

# **A Combined Bibliometric Analysis on the Data Collection and Reporting Systems for Sustainability Assessment in Higher Education**

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## **Abstract**

Sustainability in Higher Education (SHE) has been tagged as an emerging topic of concern among the research community and higher education institutions over the past decade. This paper aims to investigate the existing body of knowledge related to the SHE assessment tools, methods, data collection sources, reporting systems, methods used for rating and categories of broadening indicators using a combined bibliometric and exhaustive thematic investigations. This paper also aims at investigating the intellectual structure in the SHE field of knowledge using journal co-citation analysis, author co-citation analysis, and bibliographic coupling with the software VOSviewer. This study provides the research community with a comprehensive platform for expanding future research, highlighting the intellectual structure in the SHE assessment and implementation.

## **Keywords**

Higher Education Institution, Sustainability, Sustainability in Higher Education, Sustainable Development, Sustainability Indicators

## **1. Introduction**

Sustainability in higher education (SHE), a paradigm that has spurred interest among educational practitioners has acquired immense popularity over the recent years (Maragakis and Dobbeltstein, 2015). Higher Education Institutions (HEIs) continuously commit in fostering sustainable future in the area of research and educational excellence. Thus, sustainability is identified as sculptures that bring life to the next generation HEIs. This goal is often achieved through proper sustainability reporting. One of the most commonly used reporting tool developed by Lozano, (2011) is the “Global Reporting Initiative (GRI)” that covers all the requisites fit for educational institutions apart from teaching and research (Findler et al., 2018). These tools contain several categories of broadening indicators that aid in building an ideal sustainability model for the educational institutions (Alhor and Alkuwari, 2018). Enhancing knowledge about sustainability among the key employees can foster sustainable outcomes and help in supporting the sustainability assessment committee at the institution (Caeiro, 2015). Concerns have arisen about the lack of inclusion of educational dimensions of sustainability along with the economic, social and environmental dimensions of sustainability for the categories of broadening indicators. Hence, a better understanding on the reporting systems and indicators availability should be of great concern for researchers working in this area of knowledge to build a sustainability model.

Several research articles, conference papers, and book chapters have been published over the years, in which a clear understanding can be drawn that “Sustainability in Higher Education” is an emerging area of interest among the research community. Despite a growing concern in this area of research, it can be seen that this emerging area has not been deeply reviewed previously using a bibliometric study. As a result, the paper furnishes a bibliometric analysis on the several sources of data collection and reporting systems for sustainability related assessment and practices in HEIs. This research paper characterizes the search results according to;

- a) Journals, Conference proceedings, and Book chapters
- b) The publication year
- c) The assessment methodology
- d) The methods and techniques used for the assessment
- e) The broadening indicators availability

This paper brings to light a detailed analysis on articles published in several databases related to SHE for a period from

2005 till 2018. This is a way to understand the knowledge gap in this area of research and understand several categories of broadening indicators, reporting systems and rating tools used in the previous research studies. This article follows the outlined structure where the second section details the methods used in conducting the bibliometric analysis in a systematic approach. The third section brings out an in-depth analysis and interpretation of various aspects/findings identified through the bibliometric study in the knowledge cluster. The fourth and fifth sections elucidate a detailed analysis of data collection sources, reporting systems, methods used for rating, and categories of broadening indicators followed by the final section presenting the concluding remarks.

## 2. Research Method

The research brings to light several sources of data collection, reporting systems, significant methods used for rating, and dimensions of indicator categories related to SHE. The bibliometric study undertaken as a part of this research aims to overcome the currently existing knowledge gap as identified through the extensive literature study. The study followed three prime steps namely, a) identifying the journal/conference/book names b) counting citations, co-citations, and volume of publications c) identifying possible keywords for search and selection d) conducting in-depth content analysis.

