

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

Adeeb A. Kutty, Roa J. Shalabi, Rania M. Ibrahim

Mechanical and Industrial Engineering Department

College of Engineering, Qatar University

Doha, Qatar

akutty@qu.edu.qa, roa@qu.edu.qa, rmarouf@qu.edu.qa

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 Dobbelsteen, 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 (Alhorr 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 arised about the lack of inclusion of educational dimensions of sustainability along with the economic, social and environmental dimenaions 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.

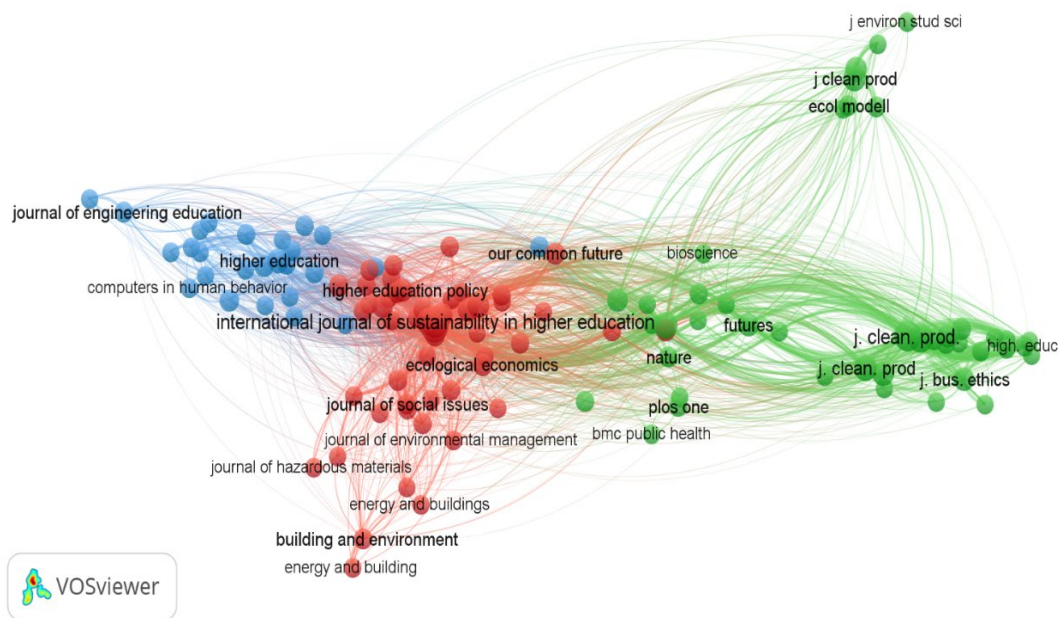


Figure 1. Journal co-citation network analysis on selected literature

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.

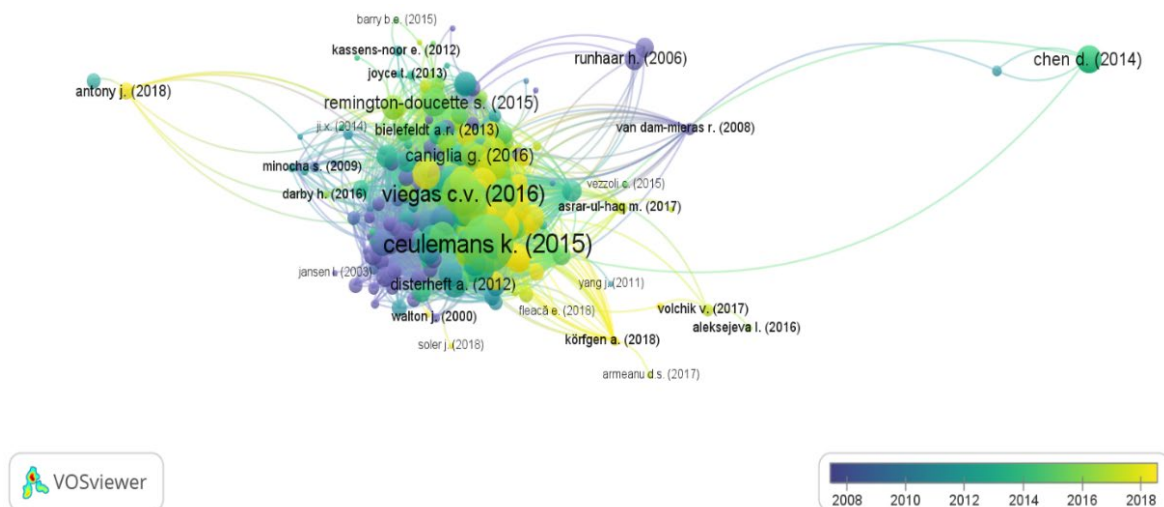


Figure 3. Bibliographic coupling results for the literatures in the area of SHE

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.

