



**Exploration and Mitigation of Green Lean Six Sigma
Barriers: A Higher Education Institutions perspective**

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Exploration and Mitigation of Green Lean Six Sigma Barriers: A Higher Education Institutions perspective

Abstract

Purpose-The study aims to identify Green Lean Six Sigma (GLSS) barriers in the context of Higher Education Institutions (HEIs) and prioritize them for executing the GLSS approach.

Design/methodology/approach-A systematic literature review (SLR) was used to identify a total of fourteen barriers, which were then verified for greater relevance by the professional judgments of industrial personnel. Moreover, many removal measures strategies are also recommended in this study. Furthermore, this work also utilizes Gray Relational Analysis (GRA) to prioritize the identified GLSS barriers.

Findings-The study reveals that Training and education, continuous assessment of SDG, organizational culture, resources and skills to facilitate implementation, and assessment of satisfaction and welfare of the employee are the most significant barriers to implementing this approach.

Research limitations/implications-The present study provides an impetus for practitioners and managers to embrace the GLSS strategy through a wide-ranging understanding and exploring these barriers. In this case, the outcomes of this research, and in particular the GRA technique presented by this work, can be used by managers and professionals to rank the GLSS barriers and take appropriate action to eliminate them.

Practical implications-The ranking of GLSS barriers gives top officials of higher education institutes a very clear view to effectively and efficiently implementing GLSS initiatives. The outcomes also show training and education, sustainable development goals, and organizational culture as critical barriers. The findings of this study provide an impetus for managers, policymakers, and consultants to embrace the GLSS strategy through a wide-ranging understanding and exploring these barriers.

Societal implications-The GLSS barriers in HEIs may significantly affect the society. HEIs can lessen their environmental effect by using GLSS practices, which can support sustainability initiatives and foster social responsibility. Taking steps to reduce environmental effect can benefit society as a whole. GLSS techniques in HEIs can also result in increased operational effectiveness and cost savings, which can free up resources to be employed in other areas, like boosting student services and improving educational programs. However, failing to implement GLSS procedures

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3 in HEIs could have societal repercussions as well. As a result, it's critical for HEIs to identify and
4 remove GLSS barriers in order to advance sustainability, social responsibility, and operational
5 effectiveness.
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8 **Originality/value**-GLSS is a comprehensive methodology that facilitates the optimum utilization
9 of resources, reduces waste, and provides the pathway for sustainable development so, the novelty
10 of this study stands in the inclusion of its barriers and HEIs to prioritize them for effective
11 implementation.
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15 **Keywords:** *Green Lean Six Sigma; Barriers; Grey relational analysis; Lean Six Sigma; Six Sigma*
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18 **1. Introduction**

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20 With over 70 million students now enrolled, India's HEIs are the largest system in the world
21 (Tobenkin, 2022). In less than 20 years, India has also been able to produce extra capacity for over
22 40 million students (Tobenkin, 2022). HEIs play a crucial part in every sector for its growth and
23 continuous improvement by using knowledge related to the respective sector with the guidance of
24 the leader of that sector. It also helps in the growth of the economy with the help of various
25 principles. HEIs will help not only students, teachers, employees, etc. but it helps all the citizens
26 who want to grow in their area with the help of research, knowledge, and technology (Weisbrod
27 et al., 2008). Six Sigma is an effective tool that reduces variations in their respective sectors
28 (Kumar et al., 2023; Mittal et al., 2023; Kumar et al., 2018). With Six Sigma, Lean is also a
29 powerful business factor that will minimize waste or non-value-added activities. In the earlier era,
30 Lean was not integrated with Six Sigma but in the current scenario, we will combine both of them
31 to achieve our goals in any field (Antony et al., 2012). The combination of lean and Six Sigma
32 will provide superior improvement in manufacturing, medical, social, and many other societies.
33 The word 'Green' represents an environment-friendly process. Many researchers combine green,
34 lean and Six Sigma (GLSS) in respective manners to achieve goals that are environment friendly,
35 have minimum waste, and by using the best method of application.
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48 The implementation of GLSS in HEIs is at a very small level but in the manufacturing sector, it is
49 applied at a wide range (Sunder, 2016a; Antony et al., 2012). There are many difficulties in the
50 application of GLSS at each and every state in HEIs but we have to focus on minimizing those
51 difficulties by using different tools and techniques such as GRA, etc. Teaching, research, and
52 public service are higher education's three main social missions in the USA (Weisbrod et al., 2008).
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3 By giving all young people access to higher education, the teaching purpose is accomplished
4 (Weisbrod et al., 2008). The second social mission is mostly supported by research universities
5 (Gholami et al., 2007). (2021). The third social purpose consists of two objectives: boosting
6 people's incomes and enabling people to make a positive social impact (Sunder and Mahalingam,
7 2018). Organizational and economic developments frequently result in adjustments and difficulties
8 for HEIs. For HEIs, particularly those in poor nations, globalization, which is founded on the
9 market-driven principle, creates more obstacles than benefits (Yang, 2003). Massive open online
10 courses, remote learning, and artificial intelligence are just a few of the emerging higher education
11 technologies that are transforming the field and presenting both opportunities and difficulties. HEIs
12 also struggle with regional and local issues in addition to those global ones. The enormous diversity
13 of HEIs and the environments in which these HEIs function make it challenging to define universal
14 principles and solutions in Africa, a continent with more than 300 universities (Teferra and
15 Altbach, 2004). For instance, Yemen lacks a common method for assessing the quality of higher
16 education (Muthanna and Karaman, 2014). Fair opportunity and egalitarian distribution are
17 challenges for China's mass higher education system (Wang, 2011). In the USA, traditional sources
18 of funding for higher education have decreased over the past two decades, and there has been a
19 rise in calls for greater transparency in public funding. At the same time, the financial structure
20 that supports HEIs does not support their capacity to fulfill their educational missions (Denneen,
21 2014).