The authors used multiple scholarly databases: Scopus, ISI Web of Science, ScienceDirect, Google Scholar, Emerald Insight, Taylor and Francis Online, and IEEE Xplore to conduct a comprehensive search for literature containing work related to sustainability in HE, over a period from 2005 until 2018. This period tallies perfectly with the “United Nations Decade of Education for Sustainable Development” from 2005 till 2014 and covers additional years (2015-2018) due to the growing concern for sustainability in HE among the research community. A typographical match to the title, year of publication, and authors were taken into account to rule out repeated documents when grouped into a single data set. Documents that were of less relevance and the ones that showed a negative impact were also ruled out. The bibliometric study initially analyzed 1,147 documents obtained through direct keyword search. These documents were then extracted out to 647 results based on “limit to” criteria for the keywords “Sustainability,” “Higher Education,” “Sustainable development,” and “Higher Education Institutions.” The term “sustainable development” is often used as a synonym for sustainability. Hence, the keyword “sustainable development” was used in the search technique, along with other relevant keywords. After skimming through the abstract, the documents were scrutinized to 237 documents. After this, citation count and volume of publications were taken into consideration along with the keyword-based search technique. This reduced the documents selected further down to 54 publications that focus best on the tools, methods, and several assessment parameters related closely to sustainability in HE.

The study conducts a bibliometric analysis and content visualization by conducting a journal co-citation network analysis, author co-citation network analysis, and a bibliometric coupling to investigate the intellectual structure in the selected school of thought. The content visualization in this study was done through a visualization platform named VOSviewer 1.6.13. Fifty four scopus indexed literature review articles formed the basis of this study. The study intends to investigate the hypotheses (Table 1) as a part of the selected literature.

Table 1. Research hypothesis

SL. No	Dimension	Underlying Assumption
1.	H1	The composition of knowledge in the field of SHE holds a mature structure within the academic community
2.	H2	Lack of proper analytical methods used for rating limits the applicability of sustainability assessment tools to a more confined scope and perspective
3.	H3	Standardized assessment techniques are used to assess HE sustainability.

## 3. Knowledge Fragmentation

The database search and analysis technique revealed that the knowledge encapsulation in the field of “Sustainability in Higher Education” (SHE), concentrated in the assessment tools, techniques, methods accounts from multiple interrelated publications by several research groups publishing contents in various subject areas namely; social sciences, energy, environmental science, business management and accounting, engineering, arts and humanities, chemistry, economics and, econometrics and finance. The amount of citations by authors from articles acts as a symbolic indicator for valuable knowledge concentration in the journal containing these articles (Garfield, 1970). The

intellectual structure in the field of tools/methods, data collection sources, reporting systems, methods used for rating, and categories of broadening indicators related to SHE has been analyzed through the co-citation relationship mapping technique. This section utilizes journal co-citation network analysis, author co-citation network analysis, and bibliometric coupling to investigate the intellectual structure in the selected research domain.

### 3.1 Journal Co-citation Analysis

A journal co-citation relationship can be defined as a relationship when two or more journals are cited in the references of a citing journal (Osareh, 2009). It helps to identify the overall intellectual structure in the specified school of thought. The software VOSviewer is used to visualize the journal co-citation map. Figure 1 above shows the journal co-citation network analysis on 137 nodes that corresponds best to the literature on SHE assessment tools, methods, data collection sources, reporting systems, methods used for rating, and categories of broadening indicators. Each node represents an indexed journal and the linkage line between the nodes shows the weight between the two nodes, i.e., the school of thought that exist between the journal and the articles published in the journal. The relative distance/linkage between the nodes is of great significance. Here, predominantly we choose two weightage attributes, namely, the aggregate of links and overall link strength. Smaller the linkage between two journal nodes, the higher the number of co-citations. This means that higher the number of publications in which two journals have both been cited.

Figure 1 highlights the 2472 strongest co-citation links between the journals with 3 clusters amounting for a total link strength of 83,682. Each color corresponds to a cluster group where the red colored cluster (cluster 1) includes journals up to 68 journals, while the green-colored cluster group (cluster 2) includes a total of 43 journals. Cluster 3, highlighted in blue color, includes 26 journals such as the “Journal of Engineering Education”, “British Journal of Educational Technology”, “Higher Education Research & Development”, “International Journal of academic development”, and several more. The co-citation link between each journal highlights the commonality in the school of thought within the selected research domain.