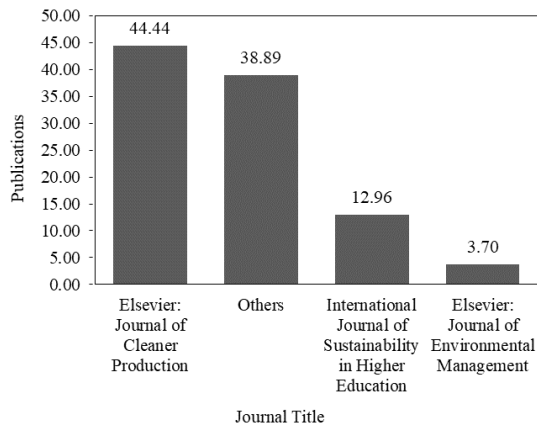


Figure 4. Distribution of Journals, conferences, and books covered in the literature review study (in %)

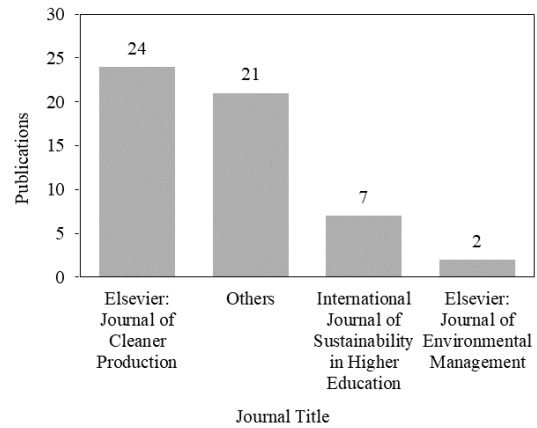


Figure 5. Distribution of no. of journals, conferences, and books covered in the review study

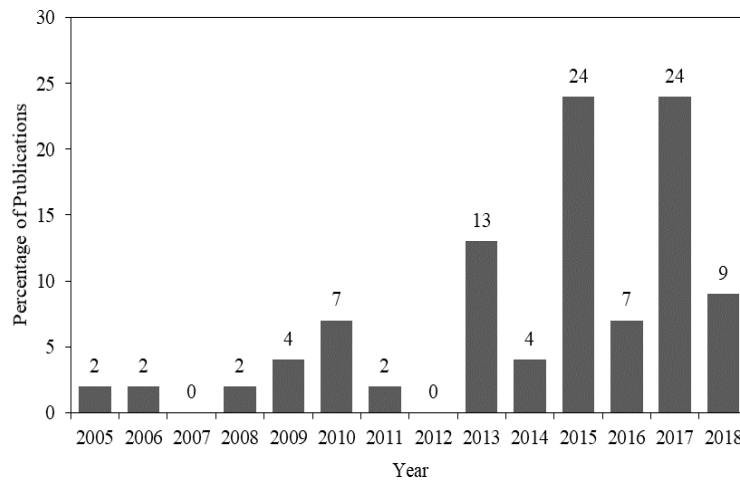


Figure 6. Percentage distribution over the years for scholarly articles reviewed

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).

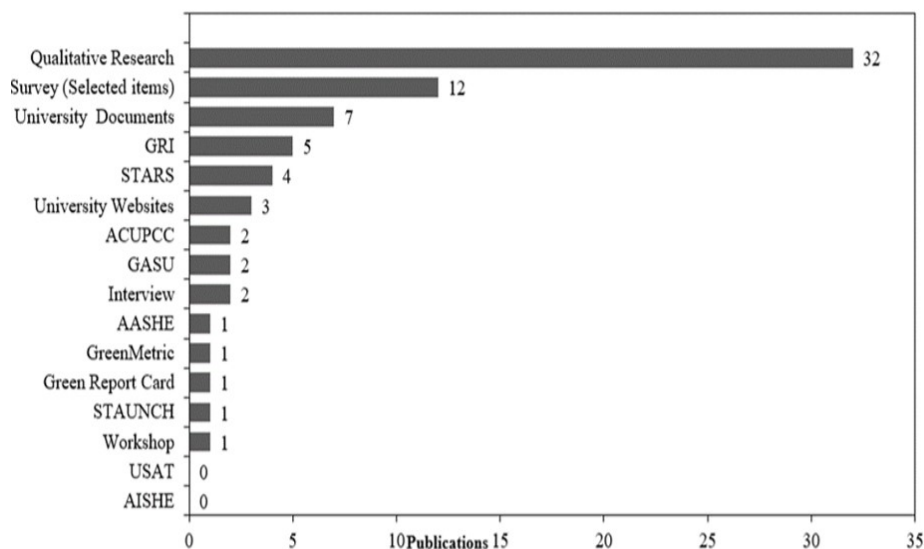


Figure 7. Data source and reporting systems as per articles reviewed

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.