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24 If the HEIs want to address this leadership bottleneck, top management, and executives must have
25 an entrepreneurial culture. HEIs struggle to accomplish long-term objectives. GLSS is a potent
26 tool for raising client satisfaction and optimizing financial performance (Antony et al., 2012). In
27 order to eliminate waste and boost operational efficiency, GLSS has been widely utilized today
28 across a number of industries, including services, healthcare, and banking (Kim, 2010). There are
29 significant operational wastes in the environment of HEIs in the areas of administration, finance,
30 and human resources. There are numerous options for HEI to reduce waste, stick to a budget, and
31 achieve long-term objectives (Antony et al., 2017). HEIs have recently begun implementing the
32 GLSS technique. The authors' research shows that HEIs are much behind in the implementation
33 and advancement of this process excellence technique, despite the fact that many manufacturing
34 and service businesses are making use of its power. Many HEIs have been implementing the Lean
35 initiative for the past six to seven years, but they are less eager to incorporate Six Sigma methods
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3 for comprehending and analyzing variation in the university business operations. According to the
4 authors, HEIs can use both techniques depending on the nature of the current issue. The authors
5 also fully believe that the Six Sigma technique (define-measure-analyze-improve-control) may be
6 very successful in resolving a variety of business issues in academic processes where there is a
7 lack of known answers or when fundamental causes are never truly identified. The goal of the
8 study is to discuss the difficulties, comprehend the CSFs, and evaluate the contribution of pertinent
9 tools and strategies for the effective introduction and deployment of GLSS in a higher education
10 setting. The research goals to complete this study are listed below in accordance with its purpose.
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12 *(i) To identify Green Lean Six Sigma barriers in HEIs by using Preferred Reporting Items for*
13 *Systematic Review and Meta-Analyses (PRISMA 2020). (ii) To prioritize GLSS barriers by using*
14 *the GRA approach.*

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22 HEIs play an important role in today's society for continuous improvement and growth. If
23 HEIs are related to green technology then there are many advantages in energy savings, reduction
24 of greenhouse gases, emission reduction, etc. Yet, the measurement, analysis, and quantification
25 of various environmental and lean wastes are necessary for the effective management of an
26 environmentally friendly strategy. GLSS is a powerful tool that will reduce waste, improve the
27 process, and environmentally friendly, energy-saving technique. There are many restrictions in the
28 implementation of GLSS in any sector that are known as barriers. The first barriers are identified
29 in the path of execution of GLSS in HELs. All barriers are not resolved at the same time therefore
30 they are ranked by the GRA approach. The main GLSS barriers in this study have been identified
31 from the literature and subsequently evaluated by academics and educational staff.

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The remainder of the essay is broken up into various sections. The literature on Lean
manufacturing, Six Sigma, Green manufacturing, Green lean, and six-sigma is described in Section
2. The two-phase study technique utilized to rank the discovered GLSS barriers was detailed in
Section 3. Section 4 of this study provides an explanation of the findings and discussion. With the
findings, contribution, and future study scope, section 5 comes to a close.

