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University Research for the Improvement of SDGs: A Framework for Mapping and Assessing SDG Science at the Country Level

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Abstract

Humankind is facing the enormous challenge of ensuring a sustainable future for new generations. A key guide to addressing this challenge is the Sustainable Development Goals (SDGs), which aim to promote economic and social development and environmental preservation. Despite the good intentions embedded in the SDGs, current performance worldwide remains below expectations. To be effective, the progress on the SDGs depends on the creation of new scientific knowledge. In this context, universities and research institutes should play a fundamental role in generating new scientific knowledge. Although recent models have been developed to assess universities' knowledge creation to advance the SDGs, it remains necessary to develop new models that can more effectively evaluate and detail this capability. The goal of this article is to introduce a three-level framework for identifying SDG science at the country level across universities and research institutes. This model is validated through a documentary study based on SciVal-Elsevier data, on Brazilian universities, and a research institute in the context of SDG 2 research—zero hunger—between 2015 and 2024. As the main results, the framework provides three levels of knowledge mapping based on subject areas, knowledge categories, and cluster names, whereas the first and the last are used in the Scopus database, and the third is proposed in this study. As a result, this framework consists of a practical instrument for the mapping of the effective issues addressed in each SDG, and for comparing the effective content of SDG science between research institutions. As the main contribution, this article introduces a practical instrument for the assessment of the contribution of universities and research institutes in SDG science. Theoretically, this framework provides a practical process for rapidly identifying the current SDG science performance in research institutions at the country level. For practical purposes, this study can be used by universities, research institutes, and policymakers to understand the current state of SDG science in a country or region and to develop new research programmes and strategies for SDG science and innovation.

Keywords: Brazil; environmental impact; knowledge mapping; SDG science; sustainable development goals; university-industry

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1. Introduction

In the third millennium, humankind is facing enormous challenges related to social problems and environmental degradation [1–3]. To address these challenges, the United Nations (UN) established the Sustainable Development Goals (SDGs) in the 2030 Agenda, which is a set of 17 goals that encompass dimensions for improving human conditions worldwide and environmental preservation [4,5]. However, several studies have pointed out that countries around the world have experienced little progress or even regression in the performance of SDGs [6–8].

Given the existing challenges, the development of SDGs depends on institutional factors [9,10] and on the development of scientific knowledge for enabling the development of new technologies [11–13]. Universities and research institutes are the most suitable institutional settings for generating scientific knowledge and, as a result, for advancing scientific understanding about sustainability [14], and specifically about SDGs [15–17] hereinafter referred as SDG science. The literature that approaches the SDGs in the university context addresses three issues: the inception of SDGs into teaching programmes [18–21]; the pursuit of the implementation of SDGs in university day-to-day activities [22–26]; and the employment of research projects that seek to improve SDG science performance [27–30].

Several recent frameworks have been developed to assess the many issues in SDG science. The majority uses bibliometric indicators to assess the SDG science performance. For instance, Mishra [5], in a study based on 12,176 articles indexed in Web of Science, seek to identify the SDGs represented in publications through keyword analysis and to identify leading journals and authors. In this vein, Prieto-Jiménez [30] conducted a review study, screening 342 articles based on SDG 4 (education), which mapped countries, journals, and thematic categories. Through a literature review based on the screening of 243 papers indexed in Scopus, Cámara [24] mapped publications related to food production that align with SDGs 2 (zero hunger) and 12 (responsible production and consumption), identifying the key countries and topics. Owing to research seeking to identify universities' and research institutions' focus on the SDGs, Körfgen [28] analysed internal and external data from Austrian institutions to assess their SDG performance at the country level. Finally, in a unique case study at University College Cork, Ireland, O'Donoghue [29] employed mixed methods to identify the SDG priorities and their corresponding thematic areas. Despite the research cited above, some drawbacks persist in assessing the SDGs within the university context. Most studies are based on article screening, in which the SDGs related to the articles are identified and listed, and, in some cases, related topics are also identified. Although it is important for the mapping process, universities and research institutes still require a more systematic and integrated map of their impact on SDG science. For instance, even though it is possible to map the SDGs approached in the research in a university (e.g., [29]), it is still necessary to have a framework capable of constructing a map of SDG science across several universities and research institutes in a country in a comparative perspective, identifying the specific knowledge areas related to a specific SDG at various levels of detail.

The goal of this article is to introduce a three-level framework for identifying SDG science at the country level across universities and research institutes. This model is validated through a documentary study, utilising SciVal-Elsevier data on Brazilian universities and a research institute in the context of SDG 2 research—zero hunger—between 2015 and 2024. It is based on the following research questions: 1—How can universities' and research institutes' SDG science be mapped, taking into account their knowledge areas? 2—How can these results be systematised at the country level? The main results are three levels of knowledge mapping for SDG 2 research in Central Brazilian research institutions: subject area, cluster names, and knowledge area. These results provide a clear understanding of

the current research focus of universities and research institutions, and their commonalities and specificities.

2. Literature Review

2.1. Science and the Improvement of SDGs

The Sustainable Development Goals (SDGs) initiative began in the context of the Paris Agreement in 2015 [31]. There are 17 SDGs, namely: no poverty (SDG 1); zero hunger (SDG 2); good health and well-being (SDG 3); quality education (SDG 4); gender equality (SDG 5); clean water and sanitization (SDG 6); affordable and clean energy (SDG 7); decent work and economic growth (SDG 8); industry, innovation, and infrastructure (SDG 9); reduced inequalities (SDG 10); sustainable cities and communities (SDG 11); responsible consumption and production (SDG 12); climate action (SDG 13); life below water (SDG 14); life on land (SDG 15); peace, justice and strong institutions (SDG 16); and partnerships for the goals (SDG 17). The practical implementation of all these goals poses multiple challenges [5], encompassing economic, environmental, and social issues that can present trade-offs across the perspectives of different stakeholders [9,10].