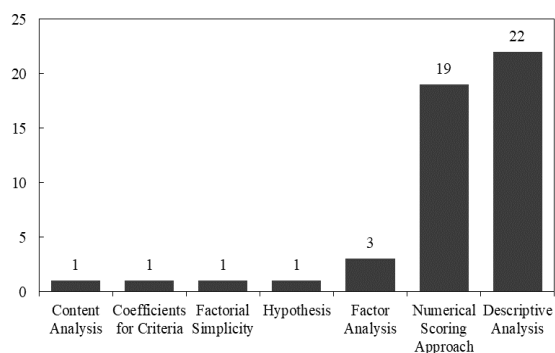


Figure 8. Rating methods used in the reviewed articles for SHE assessment related studies

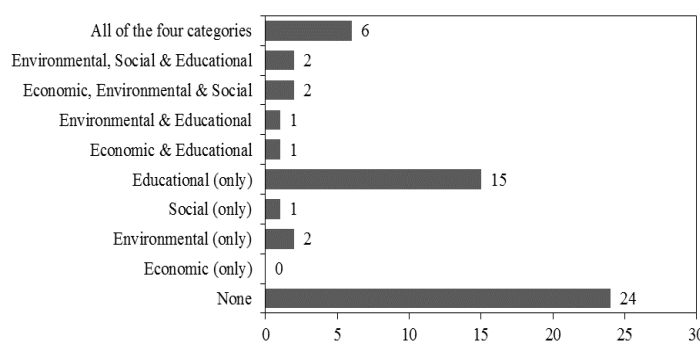


Figure 9. HEI sustainability categories of broadening indicators under each dimension as per the literature review

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. Huisingh, 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 (Elhmod 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, Elhmod and Kutty, (2021).

References

- Abdella, G. M., Kim, J., Al-Khalifa, K. N., and Hamouda, A. M. S., Penalized Conway-Maxwell-Poisson regression for modeling dispersed discrete data: The case study of motor vehicle crash frequency, *Safety Science*, vol. 120, pp. 157-63, 2019.
- Abdella, G. M., Kucukvar, M., Kutty, A. A., Abdelsalam, A. G., Sen, B., Bulak, M. E., & Onat, N. C., A novel approach for developing composite eco-efficiency indicators: The case for US food consumption. *Journal of Cleaner Production*, vol. 299, p.126931, 2021.
- Abdur-Rouf K. B., Abdella, G. M., Al-Khalifa, K. N., and Alhajyaseen, W., Ridge penalization-based generalized linear model (GzLM) for predicting risky-driving index, *In the Proceedings of the International Conference on Industrial Engineering and Operations Management*, Washington DC, USA pp. 1462-73, 2018.
- Alhorr, Y. M. and Alkuwari, M. S., GSAS Operations Guidelines & Assessment, 2018.
- Alsarayreh, M. M., AlSuwaidi, M. F., Sharif, R. A., and Kutty, A. A., The Factors Affecting CO₂ Emission in the European Union Countries: A Statistical Approach to Sustainability across the Food Industry, *2020 IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA)*, IEEE, April 16-21, 2020.
- Al-Sheeb, B., Abdella, G. M., Hamouda, A. M. S., and Abdulwahed, M. S., Predictive modeling of first-year student performance in engineering education using sequential penalization-based regression, *Journal of Statistical Management Systems*, vol. 22, pp. 31-50, 2019.
- Al-Sheeb, B., Hamouda, A., and Abdella, G. M., Investigating Determinants of Student Satisfaction in the First Year of College in a Public University in the State of Qatar, *Education Research International*, Vol. 14, 2018.
- Alshuwaikhat, H. M., and Abubakar, I., An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *Journal of Cleaner Production*, Vol. 16, no. 16, pp. 1777–1785, 2008.
- Berchin, I. I., Grando, V. dos S., Marcon, G. A., Corseuil, L., and Guerra, J. B., Strategies to promote sustainability in higher education institutions A case study of a federal institute of higher education in Brazil, *International Journal of Sustainability in Higher Education*, Vol. 18, no. 7, 2015.
- Bell, S., and Morse, S., The role of Sustainability Indicators within evidence-based policy for sustainable development in the European Union, *16th International Sustainable Development Research Conference 2010 (30 May - 1 June)*, 23, 2010.
- Berzosa, A., Bernaldo, M. O., and Fernández-Sánchez, G., Sustainability assessment tools for higher education: An