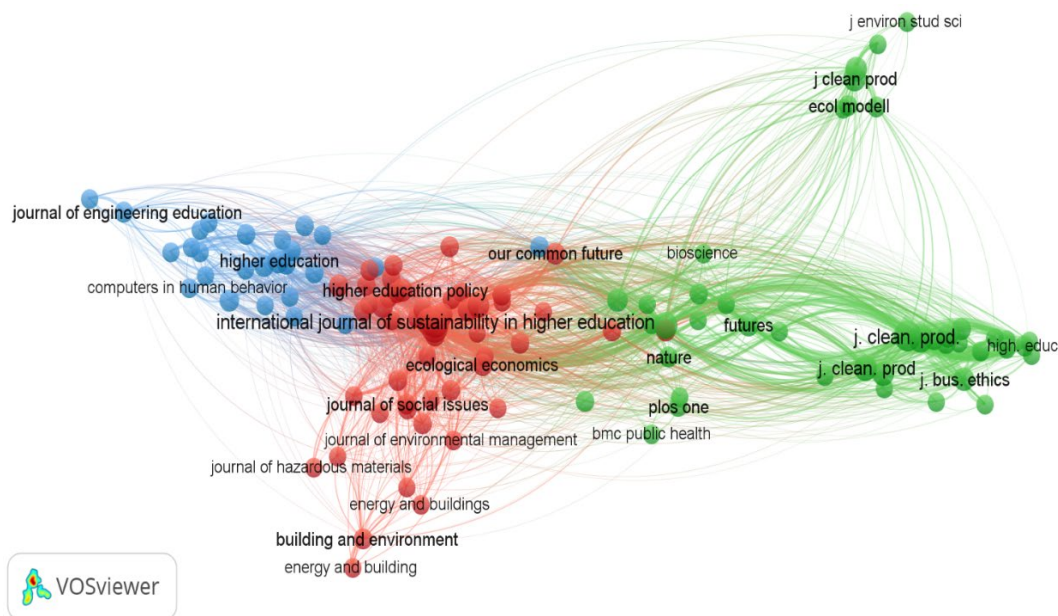


Figure 1. Journal co-citation network analysis on selected literature

### 3.2 Author Co-Citation Network Analysis

The network analysis (Figure 2) delivers a broader picture, describing the interrelationship for the most co-cited authors publishing in the selected domain of research in SHE assessment tools, methods, data collection sources, reporting systems, methods used for rating and categories of broadening indicators. The network visualization is created by the VOSviewer 1.6.13 software. The co-citation network analysis, unlike the normal qualitative citation analysis, does not relate to the quality of the author’s publications with respect to the citation count, rather shows the influence of the author in publishing within a specified field of research.

The size of each node and the link strength between two or more authors highlights this influence. From a fractional total of 292 authors who were a part of the co-citation network analysis, nearly 38 authors have outset the threshold to a minimum of 50 co-citations. The author co-citation network plot comprises three clusters, each representing a specific school of thought within the common research area. Table 2 reports the list of top authors who holds significant influence in the literature of SHE assessment with the most co-citations from each cluster.

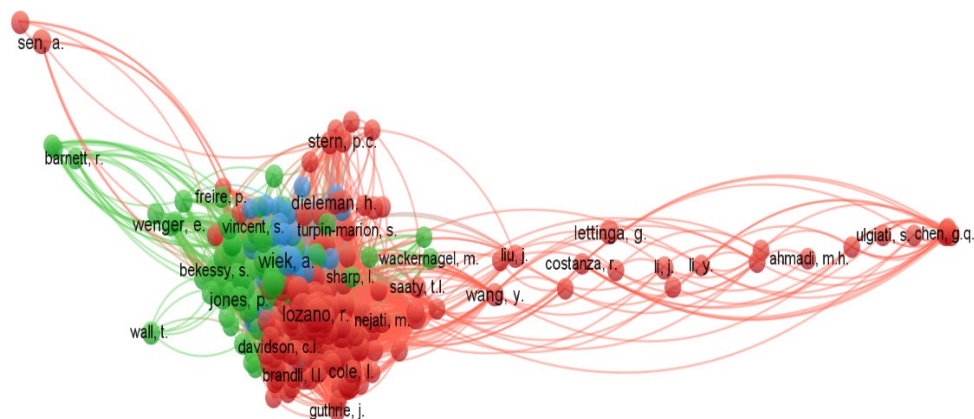


Figure 2. Author co-citation network analysis on selected literature for SHE assessment using VOSviewer 1.6.13

Table 1. Top 5 authors with the most co-citations from each cluster

Clusters	Authors	Co-citations	Weightage Attributes	
			Links	Total Link Strength
Cluster 1	R. Lozano	610	275	31150
	D. Huisingh	303	275	17575
	W. Leal Filho	262	271	11591
	W. Lambrechts	233	273	12587
	K. Ceulemans	221	275	12099
Cluster 2	S. Sterling	220	271	7375
	D. Tilbury	165	263	6495
	A.E.J Wals	164	269	6157
	I. Thomas	142	262	5868
	P.B. Corcoran	65	262	2365
Cluster 3	A. Wiek	222	268	9004
	C.L. Redman	98	262	4149
	R.W Scholz	90	257	4246
	I. Withycombe	74	256	3115
	K. Brundiers	53	239	2203