Despite the urgency of SDG improvements, several regions in the globe have experienced stagnation or even regression [6,8,11]. As such, the progress in SDGs depends on several social, cultural, and political issues [9,32,33], and on the creation of scientific knowledge [11–13]. This type of knowledge is the primary instrument for enabling the development of new technologies and institutional arrangements, thereby eliminating or mitigating several types of environmental footprints [7].

Despite the fundamental role of new scientific knowledge in improving SDG performance [34], the predominant perspectives in SDG improvement and assessment models focus on parameters such as the geographical and thematic aspects. Geographic studies about the development of SDGs are focused on the scope of the continent [35,36], or in economic blocks such as BRICS [37] and the European Union [38] at the country level [9,39,40], regional level [41], and city level [42]. Thematic studies focus on issues such as agriculture [43,44], energy [45], entrepreneurial activities [32,46], corporate policies [10], financial [43,47], food [43,47], forests [48], and health [49].

2.2. The Role of Universities in SDG Improvement

The SDGs concept has received greater attention in universities, particularly in teaching and educational activities [50,51]. The diffusion of SDG values within the university context is fundamental to their effective implementation across various fields of society [15,52]. It can be achieved by integrating the SDG concept into educational curricula [18,19]. As such, the underlying values and key technical concepts related to the SDGs have been regularly incorporated into the curricula of various university courses worldwide [23,26,53], as an instrument of societal transformation through their dissemination across various fields of human action [25,54].

The consideration of the SDG concept at the university may extend beyond educational activities. As such, it can be conceived at the strategic level, where the SDGs are incorporated into the university's business model and strategic plans, guiding its actions [21,55,56].

Considering SDG science, universities can afford to develop research across the 17 SDGs from a transversal perspective, whereby the same SDG can relate to different research topics [29], gathering scientists from different fields that can contribute to the development of new knowledge and technologies, involving multidisciplinary [11,13] and transdisciplinary [12,57] competencies.

Currently, several studies assess universities' contributions to SDG science. De la Poza [58] performed a study about the SDG performance of universities based on Times Higher Education Ranking (THE) documentary data, finding positive correlations between top-ranking universities and SDG performance, and also significant knowledge and technology transfer from them to society. Also using this same database, De Iorio [17] analysed the relationship between university disclosure of SDG performance and contextual factors. Documentary sources are used alongside other methods. González-Torre & Suárez-Serrano [59] investigated reports from 84 universities in Spain to identify their profiles and contributions to the SDGs. In a study to identify the SDG science research performance of universities in SDG 2 (zero hunger), Jetten [60] used three documentary sources: news media, social media, and the screening of publications in the Scopus database. In a country-level study to investigate the performance of 13 Austrian universities, Körfgen [28] used internal research reports and external data from publications to evaluate the performance of universities. Finally, in a recent study, O'Donoghue [29] combined qualitative research through interviews, internal documentary data analysis, and case studies, with data generation from SciVal-Elsevier to assess the SDG science performance of University College Cork in Ireland. In Brazil, the context of this study, there have been some recent studies about the relationship between universities and SDGs. As such, Gasperina [16] introduced a case study of the contribution of smart practices adopted in a Brazilian university, with analysis of their contributions to SDG improvement. First, they identified, based on literature reviews, a set of 70 smart practices, their benefits, and relations with SDGs. Also, in Brazil Vieira [26], a comparative case study of two universities assessed the barriers and motivations for the implementation of SDGs in their day-to-day practices. For their effective implementation, the authors suggested engaging different stakeholder groups.

2.3. Assessment of University Performance on SDGs

Recent literature advocates the necessity of increasing the research impact of universities on society, where researchers have a fundamental role in this process [27]. In this regard, the recent literature presents several methods for assessing universities' contributions to advancing the SDGs. There are studies based on: pure documentary/secondary data; studies that combine documentary data with respondents' data; and research based on respondents' data.

De la Poza [58] performed an analysis of universities' performance on SDGs based on the Times Higher Education report, an audited report that ranks universities around the world, combined with Elsevier database data. University data are based on teaching, student graduation, research, and other factors. In a study of the level of adoption of SDG practices in Spanish universities, González-Torre & Suárez-Serrano [59] screened reports of universities, using five dimensions to assess their level of SDG implementation—depth, priority, reach, sustainability, and visibility.

In a unique case study at a university in Ireland, O'Donoghue [29] used Scival/Elsevier data and workshops with researchers for a detailed assessment of the research performance in the 17 SDGs, presenting a detailed performance of the studied university in SDGs. In addition to the number of publications per SDG, the authors also used citation counts, field-weighted citation impact, the number of international collaborations, and the journal citation score of publications. Based on respondents' data, Leal Filho [53] introduced a framework for SDG implementation in universities, relying on four tenets—institutional, thematic, structure, and personal/individual. They surveyed universities around the world and found that universities focus on only 13% of the SDGs.

Dejo-Vásquez [61] researched foundational documents in universities in 12 countries, verifying different focuses on SDGs, with little emphasis on issues such as SDG 14, life

below water, and SDG 2, zero hunger. Despite these several models for the assessment of university research, the literature still requires a systematic framework which permits the mapping of the main knowledge areas approached in SDGs in research institutions at the country level for the identification of the general research landscape, as well as to permit comparisons among the performance of institutions in SDG science.