2. Literature review

2.1 *Green Lean Six-Sigma (GLSS)*

GLSS is an environment friendly methodology that integrates the principles of Lean Six Sigma with environmental sustainability (Yadav et al., 2022). The aim of GLSS is to minimize waste and improve environmental sustainability while improving organizational efficiency and reducing costs (Gaikwad and Sunnapwar, 2020a). The theory of GLSS was first introduced by Sarkis and Sundarraj as a methodology that integrates environmental sustainability principles with Lean Six Sigma practices (Gaikwad and Sunnapwar, 2020a). GLSS is assembled with three basic principles viz. reduces waste, enhances quality, and encourages environmental sustainability (yadav and Gahlot, 2022). The reduction of waste consists the minimizing the unwanted steps in business processes, though quality improvement consists of identifying and addressing the root causes of defects or errors in business processes (Ershadi et al., 2021). Promoting environmental sustainability involves recognizing opportunities to minimize the environmental impact of business processes (Shuhui et al., 2020; Gaikwad and Sunnapwar, 2020c). GLSS has been functional in a variety of organizations like manufacturing, healthcare, and higher education sector (Pandey et al., 2018). In manufacturing organizations, GLSS has been used to minimize waste and enhance the environmental sustainability of production processes (Sarkis et al., 2010). The GLSS enablers have been identified by Pandey et al. (2018) to help the manufacturing organization achieve customer and environmental standards. The adoption of GLSS to enhance the product and process characteristics in the manufacturing business using the ISM approach can encounter obstacles, according to Kumar et al. (2016). In the healthcare sector, GLSS has been applied to minimize the environmental impact of medical waste and improve the efficiency of healthcare processes (Al-Tahat and Al-Kloub, 2014).

2.2 Barriers to GLSS implementation

The adoption of GLSS to enhance the product and process characteristics in the manufacturing business using the ISM approach can encounter obstacles, according to Kumar et al. (2016). Based on five environmental performance dimensions, Michael et al. (2019) created the framework for GLSS execution within the organization to accomplish green objectives. Gaikwad and Sunnapwar (2020c) concentrated on the issue that arises throughout the GLSS implementation process and also showed how the individuals or management who act as the process initiators can have a significant impact on the process implementation. Using the Best Worst Method (BWM), Singh et al. (2020) identified seven enablers for the adoption and implementation of GLSS, with a focus on India's small-scale industries. Yadav (2019) highlighted fifteen obstacles that could prevent the application of GLSS in the manufacturing sector. Yadav (2019) also discussed how each of the GLSS concepts such as Green, Lean, and Six Sigma can function as a catalyst for others and help to mitigate their weaknesses. The purposed GLSS idea, according to Hussaina et al. (2019), it can enhance various aspects of the construction process, including productivity, quality, cycle time, sustainability, etc. In order to help manufacturing businesses, starts the GLSS process implementation in a methodical fashion, Singh et al. (2019) developed twelve enablers. Their research was based on the ISM methodology. Yadav et al. (2021) identified sixteen barriers that can affect the implementation of the GLSS concept in manufacturing organizations and then they prioritize their removal by using BWM. Rathi et al. (2022) studied different tools and techniques related to lean manufacturing and six-sigma and tried to analyze different barriers.

2.3 GLSS in Higher Education Institutes (HEIs)

GLSS implementation in HEIs is a moderately new area of research. Based on the previous literature review, a very few research studies have explored the implementation of GLSS principles in HEIs (Lu et al., 2017; O'Reilly et al., 2019). Shah et al., (2021) found that GLSS can help HEIs reduce their environmental impact, enhance sustainability practices, and increase operational efficiency. The study also identified some of the key challenges of implementing GLSS in HEIs, such as the need for institutional support, resources, and employee buy-in. In the higher education sector, GLSS has been applied to diminish the environmental impact of campus operations and enhance operational efficiency (Abdulrahman et al., 2018). O'Reilly et al., (2019) examined the implementation of GLSS practices in a specific department within an HEI. They found that implementing GLSS practices resulted in cost savings, reduced waste, and improved efficiency. However, the study also identified the need for ongoing monitoring and evaluation of GLSS practices to ensure their sustainability and effectiveness. Lu et al., (2017) found that the incorporation of GLSS practices in the curriculum can help prepare students to be environmentally responsible citizens and improve their employability in a rapidly changing job market. However, the implementation of GLSS practices requires institutional support, resources, and ongoing monitoring and evaluation to ensure their sustainability and effectiveness. Cudney et al., (2018) found that the HEIs implemented GLSS to streamline their operations, reduce costs, and increase sustainability.