### 3.3 Bibliographic Coupling

A bibliographic coupling, using data extracted from multiple databases, was created using VOSviewer 1.6.13. The size and the link strength of each node reflect the significance of the publication. Bibliographic coupling was chosen as the type of analysis and fractional counting as the counting method. Documents with at least five citations were chosen out of the total 1,167 documents, resulting in 273 documents meeting the threshold value. The threshold value was chosen to five citations to facilitate better visualization. For each of the 273 documents selected, the total strength of the bibliographic coupling links with other documents was calculated, resulting in a value of 2144.50.

The documents with the greatest link strength were then visualized from the network map. The analysis shows that the work by Ceulemans, (2015) holds a total link strength of 188.92, the greatest link strength among all the 273 nodes in the bibliographically coupled mapping frame. This shows that the document treats SHE assessment topics relevant to our selection criteria with great significance, and the content has been worthy of being cited through 167 links. The map contains 4 clusters with cluster 1 holding 110 items followed by cluster 2, cluster 3 and cluster 4 holding 58 items, 53 items and 52 items, respectively. Table 2 shows the list of top 5 documents based on their coupling strength. Greater the coupling strength corresponds to an increased citation by other documents from the source document.

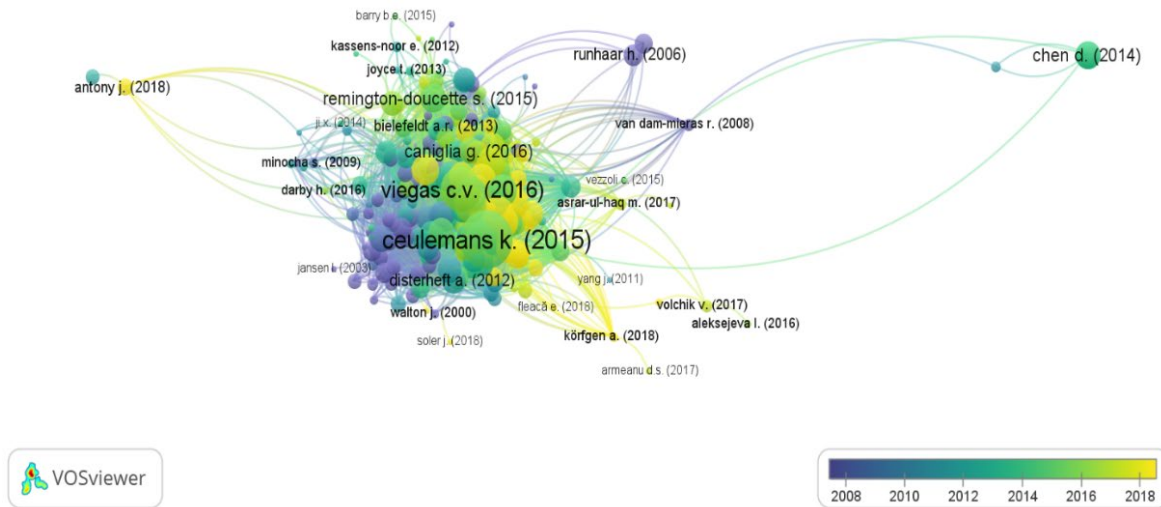


Figure 3. Bibliographic coupling results for the literatures in the area of SHE

Table 2. Top 5 list of documents based on their coupling strength

SL. No	Document	Citations	Weightage Attributes	
			Links	Total Link Strength
1.	Ceulemans et al., 2015	91	275	188.92
2.	Viegas, et al., 2016	23	150	103.00
3.	Disterheft, et al., 2016	20	120	61
4.	Guerra, et al., 2018	12	120	61
5.	Figueiró and Raufflet, 2015	47	128	50

#### 4. Data Sources and Reporting Systems

This section aims to identify the data collection sources, reporting systems, and methods used for rating and categories of broadening indicators from several literatures. The selected set of published literature review papers were assessed as per the selection criteria mentioned in section 2. These literature review documents were collected from different journals, conferences, and book chapters. These included peer-reviewed articles from 21 journals (all are international journals), 2 conference proceeding and 1 book chapter. It can be seen that most of the articles published within the selected scope of research in the area of SHE were from the “Journal of Cleaner Production”. This was backed by the “International Journal of Sustainability in Higher Education” that contained 7 review articles followed by the “Journal of Environmental Management” with 2 publications that were based on literature review. The remaining fragmentation of knowledge distribution of the published review articles is presented in Figure 4 and Figure 5.