The models of assessment of the scientific performance of research institutions are fundamental for guiding scientific policies to improve sustainability [62,63]. In the context of research institutions, these models can prompt coordinated actions within national innovation systems to improve sustainability [38,64]. This can help to address the lack of scientific metrics to assess the social impact of science and better guide public investment in research [65–67]. In the SDG landscape, the priority given to research institutions on SDGs reflects their effective research policy [59].

3. Method

Considering the goal of this article, it assumes that SDG science is fundamental to the effective improvement of the SDGs, whereas given the limitations of extant technologies, new scientific knowledge is necessary to develop technologies capable of improving SDG performance. Given that universities and research institutes are responsible for most scientific knowledge in practice, this study adopts a pragmatic perspective on how research generated in these settings can contribute to improving the SDGs. As such, a first step is to map the SDG science generated by these institutions.

This research employed a quantitative approach, based on data compilation from SciVal-Elsevier, to assess the SDG research performance of the five best-ranked Brazilian research institutions in SDG 2 (Zero Hunger). The following research institutions were identified in a decrescent order according to their scholarly output: Embrapa (Empresa Brasileira de Pesquisa Agropecuária), a Brazilian public agency for agricultural research; University of Saint Paul (USP), the most prominent public university in Brazil, located in the Saint Paul state; State University Júlio de Mesquita Filho (Unesp), also located in the Saint Paul state; Federal University of Viçosa (UFV); and Federal University of Lavras (UFLA), both located in the Minas Gerais state.

The choice of Brazil as the study country is due to three reasons. Brazil is a world-renowned food producer, thanks to its abundant natural resources and tropical climate. In the last few decades, the agricultural productivity of this country has accelerated considerably, driven by advances in scientific knowledge and the development and adoption of several technologies. Among the SDGs assessed, Brazil's best rankings are in SDGs 2 and 15, where it ranks fifth worldwide in scholarly output. Finally, the choice of SDG 2 may be due to the fact that Brazil has a representative scientific output in this SDG, with 23,005 Scopus-indexed publications.

The selection of the five institutions of this study, a research institute and four universities, is due to the fact that they are the best-ranked institutions in the quantity of publications related to SDG 2 in Brazil. Together, these five institutions account for 12,396 publications, out of a total of 23,008 publications, representing 53.87% of the total publications of Brazil on SDG 2 according to SciVal.

3.1. Data Source, Data Generation, and Treatment

This research is based on SciVal data, which comprises several statistical metrics on publications indexed in Scopus. To achieve the research goal, the following three general steps were taken (Figure 1). The data treatment in this research was first based on downloading tables from SciVal and subsequently, on compiling the data. Firstly, the world rankings of countries for the 16 SDGs were verified in the SciVal database. As a result,

Brazil's best positions were 5th place in SDG 2 (zero hunger) and SDG 15 (life on land). Considering Brazil's prominent role in world food production, SDG 2 was chosen as the focus of this research.

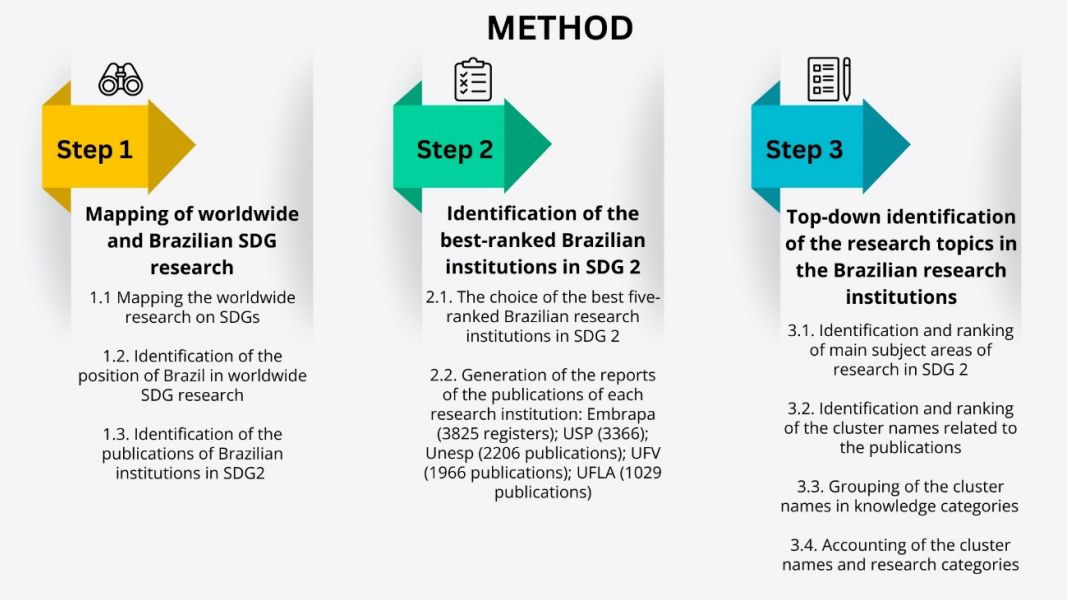


Figure 1. The basic steps of the research.

The second step involved ranking the subject areas addressed by the articles from the five research institutions related to SDG 2. In Embrapa's case, for example, 26 subject areas were identified.

