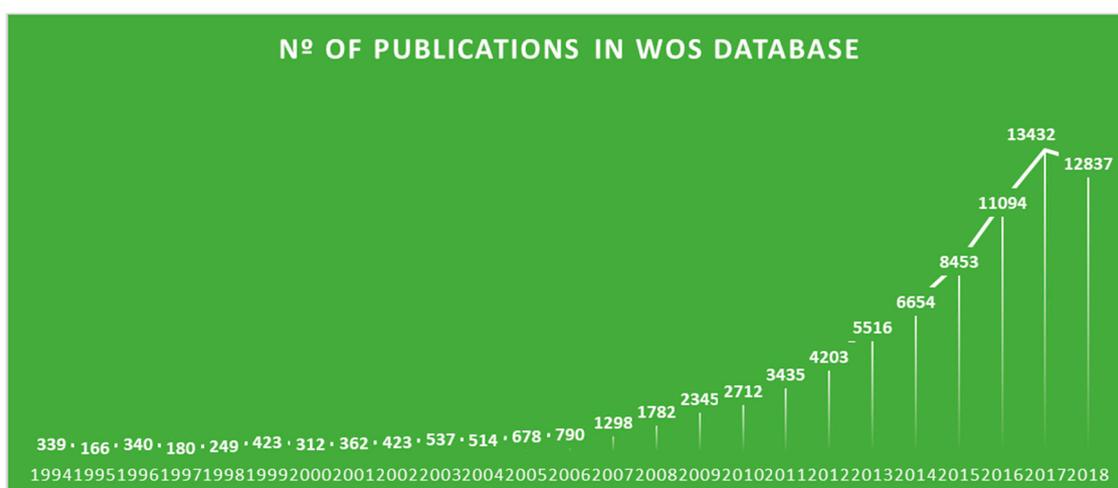


Figure 2. Annual evolution of Green and Sustainable Science and Technology (GSST) publications in WoS database. Source: Compiled by authors based on Web of Science information.

With 20% of the total, China had the highest output, followed by United States, India and England. Whilst the major countries obviously had the highest output, those values were normalised to accommodate size with the activity index (AI), which compares a country's output in a given area (GSST in this case) to its total output in the WoS database. An AI of > 1 is indicative of greater than expected output in a given field. As Table 3 shows, Netherlands, Belgium, Austria, Malaysia and Australia had particularly high AI values in GSST. In contrast, United States, England, Germany, France and Japan published fewer papers on sustainability than expected.

As Table 3 shows, Spain (with 4179 papers) ranked fifth by output, accounting for 5.3% of all world papers and exhibiting the mean yearly growth of 21.8% (3.3 points more than world growth). As shown in Figure 3, Spanish production has grown steadily and 70% is concentrated in the last 5 years. The importance of this production is also evident in the increase in the world's contribution (2% in 1994 and 5.8% in 2018).

Table 3. GSST output by countries (> 1% of total) and activity index.

Country	No. Papers	%	Activity Index (AI)
PEOPLE'S R CHINA	15,911	20.12	2.39
USA	11,226	14.20	0.47
INDIA	5411	6.84	2.72
ENGLAND	5093	6.44	0.91
SPAIN	4179	5.28	1.80
GERMANY	3985	5.04	0.77
ITALY	3635	4.60	1.23
AUSTRALIA	3606	4.56	5.35
CANADA	3010	3.81	0.92
SOUTH KOREA	2885	3.65	1.59
FRANCE	2656	3.36	0.74
NETHERLANDS	2525	3.19	> 10
JAPAN	2487	3.15	0.56
MALAYSIA	2302	2.91	9.12
IRAN	2190	2.77	3.12
SWEDEN	2041	2.58	1.73
BRAZIL	1995	2.52	1.38
TURKEY	1811	2.29	1.86
TAIWAN	1432	1.81	1.42
PORTUGAL	1213	1.53	2.59
DENMARK	1156	1.46	1.62
SWITZERLAND	1036	1.31	0.81
GREECE	1016	1.28	1.99
BELGIUM	986	1.25	> 10
FINLAND	976	1.23	1.76
SAUDI ARABIA	967	1.22	3.54
NORWAY	917	1.16	1.84
SCOTLAND	864	1.09	1.07
AUSTRIA	807	1.02	> 10

Source: Compiled by authors based on Web of Science information.