To assess the orientation of knowledge production among the scientific community, the authors attempted a differentiation process on the articles published between the years 2005 till 2018; see Figure 6. Figure 6 shows that there has been a progressive hike in the number of articles published in this selected area of research. This indicates the fact that educational institutions have started to consider sustainability in higher education more seriously. Moreover, 24% of the articles that formed the basis of the literature review in this paper were mostly published during the year 2017. Figure 7 shows the data source and the reporting systems used as per the 54 articles reviewed in the study. Most of the data were collected from literature review sources as per 32 documents that used this method in the assessment process. Another widely used data collection method is the survey. Surveys are often sought over several other approaches due to their simplicity in application. This is followed by another widely used method, the numerical scoring approach that uses visual representations such as plots, percentage representation and illustrative diagrams. As stated by Gamage & Sciulli (2017), many reporting and assessment tools, including questionnaires, are modified according to the organization/university's need.

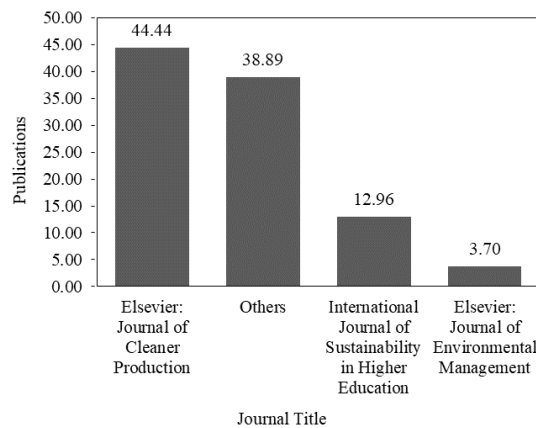


Figure 4. Distribution of Journals, conferences, and books covered in the literature review study (in %)

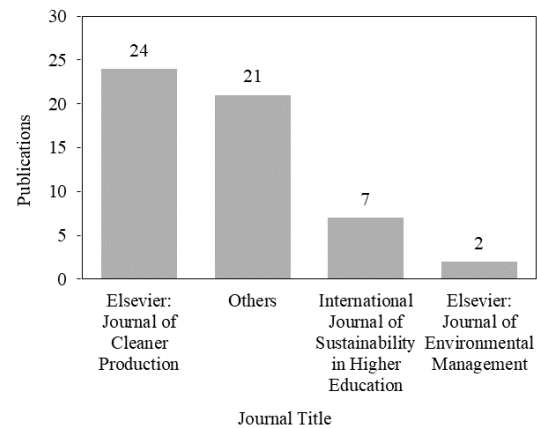


Figure 5. Distribution of no. of journals, conferences, and books covered in the review study