In the third step, reports were generated on the publications of the five Brazilian research institutions related to SDG 2. While Brazil's total number of publications on this SDG 2 is 23,009, the first five research institutions (Embrapa, USP, Unesp, UFV, and UFLA) account for 12,396 of them. Among the parameters of this report, the "topic cluster name", henceforth "cluster name", is a parameter related to each article's content. The report was revised by ranking and by quantifying the articles related to the cluster name. In the case of Embrapa, 253 cluster names were identified. As such, through Pareto ordering, it was verified that the first topic cluster names had low coverage, whereas the 30 most frequent cluster names accounted for 68.07% of the publications. As such, an upper category, called knowledge categories, was generated to aggregate similar cluster names within the same category. This step involved independent coding by the researchers, with meetings to resolve nomenclature and classification ambiguities. For example, the cluster names "Innovative Strategies for Mite and Pest Control" and "Fusarium Resistance and Biological Control in Agriculture" were associated with the knowledge category "Pest Control". As a result, in the case of Embrapa, the twenty most frequent knowledge categories covered 96.62% of the publications, with a higher coverage than the cluster names. As a result, even though the creation of the construct knowledge category permitted an intermediary element between the constructs' subject areas and topic cluster names, it also permitted a high level of mapping of the issues covered in the publications and a map with easy visualisations with fewer categories than topic cluster names with more synthesis power.

3.2. Comparative Synthesis of the Performance of Brazilian Institutions in SDG 2 Research

After accounting for the metadata of several publications from the five Brazilian institutions, a comparative analysis of their data on SDG 2 was performed. The analysis across the three scope levels, subject areas, cluster names, and knowledge areas was divided

into two approaches: internal and external. The internal approach verified the relative ranking and importance of each knowledge construct (*subject area, cluster name, knowledge area) within* the research institution. The external approach verified the relative importance of the knowledge construct across the research institutions and in a general perspective.

4. Results

4.1. The Statistics of the Subject Areas Approached by the Research Institutions

Table 1 presents the total number of articles published by research institutions between 2015 and 2024. It was possible to identify the quantity of publications in different subject areas. While a publication can be associated with more than one *subject area*, in all cases, the quantity of accumulated publications in the *subject area* exceeds the quantity of publications related to SDG 2.

Table 1. General data about the subject areas of SDG 2 research in the research institutions.

	Embrapa	USP	UNESP	UFV	UFLA
Quantity of subject areas a in SDG 2 publications	26	27	27	25	24
The cumulated quantity of publications in SDG 2 in the subject areas	5799	5611	3445	3016	1539
Total publications in the 10 best-ranked subject areas	5298	4798	2897	2699	1384
Proportion of total publications	90.66%	85.51%	86.70%	89.48%	89.92%
Total publications in SDG 2	3825	3366	2206	1966	1029

Range 2014–2025; based on SciVal data.

The accounting of the number of subject areas associated with the research institutions' publications revealed an average of 25.8, ranging from 24 at UFLA to 27 at USP and Unesp. This variation in the number of subject areas can be considered moderated, indicating a relative convergence in quantity across the research institutions despite considerable differences in the number of publications. Despite an average of 25.8 subjects areas, the total number of publications in each subject area showed that the 10 most frequent subject areas at each research institution accounted for an average of 88.45%, ranging from 85.51% at USP to 90.66% at Embrapa. It reveals that, while USP exhibits a significant distribution of publications across subject areas, Embrapa shows a concentration in some of them, with the remaining universities falling between the two institutions.

Table 2 presents the internal ranking of the top 10 subject areas for each research institution. Considering first the thematic frequency of the subject areas addressed separately at each research institution, it is possible to observe a high level of convergence. Embrapa, Unesp, UFV, and UFLA approach the same subject areas in their top 10, while USP approaches 9 of them.

Despite the thematic convergence of the subject areas, the relative counts of publications by subject area reveal considerable differences among the research institutions. As such, it is evident that total convergence and a high level of concentration are present in the two best-ranked subject areas, *Agricultural and Environmental Sciences*, as well as *Environmental Science*. However, this phenomenon occurs only in these two subject areas, whereas there is no total convergence in the remaining subject areas. The level of convergence of subject areas in line three is four out of five, whereas it is smaller in the remaining lines. This situation reveals that research institutions have different thematic emphasis. Finally, to illustrate the commonalities and differences in the relative focus of research institutions across subject areas, Figure 2 presents an affinity graph indicating the level of similarity/dissimilarity in the relative importance of subject areas among them. For instance, while UFLA has 40% affinity with Embrapa and UFV, Unesp has 50% affinity with UFV.

Table 2. The 10 best-ranked subject areas in each research institution.

Ranking	Embrapa	USP	UNESP	UFV	UFLA
1st	Agricultural and environmental sciences (2870)	Agricultural and environmental sciences (1889)	Agricultural and environmental sciences (1552)	Agricultural and environmental sciences (1416)	Agricultural and environmental sciences (808)
2nd	Environmental science (737)	Environmental science (789)	Environmental science (480)	Environmental science (347)	Environmental science (166)
3rd	Biochemistry, genetics and molecular biology (510)	Medicine (568)	Biochemistry, genetics and molecular biology (219)	Biochemistry, genetics and molecular biology (264)	Biochemistry, genetics and molecular biology (125)
4th	Social sciences (188)	Biochemistry, genetics and molecular biology (373)	Medicine (138)	Medicine (163)	Veterinary (50)
5th	Earth and planetary sciences (185)	Social sciences (290)	Social sciences (126)	Social sciences (111)	Engineering (43)
6th	Veterinary (176)	Engineering (200)	Engineering (123)	Immunology and microbiology (96)	Immunology and microbiology (45)
7th	Immunology and microbiology (169)	Nursing (196)	Earth and planetary sciences (100)	Multidisciplinary (82)	Medicine (40)
8th	Engineering (168)	Earth and planetary sciences (184)	Immunology and microbiology (86)	Veterinary (78)	Earth and planetary sciences (36)
9th	Medicine (137)	Immunology and microbiology (166)	Multidisciplinary (84)	Earth and planetary sciences (71)	Social sciences (36)
10th	Multidisciplinary (119)	Multidisciplinary (143)	Veterinary (79)	Engineering (70)	Multidisciplinary (35)
Average ranking	1.7	1.7	3.1	3.5	5