Figure 3. Number of Spanish GSST papers listed in WoS, 1994–2017. Source: Compiled by authors based on Web of Science information.

Whilst all the papers listed dealt with GSST, the publishing journals were also indexed under other subject categories. According to Figure 4, which depicts Spain's and the world's output by

subject area, Spain followed the same pattern as the world mean, with a slightly higher proportion in environment-related disciplines only.

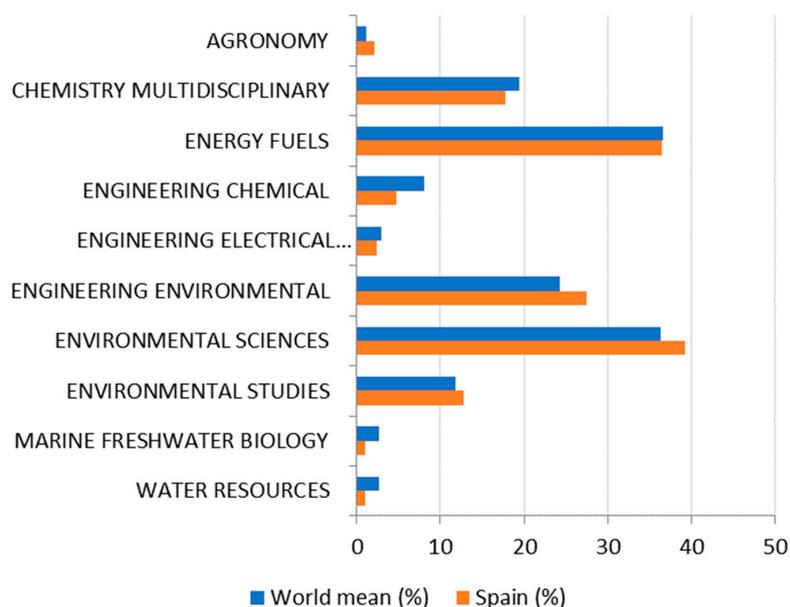


Figure 4. Number of papers by topic (Spain and world mean). Source: Compiled by authors based on Web of Science information.

Spanish output was concentrated in major cities such as Barcelona, Madrid and Valencia, although some activity was recorded in all 17 of the country's regions. This is logical, given that these cities concentrate a significant proportion of research centers and universities that are the main producers of the papers analyzed. In the distribution shown on the map in Figure 5, the size of the nodes denotes the output volume.