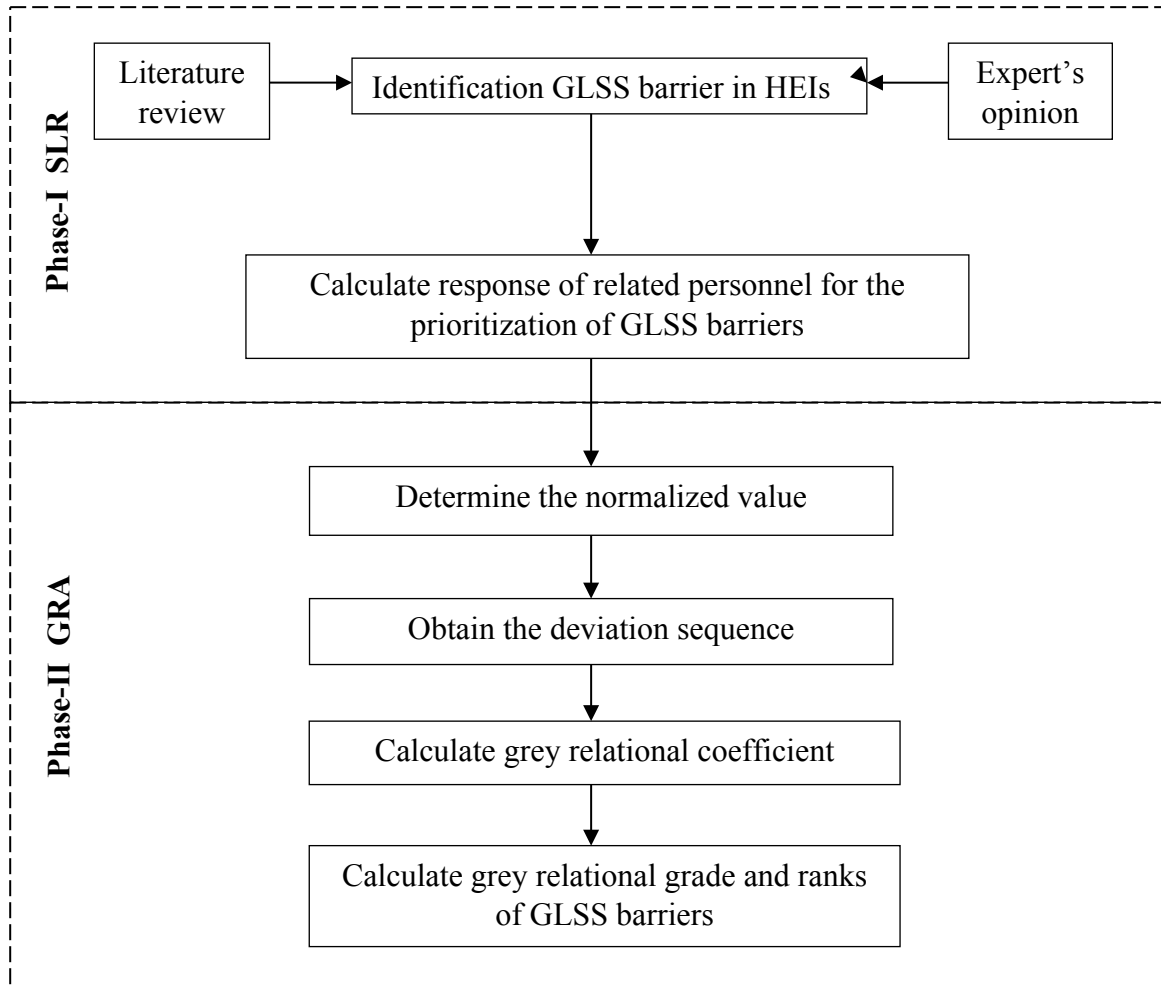
2.4 Research gaps

GLSS is a powerful tool that is used to improve the process, reducing waste and the process is eco-friendly. Although the increasing interest in GLSS implementation in HEIs, there are still research gaps that must be addressed. In the literature, there is no evidence for the investigation of GLSS