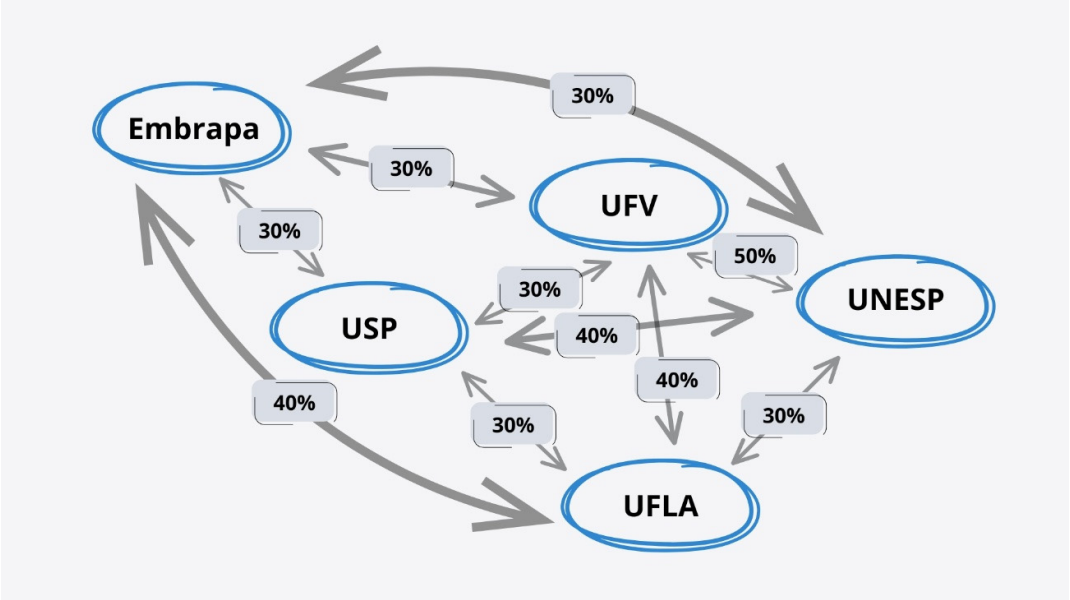


Figure 2. The affinity graph among the research institutions.

Table 3 presents the relative position of each research institution in each of the 10 best-ranked subject areas. Ultimately, the average rank of each institution is calculated by

dividing the total number of positions by 10. As such, this table shows the predominance of USP and Embrapa in the first and second places, respectively.

Table 3. The general 10 best-ranked subject areas and the respective position of the research institutions.

	Subject Areas	Publications	1st	2nd	3rd	4th	5th
1	Agricultural and environmental sciences	8535	Embrapa	USP	UNESP	UFV	UFLA
2	Environmental science	2519	USP	Embrapa	UNESP	UFV	UFLA
3	Biochemistry, genetics and molecular biology	1491	Embrapa	USP	UFV	Unesp	UFLA
4	Medicine	1046	USP	UFV	Unesp	Embrapa	UFLA
5	Social Sciences	751	USP	Embrapa	Unes	UFV	UFLA
6	Engineering	605	USP	Embrapa	Unesp	UFV	UFLA
7	Earth and planetary sciences	576	Embrapa	USP	Unesp	UFV	UFLA
8	Immunology and microbiology	562	Embrapa	USP	UFV	Unesp	UFLA
9	Multidisciplinary	463	USP	Embrapa	Unesp	UFV	UFLA
10	Veterinary	456	Embrapa	Unesp	UFV	USP	UFLA

- Veterinary is in the 15th position in internal USP ranking
- Average rank: Embrapa = USP = 1.7th; Unesp = 3.1rd; UFV = 3.5rd; UFLA = 5th

Another interesting result is that, although Embrapa has a considerable advantage in total publications on SDG 2 over USP, the relative rankings are equal. This situation, as previously noted, reveals a major distribution of USP publications across various subject areas. Although, due to the number of publications and Unesp's higher ranking relative to UFV, there is a slight ordinal difference of 3.1 and 3.5, respectively. Finally, due to its limited number of publications on SDG 2, UFLA ranks fifth across all ten subject areas.

4.2. Ranking the Research Institutions by the Cluster Names

The SciVal database also relates each publication to a specific cluster name. Compared to the subject area parameter, the cluster name parameter provides a more detailed perspective. In Table 4, the number of cluster names associated with each institution's publications is shown, with Embrapa (349), USP (447), Unesp (309), UFV (204), and UFLA (152). As previously presented, the most significant number of cluster names for USP reflects a broader research perspective on SDG 2.

Table 4. The general statistics of the cluster names in the SDG 2 research in the research institutions.

Cluster Names	Embrapa	USP	UNESP	UFV	UFLA
Total quantity of cluster names by research institution	349	447	309	204	152
Proportion of the 30 most frequent cluster names in the research institutions	68.07%	55.1%	66.59%	73.14%	89.31%

Even though all the research institutions have publications associated with a significant quantity of cluster names, cumulative accounting, departing from the most frequent cluster name until the 30th cluster name, reveals a coverage that ranges from 55.1% of the publications in USP to 89.31% in UFLA, with an average value of 70.04%.