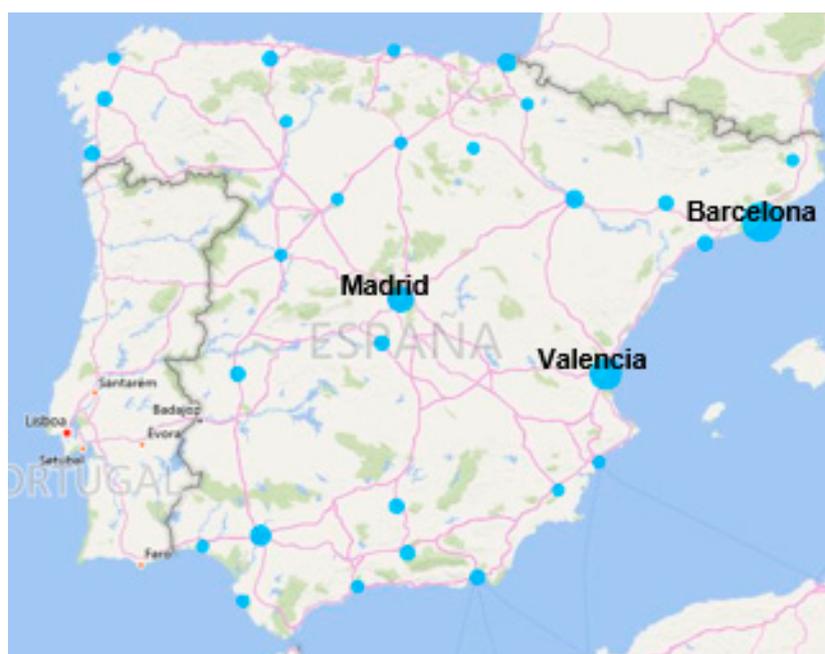


Figure 5. Distribution by city of GSST papers authored in Spain. Source: Compiled by authors based on Web of Science information.

Interestingly, Spanish output was highly concentrated in its universities, with 91% of the papers authored by at least one higher education institution.

The National Research Council (CSIC: no breakdown by institution is provided) produced more papers than any other organisation, whilst the most active universities were the Autonomous University of Barcelona and the Technical Universities of Valencia, Madrid and Catalonia (Table 4). As shown in Table 3, polytechnic universities have intensive production in the GSST field ($AI > 2$), as do other small or medium-sized universities such as La Rioja ($AI = 4.1$), Lleida ($AI = 3.7$), Almería ($AI = 3.4$) and Jaen ($AI = 3.1$). On the other hand, the large universities, being generalists, present a lower intensity of production than expected.

Spanish universities partnered most intensely with institutions in UK, Italy, USA, Portugal, France and Netherlands. Figure 6 shows the number of documents in co-authorship between Spanish universities and foreign partners (the size of the node is proportional to the number of documents). The main partners are the European and North American leaders in the topic studied (green circles in Figure 6). However, there is not such an intense relationship with large producers from other regions such as China, India, Australia, and South Korea.