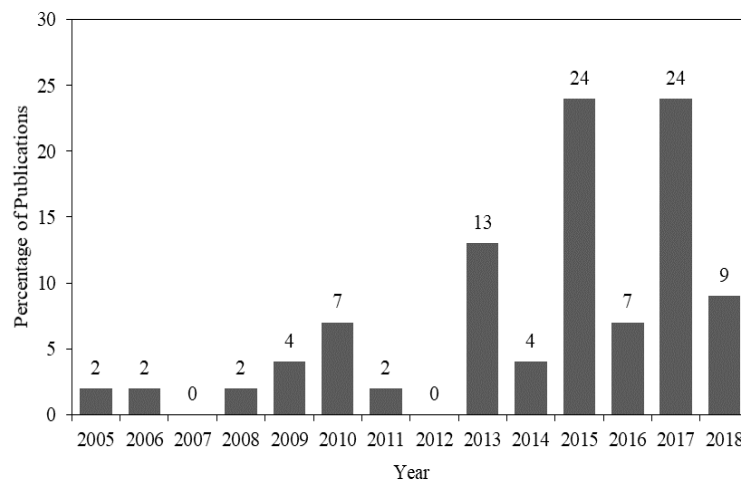


Figure 6. Percentage distribution over the years for scholarly articles reviewed

The quantitative method, mainly the survey, was used in a study done at Universidad Europea de Madrid (UEM) in Spain in which the researchers combined four different sustainable assessment tools in one survey in order to analyze the sustainability of the university (Berzosa et al., 2017). In another study done in Korea, Jang (2017) highlighted the importance of stakeholder participation in fostering sustainability. The purpose of that survey was mainly to promote understandings on sustainable internationalization rather than collecting inputs and data related to sustainability. Similarly, Christie et al., (2015), Sammalisto et al., (2015) and Harpe and Thomas (2009) distributed a questionnaire for different universities to investigate the current opinion of higher education institutions towards education for sustainability concepts. In another study done in Australia, around 27 engineering curriculums were surveyed to test the implementation of sustainability, more specifically, energy efficiency in their programs (Desha and Hargroves, 2010). While Dalati et al., (2017) used the questionnaire to collect data to assess sustainable leadership behaviors. However, Larrán Jorge et al., (2015) used the questionnaire method to identify the extend to which sustainability is practiced in Spanish universities. In a similar practice, a survey has been distributed to 70 HEI's to evaluate their commitments and implementation of sustainable practices within the institution (Lozano et al., 2015).



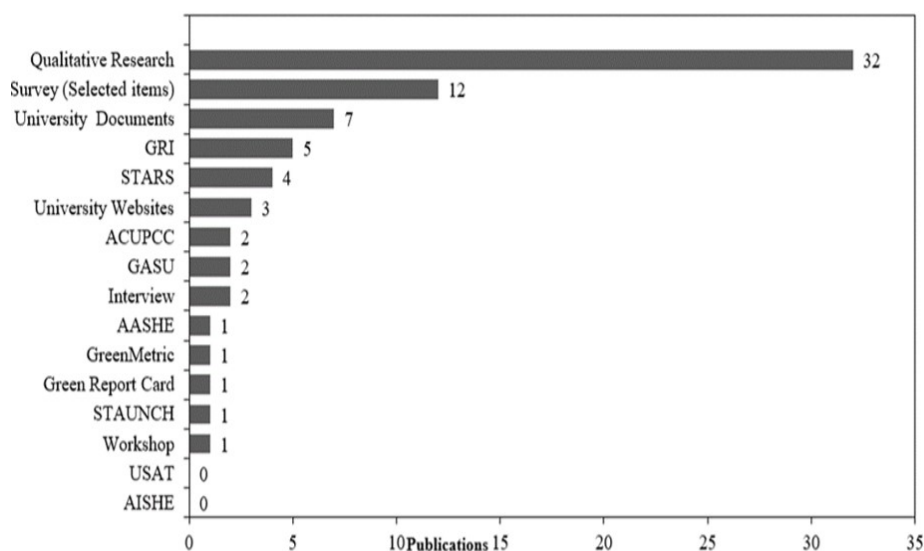


Figure 7. Data source and reporting systems as per articles reviewed

The data collection from different sources and reporting systems can be through a series of workshops, interviews, or institution documents and websites. Bell and Morse (2010) adopted group workshops approach for the data collection process for sustainability research. They organized five of the “Triple Task” workshops where some of them were generally focusing on the sustainability indicators and indices in sustainable development policy. Others, such as Martin et al., (2014), built their sustainability evaluation based on workshops and series of visits and interviews of the UK’s Green Academy. Also, semi-structured expert interviews method were used for collecting different data. It considered the expert people in sustainability and in-touch directly with the sustainability activities in order to answer a list of questions (Disterheft et al., 2015).

Apart from interviews and direct observations, the institutions’ documents are considered as a source used for collecting data related to the institutions’ sustainability (Kutty et al., 2020b). For example, a Brazilian case study conducted during early 2010 utilized several approaches such as interviews, and document analysis for data collection (Jabbour et al., 2013). Moreover, data can be collected from the institutions’ reports, documents, and seminar presentations (Holm et al., 2015). On the other hand, some studies use the institution’s websites together with the available documents for data collection and reporting. Boman and Andersson (2013), utilized the course and program catalogs as well as the institution’s website, which covers the sustainability development topic. Similarly, in the case study of Universiti Teknologi PETRONASUTP Malaysia, Büyüközkan and Karabulut (2018) looked at the UTP website, links, and documents that cover the same topic. Also, Dagiliene and Mykolaitiene (2016) collected data used in reporting sustainability and needed for the Global Reporting Initiative (GRI) through the institution website and other reports. These reports included reports such as performance reports, booklets, periodicals, social responsibility report. Others referred to obtaining the required data for sustainability from the institutions’ websites only. As stated by Xiong et al., (2013), the collected data for the 267 institutions that were related to the green curriculum was from institution websites. Furthermore, websites could be developed for collecting data and assessing the institutions’ sustainability in some research studies (Maragakis et al., 2016).