To map the most frequent cluster name, Table 5 presents the 20 most frequent cluster names among research institutions. Except for Embrapa, which ranks first among the 16 most frequent cluster names, the remaining institutions have a dispersed ranking.

However, the general ranking of the research institutions remains unchanged relative to the order presented in the previous section; notably, certain institutions excel in specific areas. For example, UFV, which ranks fourth in publications, ranks first in the cluster "Innovative strategies for mite and pest control" and second in the cluster "Biological Control and Host-Parasitoid Dynamics."

Table 5. Most frequent cluster names in research institutions.

Order	Cluster Names	Embrapa	USP	UNESP	UFV	UFLA	TOTAL
1st	Soil carbon dynamics in agricultural ecosystems	457 (1)	338 (3)	355 (2)	140 (4)	124 (5)	1414
2nd	Innovative strategies for mite and pest control	83 (4)	125 (2)	90 (3)	168 (1)	60 (5)	526
3rd	Genetic insights into crop yield enhancement	183 (1)	46 (5)	65 (4)	147 (2)	72 (3)	513
4th	Methane reduction through feed supplementation strategies	188 (1)	81 (2)	39 (4)	60 (3)	26 (5)	394
5th	Genetically modified organisms in pest management	140 (1)	84 (2)	78 (3)	52 (4)	28 (5)	382
6th	Interactions of plant growth-promoting rhizobacteria	150 (1)	62 (3)	72 (2)	24 (5)	58 (4)	366
7th	Biological control and host-parasitoid dynamics	60 (2)	32 (3)	43 (3)	140 (1)	10 (5)	285
8th	Fusarium resistance and biological control in agriculture	136 (1)	29 (4)	24 (5)	57 (2)	30 (3)	276
9th	Genetic resistance and expression in plant pathology	103 (1)	42 (3)	41 (4)	46 (2)	33 (5)	265
10th	Vegetation and climate change monitoring and modelling	58 (1)	50 (3)	57 (2)	30 (5)	32 (4)	227
11th	Innovative strategies for pest control and management	45 (4)	49 (3)	58 (1)	54 (2)	20 (5)	226
12th	Herbicide resistance and weed management innovations	70 (1)	48 (2)	47 (3)	39 (4)	17 (5)	221
13th	Entomopathogenic fungi in biological control strategies	77 (1)	55 (2)	33 (3)	30 (4)	13(5)	208
14th	Nitrogen dynamics and greenhouse gas emissions	77 (1)	61 (2)	25 (3)	23 (4)	10 (5)	196
15th	Plant responses to abiotic stress mechanisms	56 (1)	24 (4)	58 (2)	34 (3)	15 (5)	187
16th	Sustainable food systems and waste reduction strategies	31 (4)	60 (1)	35 (3)	39 (2)	12 (5)	177
17th	Conservation strategies for biodiversity and resource management	61 (1)	41 (2)	22 (3)	17 (4)	4 (5)	145
18th	Genetic diversity and evolutionary insights across species	56 (1)	41 (2)	32 (3)	14 (4)	6 (5)	149
19th	Water and carbon dynamics in ecosystems	41 (1)	36 (2)	32 (3)	19 (4)	4 (5)	132
20th	Nematode interactions in soil and plant health	53 (1)	10 (5)	24 (3)	27 (2)	21 (4)	135
	Average ranking	1.5th	2.75th	2.95th	3.6th	4.65th	

4.3. Grouping the Cluster Names in Categories to Rank the Research Institutions

This subsection presents a new approach to categorising the knowledge of research institutions in SDG 2 that goes beyond simple compilations of subject areas (Section 4.1) or cluster names (Section 4.2). We propose an intermediary framework that bridges the general parameter *subject areas* and the highly detailed cluster name parameters. Table 6 presents the 20 best-ranked knowledge categories approached in the publications of the five research institutions. The categorisation was based on the following steps. First, the cluster numbers were counted and ordered by frequency, with the most frequent first.

The second step involved associating each set of cluster names with a corresponding knowledge category. The purpose was to gather cluster names that relate to similar topics within the same category. It is important to emphasise that the same *cluster name* would be associated with more than one *knowledge category*. For example, the cluster name *"Genetically modified organisms in pest management"* was associated with the categories *"pest control"* and *"genetics"*. Given the large number of cluster names examined across the five research institutions, sets of three or more were analysed. Even so, a high level of coverage of cluster

names was obtained in the four institutions, with an average of 92.38%, ranging from 89.31% at UFLA to 96.62% at Embrapa.

Table 6. The ranking of research institutions in knowledge categories.