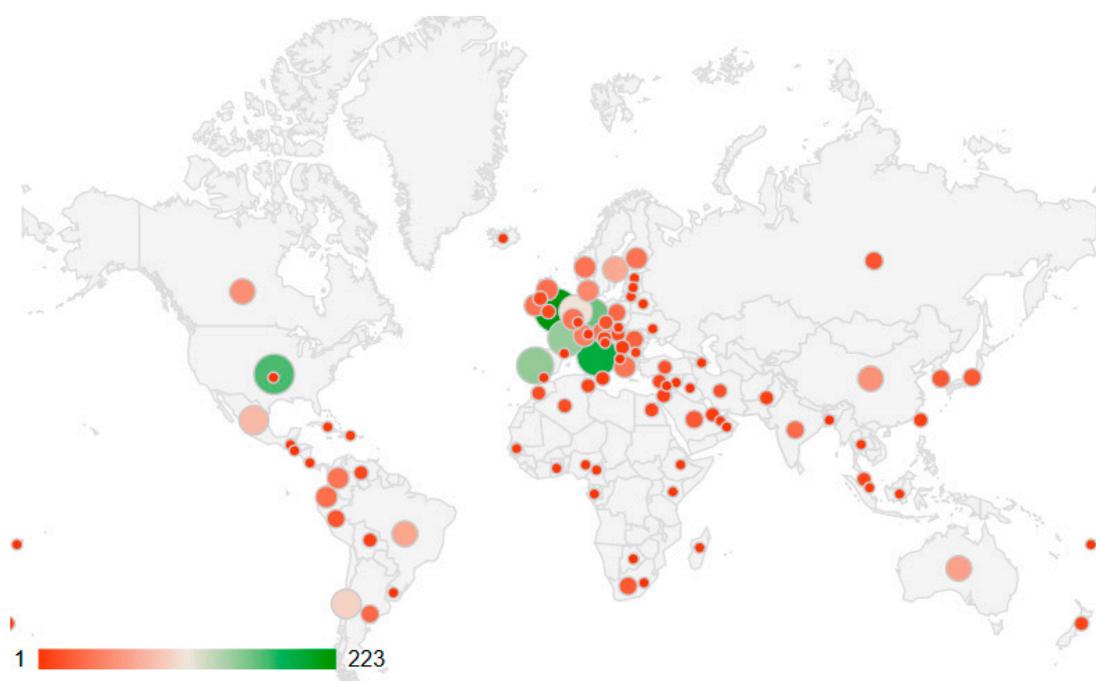


Figure 6. Countries of origin of Spanish universities' major partners. Source: Compiled by authors based on Web of Science information.

Following an analysis of the content of GSST papers, 12 of them mention tools for measuring sustainability in universities. All their authors were affiliated with universities: five in Canada, two in Saudi Arabia, two in USA and one each in Chile, UK, India and Mexico. The journals publishing the largest number of such papers were: *Journal of Cleaner Production*; *Sustainability*; *Environment Development and Sustainability*; *International Journal of Sustainability in Higher Education*.

Table 4. Output by institution (> 2% of documents).

Institution	No. Papers	%	Activity Index (AI)
NATIONAL RESEARCH COUNCIL (CSIC)	475	11.36	0.78
AUTONOMOUS UNIVERSITY OF BARCELONA	235	5.62	0.92
UNIVERSITAT POLITÈCNICA DE VALÈNCIA	217	5.19	2.09
POLYTECHNIC UNIVERSITY OF MADRID	213	5.09	2.22
POLYTECHNIC UNIVERSITY OF CATALONIA	203	4.85	1.85
UNIVERSITY OF BASQUE COUNTRY	189	4.52	1.32
UNIVERSIDAD DE CORDOBA	168	4.02	2.68
UNIVERSITY OF ZARAGOZA	166	3.97	1.36
UNIVERSITY OF SEVILLA	158	3.78	1.12
UNIVERSITY OF SANTIAGO DE COMPOSTELA	136	3.25	1.16
UNIVERSITY OF GRANADA	131	3.13	0.77
UNIVERSIDAD DE CASTILLA LA MANCHA	126	3.01	2.02
UNIVERSITAT ROVIRA I VIRGILI	125	2.99	1.91
UNIVERSITY OF OVIEDO	118	2.82	1.21
UNIVERSITAT DE LLEIDA	108	2.58	3.74
UNIVERSIDAD DE JAEN	106	2.53	3.11
UNIVERSITY OF VIGO	103	2.46	1.57
UNIVERSITY OF BARCELONA	101	2.41	0.24
UNIVERSIDAD DE ALMERIA	99	2.36	3.40
COMPLUTENSE UNIVERSITY OF MADRID	95	2.27	0.39
UNIVERSIDAD DE EXTREMADURA	84	2.01	1.69
UNIVERSITAT JAUME I	80	1.91	2.05
IRTA	73	1.74	4.60
UNIVERSITAT D ALACANT	73	1.74	1.19
UNIVERSITY OF VALÈNCIA	68	1.62	0.33
CSIC UPV INSTITUTO DE TECNOLOGIA QUIMICA ITQ	65	1.55	6.74
UNIVERSIDAD DE CANTABRIA	64	1.53	1.18
UNIVERSIDAD DE VALLADOLID	64	1.53	1.02
AUTONOMOUS UNIVERSITY OF MADRID	60	1.43	0.25
CIEMAT	60	1.43	4.77
UNIVERSIDAD DE LA RIOJA	59	1.41	4.15
UNIVERSIDADE DA CORUNA	57	1.36	1.23
BARCELONA INSTITUTE OF SCIENCE TECHNOLOGY	56	1.34	0.99
UNIVERSIDAD REY JUAN CARLOS	56	1.34	1.70
UNIVERSITAT DE GIRONA	50	1.19	1.02

Source: Compiled by authors based on Web of Science information.