## 5. Methods Used for Rating and Categories of Broadening Indicators

After identifying that the published literature sources and survey methods are a key to solicit information for SHE related assessments through an in-depth content analysis, the research extends its focus on several methods used for rating and categories of broadening indicators. When analysing in depth the rating methods from all the 54 articles reviewed, descriptive analysis can be seen as the widely adopted method for rating and is mentioned in 22 articles (see Figure 8). The numerical scoring approach is the second highly used method as per literatures followed by “Principle Compound Analysis (PCA)” as mentioned in the articles by Meiboudi et al., (2017), Dalati et al., (2017) and Klein-Banai and Theis, (2013), considered through surveying approaches and the “American College and University Presidents’ Climate Commitment (ACUPCC)” tool. Approaches such as the “Content Analysis”, “Coefficients for Criteria’s”, “Factorial Simplicity”, and “Hypothesis” are some of the other commonly used methods found in the literatures.

It can be seen from Figure 9 that, out of the 54 reviewed articles, around 24 articles did not discuss about any categories of broadening indicators under the selected dimensions of sustainability namely; the social, economic, educational and environmental pillars. While, 15 articles focused on only the educational dimension of sustainability followed by 1 article by Gamage and Sciulli, (2017) on the social dimension; 2 articles by Meiboudi et al., (2017) and Klein-Banai and Theis, (2013) stretched concerns under the environmental pillar alone and none under the economic pillar of sustainability related to HE. All the four pillars of SHE were covered under 6 review articles that focused on several indicators under these pillars for addressing higher education sustainability concerns. These included articles; (Huber and Bassen, 2018), (Berzosa et al., 2017), (Lozano, 2011), (Wigmore and Ruiz, 2010), (Ramos, 2009), and (Lozano, 2006). Further, Berchin et al., (2017) focused both on the indicators under educational and economic pillars; while, Lauder et al., (2015) focused on the indicators under the educational and the environmental dimensions of sustainability. While, articles by Dagilienė and Mykolaitienė, (2016) and Lozano and Young, (2013) covered categories of broadening indicators under the socio-economic and environmental perspectives of SHE. Larrán Jorge et al., (2015) and Alshuwaikhat and Abubakar, (2008) studied the categories of broadening indicators under the social, educational and environmental dimensions of SHE. Thus, of the total 54 articles reviewed, 25 articles had focused on categories of broadening indicators under the educational dimension. When, 13 articles mentioned about the categories of broadening indicators under the environmental category, around 11 and 9 articles respectively focused on the social and economic pillars of sustainability.

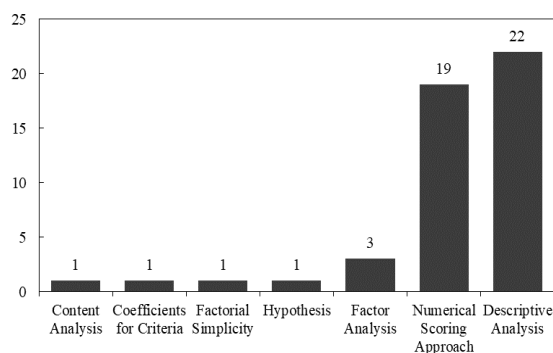


Figure 8. Rating methods used in the reviewed articles for SHE assessment related studies

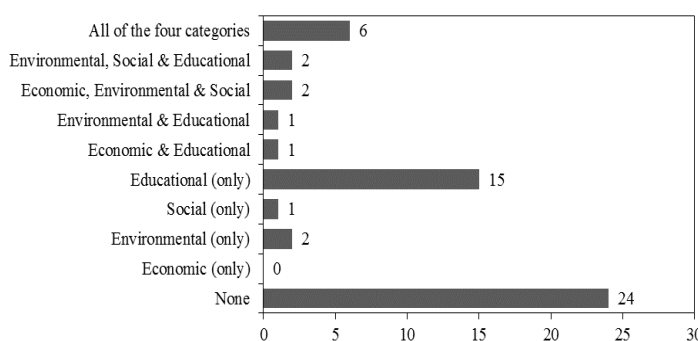


Figure 9. HEI sustainability categories of broadening indicators under each dimension as per the literature review

A growing trend can be observed lately for sustainable practices in education. HEIs have been attempting to redirect their actions and frame policies to deliver sustainable results in the area of education and research (Zainordin, and Ismail, 2018). These HEIs act as prime enablers of sustainable practices in the area of teaching, research, co-curricular activities and other institution related services, thus supporting the “United Nations Education Program Agenda (UNEPA)” through policies and action plans. These agendas keep universities committed towards achieving excellence by framing policies and action plans that tend to support sustainability in HE (Geryk, 2018).