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3 barriers in the context of HEIs for improvement in sustainable performance. In the literature, there
4 is a lack of empirical studies that assess the effectiveness of GLSS implementation in HEIs. GLSS
5 implementation in HEIs is influenced by leadership style, organizational culture, and employee
6 attitudes (Cudney et al., 2020; Yadav and Gahlot, 2022). Still, there is a lack of research that
7 explores the influence of these factors on GLSS implementation in HEIs. There are also no facts
8 illustrating case studies to validate these barriers that convoy more practical targeted outcomes in
9 HEIs. There are no facts on dispensing a path to this sector for the acquisition and implementation
10 of GLSS in the analytical form. In the literature, there is no evidence of the recognition of GLSS
11 barriers simultaneously with exploring the correlation between these. There is no evidence in the
12 literature to rank GLSS barriers in HEIs further there is no evidence to prioritize GLSS barriers
13 using the GRA method. Talking to these research gaps is necessary for a more complete
14 understanding of GLSS implementation in HEIs and for the effective exploration and mitigation
15 of GLSS implementation barriers in HEIs.
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35 **3. Research methodology**

36 The current investigation is conducted in two phases. The first phase of this study is based on a
37 systematic literature review to identify the GLSS barriers in the context of HEIs. To perform the
38 SLR, the PRISMA-2020 approach has been followed. While the prioritization of GLSS barriers
39 through the GRA approach has been done in the second phase of this study. The ultimate aim of
40 this two-phase methodology is to identify the GLSS barriers and prioritization them in the context
41 of HEIs. Figure 1 displays the research methodology's flowchart.
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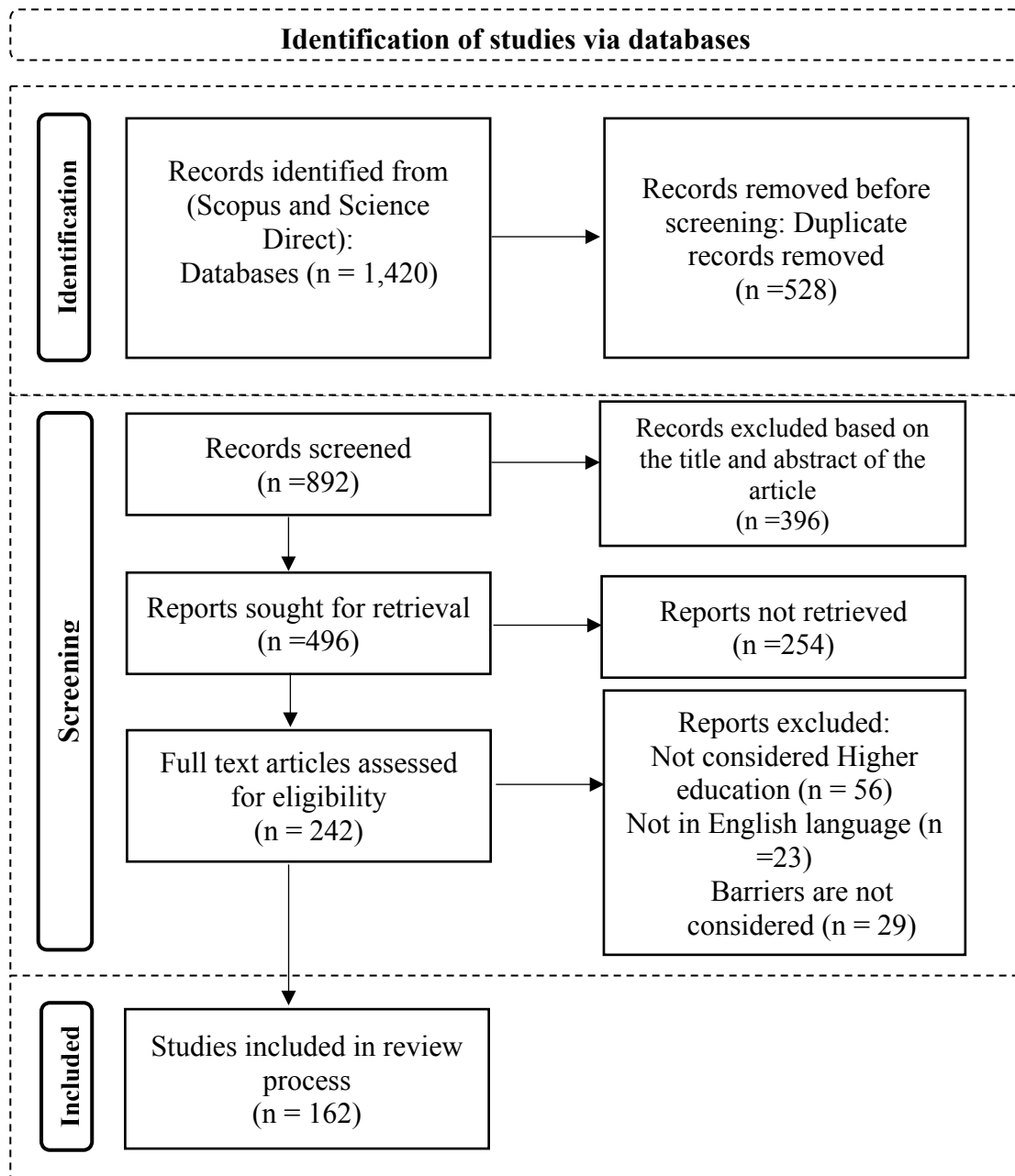
Figure 1 Research methodology flow diagram