3.4. Sustainability Projects

European calls for projects have become one of the main avenues for scientific and technological activity and a major source of funding for Spanish institutions. For the analysis of projects related to sustainability, the call of the 7th Framework Programme has been chosen and information retrieved

from the CORDIS database confirmed Spain's significant participation in this call (Spanish institutions took part in a quarter of the total projects) (Table 5).

Table 5. Distribution of projects under Framework Programmes, by call (all topics).

Call	No. of Projects	Spanish Participation	% Spanish Participation/Total Projects
H2020 (2014–2020)	5348	1530	28.61
FP7 (2007–2013)	25,630	6334	24.71
FP6 (2002–2006)	10,102	2822	27.94
FP5 (1999–2002)	17,202	3710	21.57
Total	58,282	14,396	24.70

Source: Compiled by authors based on CORDIS information

According to a report by the Centre for Technological Development in Industry, in the Seventh Framework Programme (FP7, 2007–2013), Spain ranked in the same sixth place in funding received (after Germany (17.8%), United Kingdom (17.2%), France (12.5%), Italy (9.3%) and Netherlands (8.4%)) as it had under FP6. Qualitatively speaking, the results attained in FP7 were substantially better than in the preceding edition, where Spain headed 10.7% of the projects, compared to 6.0% in FP6.

The Seventh Framework Programme comprised 23 calls in different areas. Spain participated in over 50% of the projects awarded under eight of those calls. It was particularly active in FP7-SME (Specific Programme-Capacities: Research for the benefit of SMEs), designed to strengthen small and medium-sized enterprises; FP7-KBBE (Specific Programme-Cooperation: Food, Agriculture and Biotechnology); FP7-INFRASTRUCTURES (Specific Programme-Capacities: Research Infrastructures) and PF7-NMP (Specific Programme-Cooperation: Nanosciences, Nanotechnologies, Materials and New Production Technologies).

Six of the subjects addressed by those projects were associated with sustainability. Environmental protection attracted the largest number of projects (823), whilst 264 addressed energy savings. Spain had a significant presence in all six, with participation ranging from 34% in biofuels to 73% in waste management (Figure 7).

Universities were scantily involved in these projects, contributing to 16% at most. The highest rates of participation were observed in projects on sustainable development and environmental protection. The latter was the area where the largest number of higher education institutions participated (Table 6).

Table 6. Spanish university participation in FP7 sustainability-related projects.

Area	Spanish University Participation		
	No. of Projects	% Projects	No. of Universities
Energy Savings	25	9.47	15
Biofuels	2	5.26	2
Sustainable Development	13	16.25	9
Renewable Energies	9	13.43	8
Waste Management	1	6.67	1
Environmental Protection	127	15.43	37

Source: Compiled by authors based on CORDIS information.

A total of 40 Spanish universities, 39 public and one (Pontifical University of Comillas) private, participated in European sustainability-related projects. Technical universities participated most intensely, with the Technical University of Madrid heading the list. Taken together, however, the Catalonian institutions (Autonomous University of Barcelona, the Technical University of Catalonia and the University of Barcelona) had a significant presence in these calls (Table 7).

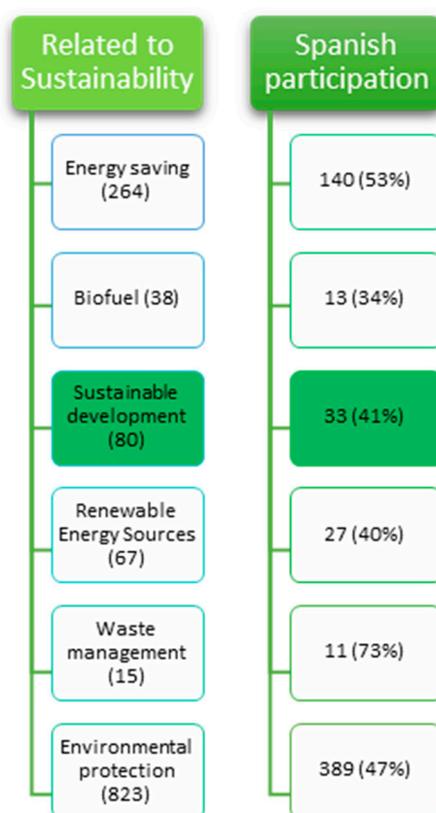


Figure 7. Total sustainability-related projects and Spanish participation. Source: Compiled by authors based on CORDIS information.