## 6. Discussion and Conclusion

The study initially analyzed the composition of knowledge in the area of SHE assessment methods, data collection sources, reporting systems, methods used for rating and categories of broadening indicators using network analysis and bibliographic coupling techniques with VOSviewer 1.6.13. Although conflict of interest does not exist among the research community in terms of structuring a holistic and mature foundation in the selected domain of research, lack of proper analytical methods often brings about limitations to this field of research. Generic qualitative and quantitative methods back the empirical study that limits its applicability to a more confined scope and perspective.

The study identified key authors through author co-citation analysis that contributes well to this specific area of research. These authors include but are not limited to R. Lozano, D. Huisinigh, W. Leal Filho, W. Lambrechts, K. Ceulemans, S. Sterling, D. Tilbury A.E.J. Wals, and A. Weik. I. Thomas are among the few valuable knowledge contributors in this field of research. Besides, the study also identified significant documents in the selected domain of research. The bibliometric analysis conducted in this study covers all the prime areas of concern related to the methods and approaches for sustainability assessment from recently published international studies. HEI’s sustainability assessment is spanned under the social, environmental and academic dimensions of sustainability. These assessments are carried out by HEI’s to bridge the gap that exist in the area of education and research were the prime focus was the academic dimension of sustainability. This can help in achieving academic excellence, improve student and staff retention and ensure student satisfaction (Al-Sheeb et al., 2018). The other pillars such as the social, economic



and environmental dimensions of sustainability are often neglected when conducting sustainability assessments in HE. The scoring and ranking approaches for most of the sustainability assessment tools are also not explained clearly. Frequently used sustainability assessment tools for HE such as the “Assessment Instrument for Sustainability in Higher Education (AISHE)” has not defined any approach for weighting the indicators. The tools such as “The Sustainability Tracking, Assessment & Rating System (STARS)” have partially brought out a method to weight the indicators. A difficulty in comparing measures can be catered by attempting a numerical transformation of data into a scale from 0-2 as proposed by (Lozano et al., 2015).

Several approaches can be seen in the literatures that are used in weighting and aggregating indicators in SHE related assessments. The commonly used indicator weighting approaches as found in the literatures are; weighted average method, Principal Component Analysis (Elhmoud et al., 2021), regression analysis (Alsarayreh et al., 2020; Kutty et al., 2020; Abdella et al., 2021), Unobserved component models, Analytic Hierarchy Process (AHP), expert weighting and Conjoint Analysis (CA) method. While, the most commonly used indicator aggregation approaches include; additive aggregation, geometric aggregation and “Non-compensatory” aggregation. Understanding the conditions of applicability of these approaches are crucial for the successful implementation of each of these methods in the sustainability assessment process (Gana et al., 2017). For future research, combinatorial approaches are well suggested when attempting to assess the sustainability performance of higher education, such as a variable selection approach when using large data sets (Yang et al., 2012). Weight restriction helps us identify whether discrimination limits the capacity of a model to bring efficient results compared with the traditional unrestricted models such as when using envelopment analysis for HEI performance assessment. Penalized-based weighting approaches are best suggested for weight restriction while running a weighted Data Envelopment Analysis (DEA) model for sustainability assessment. To better understand various statistical-based weighting approaches, readers can further refer; Abdur-Rouf et al., 2018; Abdella et al., 2019; Al-Sheeb et al., 2019; and Kutty et al., 2020a. Expert-based weights can also be assigned to the eco-efficiency indicators to run fuzzy-weighted models for sustainability assessment, as shown in Egilmez et al., 2016. To get a comprehensive understanding on all the tools and techniques used for sustainability assessment that can possibly be applied in the area of higher education, interested readers may refer: Kutty and Abdella, (2020) and, Elhmoud and Kutty, (2021).

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