Phase 1: Identification of GLSS barriers through Selective Literature Review (SLR)

A strong literature review offers foundational information about a study issue. SLR is used to determine the relationships at work (Chountalas and Tepaskoualos, 2019). In this phase of the research paper SLR using PRISMA-2020 guidelines has been utilized for reviewing the present status of GLSS barriers in HEIs. The essential qualities of a tool or technology that prevent it from fulfilling the organization's goals are its barriers (Kaswan et al., 2020; Kumar et al., 2020; Mittal et al., 2021). Although many manufacturing and service firms have implemented GLSS, its applications in HEIs have proven to be very difficult for those involved in the deployment. To categorize, pick, examine, and review the most important research papers SLR through PRISMA has been used (Verma et al., 2021).

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3 In this phase of the study, the search for research articles has been carried out in two more reliable
4 and frequently used databases, namely Scopus and Science Direct. The search constraints have
5 been focused on peer-reviewed international academic journals, and conference articles specially
6 written in the English language. The search period has been limited to the range from 1985 to
7 2022. In line with the objectives of this study, we defined the search strategies and search strings.
8 With the help of OR and AND operatives, the primary studies have been collected using the terms
9 Six-sigma, Lean, GLSS, Barriers, and HEIs in the title, abstract, and keywords. The search strings
10 have been carried out on 12th October 2022. Based on these terms, this process leads to the addition
11 of 1420 articles, of which 528 articles were removed due to duplication for the present review. A
12 further, 396 articles were excluded due to the unsuitability title and abstract. Again, 254 articles
13 that have not been downloaded for systematic surveys were excluded. Consequently, a total of 242
14 full-text assessed articles were left and eligible. Of these the articles that were not directly linked
15 with HEIs (n= 56), barriers (n=29), and not published in the English language (n=23), were also
16 excluded. Chasing these routes, a total of 162 articles were eligible and included in the review
17 process as presented in Figure 2.
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29 The findings of PRISMA-2020 show a total of 162 eligible articles reveal the barriers for
30 GLSS in HEIs. An in-depth literature reviews as presented in section 2, and with academician
31 expert's opinion reveals findings of the fourteen barriers of GLSS in the HEIs environment. The
32 identified fourteen GLSS barriers are Linking GLSS to institution strategy, Customer focus,
33 Management commitment and resources, Leadership and vision, Selection of the ought human
34 resources, Effective communication to all levels of an organization, Identification of 3R
35 opportunities, Developing organizational readiness, Project selection and prioritization, Resources
36 and skills to facilitate implements, Training, and education, Continuous assessment of SDG,
37 Assessment of satisfaction and welfare of the employee and Organizational culture.
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46 **Figure 2: Systematic Literature Review *Source (PRISMA 2020)**

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49 Table 1 depicts the GLSS barriers with their source in the HEIs environment. To authenticate the
50 identified GLSS barriers through academician experts a questionnaire survey-based study has also
51 been done. On a scale of 1 to 5, with 1 denoting the least important barriers and 5 denoting the
52 most significant impediments to GLSS, 110 experts from the fields of education and academia
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were asked to rate the importance of the enumerated barriers. The demographic details of respondents have been presented in Table 2.