		Embrapa	Usp	Unesp	UFV	Ufla	Total
1	Pest control	801 (1)	453 (3)	373 (4)	549 (2)	203 (5)	2379
2	Ecosystems dynamics	780 (1)	338 (3)	508 (2)	270 (4)	208 (5)	2104
3	Genetics	774 (1)	344 (3)	271 (4)	348 (2)	168 (5)	1905
4	Crop-yielding—food production	539 (1)	226 (4)	349 (2)	272 (3)	176 (5)	1562
5	Climate change	225 (2)	228 (3)	172 (4)	233 (2)	80 (5)	938
6	Plant resistance	337 (1)	109 (4)	142 (3)	169 (2)	56 (5)	813
7	Human health	56 (5)	508 (2)	106 (3)	86 (4)	31 (5)	787
8	Human nutrition	185 (3)	346 (2)	88	111 (4)	34 (5)	764
9	Greenhouse gas control	265 (1)	68 (4)	72 (3)	83 (2)	39 (5)	527
10	Biodiversity	245 (1)	171 (3)	222 (2)	113 (4)	47 (5)	798
11	Ecosystems contamination	76 (2)	114 (1)	59 (3)	39 (4)	39 (4)	327
12	Forestry	139 (1)	108 (2)	55 (4)	58 (3)	26 (5)	386
13	Entomology	124 (1)	131 (3)	104 (4)	150 (2)	103 (5)	612
14	Waste reduction	56 (2)	115 (1)	47 (3)	39 (4)	12 (5)	269
15	Livestock	96 (1)	93 (2)	50 (4)	74 (3)	10 (5)	323
16	Image processing	71 (2)	93 (1)	12 (4)	19 (3)	7 (5)	202
17	Aquatic systems	44 (3)	46 (2)	62 (1)	12 (4)	9 (5)	173
18	Conservation of natural resources	61 (1)	58 (2)	18 (4)	26 (3)	4 (5)	167
19	Renewable fuels	51 (1)	40 (2)	12 (5)	23 (3)	14 (4)	140
20	Animal health	16 (3)	14 (4)	28 (1)	14 (4)	18 (2)	90
	Average in the ranking	1.7th	2.55th	3.00th	3.1th	4.75th	
	Proportion of total cluster names	96.62%	90.96%	90.20%	94.81%	89.31%	
	There were grouped cluster names with frequency greater than 3						

The internal relative performance of the five research institutions in knowledge categories follows the same patterns already detected in the two previous subsections. The general order of frequency of the five institutions remains unchanged.

Comparing the classification based on knowledge categories with that based on subject areas allows for a more detailed examination of knowledge. For example, the subject of medicine in this last classification is associated with human health and nutrition. On the other hand, by comparing this classification to that based on cluster names, it is possible to verify that a smaller quantity of categories permits a better understanding of the topics, avoiding the individual accounting of so many cluster names by grouping them in representative categories that permit understanding the general knowledge map of SDG research in a given topic.

5. Discussion

The analysis of the framework's contribution to mapping SDGs in this study, in relation to the extant literature, will consider the following parameters: method, focus on a specific SDG, geographic scope, research object, and content of analysis. In relation to the method, as some contemporary studies [30,68] have employed the quantitative approach, this research also employed a quantitative approach which enabled the construction of a

general map of research on SDG 2 in Brazil, with high coverage of the total research in this country based on the main research institutions. Unlike these studies, which typically conduct bibliometric research on large numbers of articles, the present study utilised general statistical data generated in SciVal, a fast and practical approach for the quantitative mapping of SDG research.

Even though this study used document analysis as the main data source, as well as bibliometrics studies [5,30,36] which are based on publications methadata such as keywords, journal name, and year of publication, this study is based on the metadata subject area and topic cluster name that were used to identify the specific knowledge areas which a research institution published on SDG 2. In this case, it is important to consider that this research advances current research about SDGs in research institutions, showing specific focus on SDG science. It is important because an SDG can be seen as a general term that can mean several different specific things. For example, though in a hypothetical assumption two research institutions focus on SDG 2, this framework shows that it can mean different things; for example, one can focus on pest control, and another on ecosystem dynamics. Considering the constitution of the proposed framework based on three levels, the proposal of the intermediary category, knowledge categories, as an intermediary level between subject areas and cluster names permits the configuration of an integrative framework with a top-down visualisation of the scope of the SDG research in a research institution.

In relation to the SDG focus, this study is in line with studies [30,60] that mapped single SDGs, respectively, SDG 4 (education) and SDG 2 (zero hunger). Considering the geographic scope, this study mapped SDG 2 research in Brazil, a notable food producer that ranks fifth worldwide in the number of SDG 2 research publications. As such, the SDG 2 mapping was made from a single country perspective, which aligns with recent studies in Spain and Austria [28,59].

Considering the research object, several recent frameworks have been developed to assess several issues in SDG research. The majority uses bibliometric indicators to assess the performance of fields. For instance, Mishra [5], in a study based on 12,176 articles indexed in Web of Science, sought to identify the SDGs represented in publications through keyword analysis and to identify leading journals and authors. In this vein, to identify the focus of universities and research institutions on the SDGs, Körfgen [28] analysed internal and external data from Austrian institutions to assess their SDG performance at the country level. Finally, in a unique case study, the University College Cork, Ireland [29] employed mixed methods to identify the SDG priorities and their corresponding thematic areas. Considering the content of the analysis, this study is in line with O'Donoghue [29]. However, while these authors conducted a comprehensive analysis of all SDGs in an university, employing various methods, including research in SciVal, with the focus of identifying the SDGs related to schools, departments, and researchers, this present study focused solely on SDG 2, but with a proposal for a wide identification of the topics approached in research institutions in three alternative scope levels.

Additionally, the developed framework enabled the verification of several commonalities and particularities among research institutions in SDG 2. Regardless of the classification parameter, the quantity of publications by an institution tends to influence its ranking position. That is, the general ranking order based on the number of publications from Embrapa, USP, Unesp, UFV, and UFV was also repeated in the general classifications by subject area, knowledge area, and cluster name. This study also revealed several specific topics related to SDG 2. In this case, it is possible to observe that the specialisation of institutions in a specific topic related to an SDG can make it best positioned for this particular topic.