Table 7. Universities participating in FP7 university-related projects (>2 projects).

University	No. of Projects
Univ. Politécnica de Madrid	19
Univ. Autónoma de Barcelona	16
Univ. Politécnica de Cataluña	12
Univ. Politécnica de Valencia	11
Univ. de Barcelona	9
Univ. Complutense de Madrid	8
Univ. de Santiago de Compostela	7
Univ. de Córdoba	6
Univ. de Granada	6
Univ. de Cantabria	5
Univ. del País Vasco	5
Univ. Pontificia de Comillas	5
Univ. de Almería	4
Univ. de Oviedo	4
Univ. de Sevilla	4
Univ. de Valencia	4
Univ. de Valladolid	4
Univ. de Zaragoza	4
Univ. Carlos III de Madrid	3
Univ. de Alcalá de Henares	3
Univ. de Alicante	3
Univ. de Castilla la Mancha	3
Univ. Pablo de Olavide	3
Univ. Politécnica de Cartagena	3

Source: Compiled by authors based on CORDIS information.

4. Discussion

The assessment mechanisms are useful tools for diagnosing universities' sustainability performance. The most prominent international studies conducted on the subject have as a rule used information delivered by green metrics, a tool that processes data very generically and yields no details on research particulars such as project participation or paper write-up. Using this tool to analyse nine Indian HIEs, Parvez and Agrawal [46] found that only two had made formal sustainability progress in terms of education. The specific indicators studied were academic courses on sustainable development and the existence of a website on sustainability. They did not, however, analyse research findings or papers on sustainability. Similarly, Marrone, Orsini, Asdrubali and Guattari [53] analysed the green metrics scores for universities in several countries and regions (India, Indonesia, Japan, USA, Canada, Africa, Middle East, South America and European Union). The findings were also given generally, by category only and focusing on inter-country comparisons, with no information on indicators. In education, Canada and the European Union scored highest. Suwartha and Sari [54], in turn, studied 25 US universities that used the tool in 2011, analysing the scores for each by indicator, although in this case the authors grouped education under the category, setting and infrastructure.

Beringer, Wright and Malone [55] studied the state of sustainability in higher education (SHE) in Atlantic Canada, in which the tool of choice was SAQ. They found that the majority of higher education institutions in Atlantic Canada were engaged in sustainable development work, most notably in the area of curriculum. Sustainability research and scholarship is spread amongst faculty and students. Many institutions have inter- or multi-disciplinary research structures to address sustainability questions across campus and in collaboration with community partners. They nonetheless acknowledged that the dimension to be still only moderately developed and identified student commitment to research projects as an avenue for speedier progress.

Consernign SAQ, a paper by Lidstone, Wright and Sherren [15] on sustainability research reviewed 21 Canadian HEIs that used this measuring tool. Their findings showed that 50% of these universities' research plans included sustainability goals. The particulars most intensely studied by these universities included funding, interdisciplinarity and structures (organisation and other university resources). This tool was also analysed by Parvez and Agrawal [46] in their study of nine HIEs in India. The findings on research delivered by STARS are somewhat more detailed, for they include three groups of research-related indicators: research and scholarship, support for research and open access to research, with at least 10 items under each. The latter authors concluded that two of the nine Indian universities, in addition to offering courses on sustainability, undertook initiatives to establish new courses and mechanisms to support and fund research.