- empirical comparative analysis, *Journal of Cleaner Production*, Vol. 161, pp. 812-820, 2017.
- Boman, J., and Andersson, U. P., Eco-labelling of courses and programs at University of Gothenburg, *Journal of Cleaner Production*, Vol. 48, pp. 48-53, 2013.
- Büyükköçkan, G., and Karabulut, Y., Sustainability performance evaluation: Literature review and future directions. *Journal of Environmental Management*, Vol. 217, pp. 253–267, 2018.
- Caeiro, S., Ceulemans, K., Ramos, T. B., van Hoof, B., Huisingh, D., and Lozano, R., Experiences from the implementation of sustainable development in higher education institutions: Environmental Management for Sustainable Universities, *Journal of Cleaner Production*, Vol. 106, 3-10, 2015.
- Ceulemans, K., Molderez, I., and Van Liedekerke, L., Sustainability reporting in higher education: A comprehensive review of the recent literature and paths for further research, *Journal of Cleaner Production*, Vol. 106, pp. 127-143, 2015.
- Christie, B. A., Miller, K. K., Cooke, R., and White, J. G., Environmental sustainability in higher education: What do academics think? *Environmental Education Research*, Vol. 21, no. 5, pp. 655-686, 2015.
- Dagilienė, L., and Mykolaitienė, V., Sustainability reporting in the higher education sector – Case study of Lithuania, *Zeitschrift Für Öffentliche Und Gemeinwirtschaftliche Unternehmen*, Vol. 39, no. 1-2, pp. 163-174, 2016.
- Dalati, S., Raudeliūnienė, J., and Davidavičienė, V., Sustainable Leadership, Organizational Trust on Job Satisfaction: Empirical Evidence from Higher Education Institutions in Syria, *Business, Management and Education*, Vol. 15, no. 1, 14-27, 2015.
- Desha, C. J., and Hargroves, K. (Charlie), Surveying the state of higher education in energy efficiency in Australian engineering curriculum. *Journal of Cleaner Production*, Vol. 18, no. 7, pp. 652–658, 2010.
- Disterheft, A., Caeiro, S. S., Filho, W. L., and Azeiteiro, U. M., The INDICARE-model – measuring and caring about participation in higher education's sustainability assessment. *Ecological Indicators*, Vol. 63, 2016.
- Disterheft, A., Caeiro, S., Azeiteiro, U. M., and Filho, W. L., Sustainable universities - A study of critical success factors for participatory approaches, *Journal of Cleaner Production*, Vol. 106, pp. 11-21, 2015.
- Elhmoud, E. R., Kutty, A. A., Abdalla, G. M., Kucukvar, M., Bulak, M. E., and Elkharaz, J. M., Eco-Efficiency Performance of Airlines in Eastern Asia: A Principal Component Analysis Based Sustainability Assessment, *In the Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management, Singapore*, March 7-11, 2021.
- Elhmoud, E. R., and Kutty, A. A., Sustainability Assessment in Aviation Industry: A Mini-Review on the Tools, Models and Methods of Assessment, *In the Proceedings of the International Conference on Industrial Engineering and Operations Management, Harare, Zimbabwe*, October 20-22, 2021.
- Egilmez, G., Gumus, S., Kucukvar, M., and Tatari, O., A fuzzy data envelopment analysis framework for dealing with uncertainty impacts of input–output life cycle assessment models on eco-efficiency assessment, *Journal of cleaner production*, vol. 129, pp. 622-636, 2016.
- Figureiró, P. S., and Raufflet, E., Sustainability in higher education: a systematic review with focus on management education, *Journal of Cleaner Production*, Vol. 106, pp. 22-33, 2015.
- Findler, F., Schönherr, N., Lozano, R., and Stacherl, B., Assessing the impacts of higher education institutions on sustainable development-an analysis of tools and indicators, *Sustainability (Switzerland)*, Vol. 11, no. 1, 2018.
- Gamage, P., and Sculli, N., Sustainability Reporting by Australian Universities. *Australian Journal of Public Administration*, Vol. 76, no. 2, pp. 187-203, 2017.
- Gana, X., Fernandez, I. C., Guo, J., Wilson, M., Zhao, Y., Zhou, B., and Wu, J., When to use what: Methods for weighting and aggregating sustainability indicators, *Ecological Indicators*, pp. 491-502, 2017.
- Garfield, E., Citation Indexing for Studying Science. *Nature*, Vol. 227, pp. 669-671, 1970.
- Geryk, M., Sustainable development goals as a perspective for higher education institutions, *Prace Naukowe Uniwersytetu Ekonomicznego We Wrocławiu*, Vol. 520, pp. 54-63, 2018.
- Guerra, J. B., Garcia, J., Lima, M. A., Barbosa, S. B., Heerdt, M. L., and Berchin, I. I., A proposal of a Balanced Scorecard for an environmental education program at universities. *Journal of Cleaner Production*, Vol. 172, 2018
- Harpe, B., and Thomas, I., Curriculum Change in Universities. *Journal of Education for Sustainable Development*, Vol. 3, no. 1, pp. 75-85, 2009.
- Holm, T., Vuorisalo, T., and Sammalisto, K., Integrated management systems for enhancing education for sustainable development in universities: A memetic approach, *Journal of Cleaner Production*, Vol. 106, 155-163, 2015.
- Huber, S., and Bassen, A., Towards a sustainability reporting guideline in higher education, *International Journal of Sustainability in Higher Education*, Vol. 19, no. 2, pp. 218-232, 2019.
- Jabbour, C. J. C., Sarkis, J., De Sousa Jabbour, A. B. L. and Govindan, K., Understanding the process of greening of Brazilian business schools. *Journal of Cleaner Production*, Vol. 61, pp. 25-35, 2013.
- Jang, E. Y., Sustainable internationalization in South Korean higher education: Languages and cultures in a foreign professor's course. *Higher Education*, Vol. 73, no. 5, 673-689, 2017.