Table 1: GLSS barriers in HEIs

S.N.	Barriers	Reference
1	Linking GLSS to institution strategy	Lu et al., (2017)
2	Customer focus	Sunder and Mahalingam, 2018; Albliwi et al., 2014
3	Management commitment and resources	O'Reilly et al., 2019
4	Leadership and vision	Cudney et al., 2020
5	Selection of the ought human resources	Sunder and Mahalingam, 2018; Costa and Godinho Filho, 2016
6	Effective communication to all levels of an organization	Dalenogare et al., 2018
7	Identification of 3R opportunities	Cudney and Elrod, 2010
8	Developing organizational readiness	Singh et al., 2021
9	Project selection and prioritization	Kaswan et al., 2021
10	Resources and skills to facilitate implements	Gedam et al., 2021
11	Training and Education	Farooque et al., (2020)
12	Continuous assessment of SDG	Self-developed
13	Assessment of satisfaction and welfare of the employee	Self-developed
14	Organizational culture	Self-developed

Table 2: Demographic details of respondents

S.No.	Work profile	No. of persons	Percentage	Average work experience
1	Director	22	20	23
2	Principal	18	16.36	19
3	Associate Professor	13	11.81	15
4	Assistant Professor	41	37.27	12
5	Senior Instructor	16	14.54	10

Phase 2: Prioritization of GLSS barriers through GRA

GRA was developed by Deng. GRA is an efficient indicator of investigating the association among series with less information and can conquer the drawbacks of the numerical method (Kumar et al., 2023). Many MCDM issues have been solved with the help of GRA. In this method, we have to indicate minimum and maximum values in given data. With the help of these values, we will

calculate normalized values, which are used in the calculation of the deviation sequence. After calculating the deviation sequence grey relational coefficients are determined which are used to calculate the grey relational grade. The lowest rank means the most important barrier and the higher rank means the least important barrier. The different steps GRA methodology is as follows:

Step 1: Grey relation generation (normalization).

The first step of GRA analysis is to process the collecting information that creates additional information necessary to examine the system. This step is also known as normalizing or grey relational generation. The collected information can be normalized by using the following two equations:

$$x_{i,j} = \frac{[(y_{ij}) - \min(y_{ij}, i = 1, 2, \dots, m)]}{[\max(y_{ij}, i = 1, 2, \dots, m) - \min(y_{ij}, i = 1, 2, \dots, m)]} \quad (1)$$

$$x_{i,j} = \frac{[\max(y_{ij}, i = 1, 2, \dots, m) - (y_{ij})]}{[\max(y_{ij}, i = 1, 2, \dots, m) - \min(y_{ij}, i = 1, 2, \dots, m)]} \quad (2)$$

Personnel of the education department responded to each barrier. Here first equation is used if the collected information is beneficial and the second equation is used if the collected information is non-beneficial. Suppose there are m alternatives and n criterion in a decisiveness problem then, i^{th} option can be written as

$$Y_i = (y_{i1}, y_{i2}, \dots, y_{ij}, \dots, y_{in}),$$

* y_{ij} = performance importance of criterion j of alternative i.

The terminology ' Y_i ' can be transformed into the applicable comparability series (X_i) by using the above-mentioned equations '1' or '2'.

$$X_i = (x_{i1}, x_{i2}, \dots, x_{ij}, \dots, x_{in})$$

Step 2: Define the reference sequence.

After the generation of grey relational, the second step is to scale all performance data into 0 and 1. For an attribute 'j' of substitute 'i', if the value x_{ij} , which is processed by using the first step of the procedure, is equal to 1 or close to 1 than the value of any other alternative, it implies that alternative i's performance is the best for that criterion j. The reference alternative is defined as X_0

$= (x_{01}, x_{02}, \dots, x_{0j}, \dots, x_{0n}) = (1, 1, \dots, 1, \dots, \dots, 1)$. The purpose is to find out the substitute whose comparability series is the nearest to the reference series.

Step 3: Calculate the grey relational coefficient (Ψ).