Likewise using STARS data, Salvioni, Franzoni and Cassano [43] analysed three groups of universities in the 2015 international Academic Ranking of World Universities (ARWU) Top 500: The first twenty best positions in the Top 500, an intermediate group formed by the last twenty universities classified among the Top 100 and the last twenty positions in the Top 500. The authors acknowledged that universities in the first group assumed sustainable culture more effectively in areas such as research. They stressed that "there is higher integration and inclusion of the sustainability theme in the institutional, managerial, research and teaching activities of universities placed in the Top 5 rankings compared to universities in subsequent position".

In another study, Alshuwaikhat, Adenle and Saghir [56] using SAQ, found public universities in Saudi Arabia to be in the initial stage of integrating sustainability in both the curriculum and research, stating "sustainability-related projects are not prioritised within universities and sustainable financial management practices are not significant".

It is important to note that all these sustainability assessment tools are used by universities on a voluntary basis. However, public authorities in most countries are promoting the transparency and accountability of universities through more information about their activities to society, which may include sustainability reports. In the area of public funding of universities, the use of allocation mechanisms at least partially performance-based for teaching and research is spreading [57], but they

still do not include sustainability indicators. In many countries, the most important outputs taken into consideration for performance-based funding are those related to research, which also do not introduce criteria that promote sustainability research.

The case of Spain, as mentioned above, is interesting because of the relevant role played by the higher education system. It also has its own initiatives for the analysis and measurement of sustainability in universities. When analyzing the results obtained in this study, it can be observed that in terms of measures for the development of sustainability, universities scored highest in items relating to university community engagement (7.6), waste management (6.5) and campus grounds and biodiversity (6.0) and lowest in environmental impact assessment and green procurement (<5.0). The 2010 and 2017 reports also revealed considerable room for improvement in all areas, especially environmental impact assessment, social responsibility, green procurement, education and research. Although environment-related degrees have been in place in the last two areas, sustainability has yet to be integrated holistically across all university activities, rather than as a separate chapter or stand-alone curricular content.

The Spanish experience has also served as a reference for other regions. This is why a similar study was carried out in Latin America under the title “Definición de indicadores para la evaluación de las políticas de sustentabilidad en universidades latinoamericanas” (definition of indicators for assessing sustainability policies in Latin American universities). According to the findings, the region’s countries scored lower than Spain. With a score of 6.1 (higher than Spain’s 3.3), social responsibility was the sole exception and the only item attesting to significant commitment to sustainability [58]. In all the other items analysed (sustainability policy, university community engagement, education, research, urban planning, energy, water, transportation, waste management, green procurement, environmental impact assessment), Latin American universities scored lower than their Spanish counterparts, in particular in connection with green procurement and transportation. The report consequently identified a pressing need to develop and integrate sustainability in all aspects of university life.

Spanish governing bodies introduced a new way to allocate public universities funding based on performance criteria. By funding universities according to their outputs, rather than inputs, state policy makers in Spain believe they are providing an incentive for universities to improve their quality management and accountability [59]. In other words, it is about universities optimizing their management and activities considering ethical values and transparency to achieve a greater positive impact on all aspects of society. One of the main outcomes of this performance funding system has been the greater number of strategic plans or sustainability reports articulated and published online by Spanish universities in recent years [60].

Reviewing R&D+I from a bibliometric perspective, the number of scientific papers constitutes a good measure of the scientific community’s interest in a given subject. The creation in Journal Citation Reports of the subject category Green and Sustainable Science and Technology (GSST) laid the ground for measuring the impact of sustainability-related research.

Although the earliest papers on the subject date back to the nineteen nineties, the number of articles has risen substantially in the last 5 years, especially at a yearly rate of over 17%.

Whilst research majors (China, USA, India, etc.) account for the highest output in GSST, smaller countries (Netherlands, Belgium, Austria and Malaysia) devote more effort to the area relative to the total research effort deployed.