This research also shows that the general thematic focus of the research institutions is highly convergent. For instance, all research institutions publish in the 20 most fre-

quent knowledge categories, which account for more than 92.38% of the studies' coverage. However, it is evident that there are considerable differences in the specific focus of each institution. For example, the subject area of medicine ranks differently across the five institutions, namely, nineth, third, fourth, fifth, and seventh, respectively, at Embrapa, USP, Unesp, UFV, and UFLA. This finding reveals different relative research priorities among research institutions on the research into an SDG.

This study shows that there is vast and diversified research on SDG 2 in Brazil. If one looks only at the broad labels (subject areas), it seems that every institution is moving in the same direction, covering general fields like agriculture and the environment. However, the proposed framework reveals that at the research 'shop floor' level (the clusters), each institution has found its own niche. As a result, there is an organic complementarity creation of scientific knowledge within the research institutions.

The approach adopted in this article expands the concept of SDG qualitatively, showing in major detail the several specific topics and emphasis of research institutions in SDG 2. As such, it is based on the quantity of publications for an SDG by the research institutions. As such, this metric can be expanded with additional ones, for better assess the impact and the impact of publications, such as, number of citations, cite score of journals where the articles are published, and field weight citation index [29]. It is possible to consider other indicators of scientific production and transfer of knowledge, such as patents, as well as their licencing, and projects of technology transfer performed of research institutions.

Finally, the framework introduced in this article can be used by foment agencies and research institutions to establish policies that align with SDG science and the communities' demands in sustainability challenges [69,70].

Practical Implications for Research Policy

Given the importance of precise assessment and metrics for scientific production as a guiding reference for research policies [62,63], this study introduces a model to assess the scientific production of universities and research institutions from the SDGs perspective. In this three-layer model, the proportion of the knowledge category serves as an intermediary category for the classification of the SDG science of a research institution. The contribution of the introduction of the knowledge category in the model serves as an intermediary category between the opposites, subject areas and cluster name, permitting, at the same time, a panoramic view of the SDG science of research institutions in a country, and as a powerful pillar with a high level of coverage of SDG science approached thematically.

As a practical contribution, this model can be easily applied by research institutions, government agencies, and other public agents to assess the current status of SDG science in a country and to deploy incentive policies for scientific and technological development and knowledge transfer guided by the SDGs concept. This aligns with the view of authors in the literature [65–67], offering a practical instrument to conduct research and technology policies for SDG improvement.

6. Conclusions

This article introduces a framework for country-level SDG research mapping by identifying publications from research institutions. This model was applied to map publications on SDG 2 (zero hunger) indexed in Scopus across the five best-ranked Brazilian research institutions, using SciVal reports. A framework with three alternative and complementary scope levels has been introduced: subject areas, knowledge categories, and cluster names. The main contribution of this article is to present a replicable framework for mapping the SDGs at the country level, with a detailed view about what specific topics are approached by each research institution in an SDG. As such, it offers a methodological contribution

that provides an easy way to assess the level of development of research institutions for each SDG. The proposed framework is opportune in a situation which requires a clear link between the demand for more sustainable solutions in several perspectives (economic, environmental, and social) and the development of SDG science in several sub-topics.

The employment of these three alternative scope-level mappings enabled a deep understanding of the main topics studied under SDG 2 at the best-positioned research institutions in Brazil.

Given its replicability, the framework proposed in this study presents the following implications for the practice. Universities and research institutes can use it to evaluate their performance in SDG research within their respective countries and regions. As such, it can serve as a benchmark and a means to assess and deploy research strategies for creating knowledge about the SDGs. For policymakers, this study can be replicated to map current SDG research in their respective countries, providing insight into their SDG research landscape, informing technology transfer programmes, and fostering improvements in SDG research in deficient areas. For strengths, the introduced framework performs an easy and replicable method based on a three-layer framework for mapping the performance of universities and research institutions on SDGs, and permits the qualitative detailing of the specific topics with which an SDG is associated in each university or research institute.

As a limitation, this study assumes that the number of publications in an SDG may be indicative of research quality. Even though the quantity of publications can be naturally considered as a reference parameter, it is not the unique parameter. It could be other indicators, such as the number of citations and the quality of the journals in which the documents are published. As such, future studies can consider these parameters for mapping and qualify the SDG research. Still, in this aspect, other parameters such as patents, licencing agreements, and technology transfer projects may be used to assess the effective contribution of research institutions for the improvement of SDGs in communities. Another aspect is the addressing of only five Brazilian institutions. Even though there are five most prominent research institutions for SDG 2, based on their quantity of publications, there are other relevant institutions not covered in this study.

As a suggestion for future studies, this study can be replicated to assess SDG science progress in other countries. In the case of Brazil, this approach can be replicated to map the country's performance across the remaining SDGs and to analyse the types of correlations among them. This study can also be replicated on a global scale to assess the topics addressed in the literature for each SDG, identify and rank countries and research institutions, and assess the extent to which these institutions are engaged in research on each SDG. For each research institution, this framework can be updated periodically to permit the assessment of the evolution of the its SDG science performance in a dynamic perspective.

Ultimately, this work's major contribution is not just the SDG 2 map, but the navigational tool presented. Science and technology managers face a dilemma: they either rely on macroscopic data that offer little insight (such as 'Agricultural Sciences') or get lost in thousands of micro-topics. The proposed 'intermediate level' (knowledge areas) solves this issue. It offers the balance point for making funding decisions without requiring expertise in every single subfield. To accelerate the SDG agenda, this model provides exactly the missing radar to connect academic output with society's real demands.

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