- Klein-Banai, C., and Theis, T. L., Quantitative analysis of factors affecting greenhouse gas emissions at institutions of higher education, *Journal of Cleaner Production*, Vol. 48, pp. 29-38, 2013.
- Kutty, A. A., Yetiskin, Z., Abraham, M. M., Nooh, M. A., Kucukvar, M., and Abdalla, G. M., An Empirical Assessment on the Transportation Sustainability Indicators and their Impact on Economic Productivity, *Proceedings of the 5th NA Conference on Industrial Engineering and Operations Management*, Detroit, Michigan, USA, August 10-14, 2020.
- Kutty, A. A., Abdella, G. M., and Kucukvar, M., Ridge Penalization-based weighting approach for Eco-Efficiency assessment: The case in the food industry in the United States. In *IOP Conference Series: Materials Science and Engineering*, vol. 947, no. 1, pp. 012003, IOP Publishing, 2020a.
- Kutty, A. A., Abdella, G. M., Kucukvar, M., Onat, N. C., and Bulu, M., A system thinking approach for harmonizing smart and sustainable city initiatives with United Nations sustainable development goals. *Sustainable Development*, vol. 28, pp. 1347-1365, 2020b.
- Kutty, A. A., and Abdella, G. M., Tools and Techniques for Food Security and Sustainability Related Assessments: A focus on the Data and Food Waste Management System, *Proceedings of the 5th NA Conference on Industrial Engineering and Operations Management*, Detroit, Michigan, USA, August 10-14, 2020.
- Larrán Jorge, M., Herrera Madueño, J., Calzado Cejas, M. Y., and Andrades Peña, F. J., An approach to the implementation of sustainability practices in Spanish universities, *Journal of Cleaner Production*, Vol. 106, pp. 34-44, 2015.
- Lauder, A., Sari, R. F., Suwartha, N., and Tjahjono, G., Critical review of a global campus sustainability ranking: GreenMetric, *Journal of Cleaner Production*, Vol. 108, pp. 852-863, 2015.
- Lozano, R., A tool for a Graphical Assessment of Sustainability in Universities (GASU), *Journal of Cleaner Production*, Vol. 14, no. 9–11, pp. 963–972, 2006.
- Lozano, R., The state of sustainability reporting in universities. *International Journal of Sustainability in Higher Education*, Vol. 12, no. 1, pp. 22-40, 2011.
- Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F. J., Waas, T., ... Hugé, J., A review of commitment and implementation of sustainable development in higher education: Results from a worldwide survey, *Journal of Cleaner Production*, Vol. 108, pp. 1–18, 2015.
- Lozano, R., and Young, W., Assessing sustainability in university curricula: Exploring the influence of student numbers and course credits. *Journal of Cleaner Production*, Vol. 49, pp. 134-141, 2013.
- Lukman, R., Lozano, R., Huisingh, D., Lozano, F. J., and Lambrechts, W., Declarations for sustainability in higher education: becoming better leaders, through addressing the university system, *Journal of Cleaner Production*, Vol. 48, pp. 10-19, 2013.
- Maragakis, A., Dobbeltstein, A., Van D., and Maragakis, A. (2016). Stakeholders Perceptions of a Universal Sustainability Assessment in Higher Education - A Review of Empirical Evidence. *International Journal of Higher Education*, 5(4), 247–254.
- Martin, S., McCoshan, A., and McEwen, L., Embedding Sustainability Into the Higher Education Curriculum: Lessons From the UK's Green Academy Institutional Change Programme, Vol. 2, 2014.