Spain ranks fifth worldwide by total number of articles on the subject and its output is growing faster than the world average (21.8% versus 17.0%). The intensity of the country’s activity in the area is also attested to by its activity index which, at 1.8, denotes greater devotion to the area than expected on the grounds of its overall WoS-listed output. Further WoS evidence for that assertion lies in Spain’s ninth place in overall output compared to its fifth place in papers relating to sustainability.

Another feature of Spain’s activity in the field is the concentration of sustainability research in three of its major cities (Barcelona, Madrid and Valencia), cities that concentrate the great universities. The presence of powerful university systems in all three is consistent with the fact that universities account

for 91% of Spain's output in this subject category and with the community's interest in sustainability and related issues.

Although the country's most productive institution is the National Research Council, four universities also lay claim to significant output figures: The Autonomous University of Barcelona and the Technical Universities of Valencia, Madrid and Catalonia. Together, those five institutions account for over 20% of Spain's entire production in this area of research. Likewise, it has been shown how some small and medium sized universities present an intense productive activity in subjects related to sustainability.

Spain also plays a significant role in European projects on the subject, with a success rate of over 30% in the most prominent sustainability-related calls organised under the Seventh Framework Programme. One less favourable aspect of that success is that universities participate only marginally in such calls, where the private sector prevails. Earlier studies have shown that this is not uncommon in several other areas [21]. In any event, the same four universities found to reign in scientific paper output also rank highest by the number of Seventh Framework Programme projects, accounting for over 30% of the projects awarded in the area to the SUS as a whole.

Spanish universities' scant presence in sustainability projects should prompt academic management to change their research strategies for the present findings confirm the HEI community's interest in engaging in science on the subject. One possible way to raise participation would be through partnering with the private sector, for companies have acquired an ever more significant role, comparable to their predominance in patent applications in areas such as renewable energies.

It is evident that the use of scientometric tools, such as the analysis of publications or projects, has certain limitations. Among them is the difficulty of accurately defining the specific area of sustainability, so all quantitative studies are an approximation. However, the use of tools external to the information provided by the universities themselves can contribute to reducing the biases of interpretation (or manipulation) of the data. Likewise, the use of absolute indicators, such as the number of projects or publications, combined with relational indicators, such as the activity index, can offer a good measure of the effort of each of the institutions. In this sense, the case of Spain shows that the limitation raised in the literature on the scarcity of indicators on research in universities (compared to the total of the indicators of each tool) can be approached in a complementary way from a scientometric perspective.

5. Conclusions

After the development of this study, some relevant aspects should be mentioned as conclusions.

It has been detected that the interest in sustainability has been growing and this is evident in publications and projects on the subject as well as in the initiatives developed in different environments to promote it. The higher education sector is presented as one of the most fertile spaces for the development of measures in this field.

The methodology used in this study, which combines bibliometric techniques with the analysis of institutional documents, may be useful to identify a country's commitment to the development of initiatives, such as those related to sustainability.

The Spanish case can be taken as a reference to analyze the situation of other European and Latin American countries and detect points and strengths with respect to the implementation of measures on sustainability in universities.

The most common tools for measuring sustainability in universities use a small number of generic indicators (compared to the total of the indicators of each tool) of scientific output on sustainability. The presented study of the Spanish case shows the possibility of including several more specific indicators to analyse the topic of university research in sustainability (thematic specialization and AI). It would be very interesting for the different tools to include some of these indicators collected externally with an objective criterion, which would allow studies to be carried out with more reliable data in order to make international comparisons and facilitate the university's accountability in this area.

Regarding public policies that aim to promote the sustainability of universities, it should be noted that although the use of the tools studied is voluntary for the institutions, actions in terms of transparency and accountability can help to promote measures that encourage information on the impact of their actions on society. In the field of research, the incorporation of indicators on sustainability research, analysed for the Spanish case, in the performance-based funding models would provide an important incentive to promote research in this field.

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