- Meiboudi, H., Lahijanian, A., Shobeiri, S. M., Jozi, S. A., and Azizinezhad, R., Development and validation of sustainability criteria of administrative green schools in Iran, *Journal of Environmental Management*, Vol. 197, pp. 605-609, 2017.
- Maragakis, A., and Dobbeltstein, A. V., Sustainability in Higher Education: Analysis and Selection of Assessment Systems. *Journal of Sustainable Development*, Vol. 8, no. 3, 2015.
- Osareh, F., Bibliometrics, Citation Analysis and Co-Citation Analysis: A Review of Literature I, *International Journal of Libraries and Information Studies*, Vol. 46, no. 3, pp. 149-158, 2009.
- Ramos, T. B., Development of regional sustainability indicators and the role of academia in this process: the Portuguese practice, *Journal of Cleaner Production*, Vol. 17, no. 12, pp. 1101–1115, 2009.
- Sammalisto, K., Sundström, A., and Holm, T., Implementation of sustainability in universities as perceived by faculty and staff - A model from a Swedish university, *Journal of Cleaner Production*, Vol. 106, pp. 45-54, 2015.
- Viegas, C. V., Bond, A. J., Vaz, C. R., Borchardt, M., Pereira, G. M., Selig, P. M., and Varvakis, G., Critical attributes of Sustainability in Higher Education: a categorisation from literature review. *Journal of Cleaner Production*, Vol. 126, pp. 260-276, 2016.
- Wigmore, A., and Ruiz, M., Sustainability Assessment in Higher Education Institutions - The STARS System, *Ramon Llull Journal*, 2010.
- Xiong, H., Fu, D., Duan, C., Liu, C. E., Yang, X., and Wang, R., Current status of green curriculum in higher education of Mainland China, *Journal of Cleaner Production*, Vol. 61, pp. 100-105, 2013.
- Yang, K., Abdella, G., and Alaeddini, A., Effect of location of explanatory variable on monitoring polynomial quality profiles. *International Journal of Engineering*, vol. 25, no. 2, pp. 131-140, 2012.
- Zainordin, N., and Ismail, S., Sustainability assessment for higher education institutions: A review on strengths and

weaknesses, *AIP Conference Proceedings*, 2018.

Biographies

Adeeb A. Kutty is an accomplished professional with a bachelor's degree from University of Calicut, India, in Electrical and Electronics Engineering and a master's degree holder in Technology and Engineering management from Universitat Rovira i Virgili, Tarragona, Kingdom of Spain. He is currently doing his PhD in Engineering Management and works as a Graduate Teaching and Research Assistant in the Department of Industrial Engineering at Qatar University. His area of research interest include Sustainability and Systems Engineering, Higher Education, Smart Cities and Regional Development, Electric Vehicles, Transportation and Project Management.

Roa Jehad Shalabi received her MSc. in Engineering Management from Qatar University, and is currently working as an Accreditation Specialist in the Institutional Research and Analytic Department at Qatar University, Doha-Qatar. Her area of research includes Sustainability and Systems Engineering, Higher Education, Lean Management, and Quality Control Applications.

Rania M. Ibrahim was awarded her MSc. in Engineering Management from Qatar Univeristy, Doha-Qatar in 2015. She is working as a Teaching Assistant at Qatar University since then, training students in several industrial engineering capstone design projects and research experience programs. Her research spans across areas such as Sustainability, Operations Research and Project Management.