In this step, the Grey relational coefficient is used to formative how close x_{ij} is to x_{0j} . The maximum value of the coefficient, the closer x_{ij} is to x_{0j} .

$$\Psi(x_{0,i}, x_{i,j}) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{i,j} + \zeta \Delta_{\max}} \quad (\text{for } i=1, 2, \dots, m \text{ and } j=1, 2, \dots, n) \quad (3)$$

Where $\Psi(x_{0,i}, x_{i,j})$ is the grey relational coefficient between $x_{i,j}$ and $x_{0,i}$, $\Delta_{i,j} = |x_{0j} - x_{ij}|$

$$\Delta_{\min} = \min \{ \Delta_{i,j}, 1, 2, \dots, m; j=1, 2, \dots, n \}$$

$$\Delta_{\max} = \max \{ \Delta_{i,j}, 1, 2, \dots, m; j=1, 2, \dots, n \}$$

and ζ is the distinctive coefficient (DC) ($\zeta \in [0,1]$), generally taken as 0.5.

The purpose of DC is to enlarge the variety of the grey relational coefficient.

Step 4 Compute the grey relational grade.

The grey relational grade will be determined in the following stage using the following equation, the weight of the j^{th} criteria, w_j , is calculated by the decision-maker.

$$\Gamma(x_0, x_i) = \sum_{j=1}^n w_j \Psi(x_i, x_{ij}) \quad (\text{for } i=1, 2, \dots, m) \quad (4)$$

Where

$$\sum_{j=1}^n w_j = 1$$

The grey relational grade displays the degree of correlation between the deviation data and normalized data. The alternative is the greatest choice since its comparability series has the highest maximum grey relational grade which is the most similar to the reference series.

4. Results and Discussions

Based on the judgment of academicians experts and literature review, a total of fourteen GLSS barriers in HEIs are considered for additional investigation. The considered GLSS barriers have been examined with the MCDM approach GRA to discover the relative ranking among them. The fourteen GLSS barriers in HEIs are presented in Table 3 and examined with original data from 111 experts as genuine and usable responses. This sample size of professionals taken is sufficient and must utilize for information gathering and the concluding examination (Kumar et al., 2022; Luthra et al., 2016). The questionnaire is attached in appendix A and appendix B.

Table 3 Fourteen GLSS barriers

S. No.	Barriers	Abbreviation
1	Linking GLSS to institution strategy	B1
2	Customer focus	B2
3	Management commitment and resources	B3
4	Leadership and vision	B4
5	Selection of the ought human resources	B5
6	Effective communication to all levels of an organization	B6
7	Identification of 3R opportunities	B7
8	Developing organizational readiness	B8
9	Project selection and prioritization	B9
10	Resources and skills to facilitate implements	B10
11	Training and Education	B11
12	Continuous assessment of SDG	B12
13	Assessment of satisfaction and welfare of the employee	B13
14	Organizational culture	B14

The first step of GRA is data processing or normalization in which responses are collected from academicians experts against each barrier which is summed up in Table 4. The responses from academicians professionals viz. Director (D), Principal (P), Associate Professor (AsP), Assistant Professor (AP), and Senior Instructor (SI) have been used to prioritize barriers. The next step is to convert the expert marks for each GLSS barrier into a normalized series by the mean value method for comparison. The normalized values are calculated by using equations 1 & 2 and presented in Table 5.

Table 4 Responses from Academician personal

Barriers	D	P	AsP	AP	SI
B1	536	447	367	333	254
B2	516	438	389	312	226
B3	458	467	345	298	217
B4	489	387	362	317	209
B5	495	476	409	279	178
B6	502	452	378	343	186
B7	527	356	386	326	206
B8	483	479	358	324	166
B9	507	432	416	285	197
B10	446	392	334	342	202
B11	436	383	325	336	155
B12	478	405	359	263	168
B13	457	414	373	307	185
B14	479	397	345	299	158
Min	436	356	325	263	155
Max	536	479	416	343	254

Table 5 Normalized values

B1	0	0.2601	0.5384	0.125	0
B2	0.2	0.3333	0.2967	0.3875	0.2828
B3	0.78	0.0975	0.7802	0.5625	0.37374
B4	0.47	0.7479	0.5934	0.325	0.4545
B5	0.41	0.0243	0.0769	0.8	0.7676
B6	0.34	0.2195	0.4175	0	0.68687
B7	0.09	1	0.3296	0.2125	0.48484
B8	0.53	0	0.6373	0.2375	0.88889
B9	0.29	0.3821	0	0.725	0.57576
B10	0.9	0.7073	0.9010	0.0125	0.5225
B11	1	0.7804	1	0.0875	1
B12	0.58	0.6016	0.6263	1	0.86869
B13	0.79	0.5284	0.4725	0.45	0.6969
B14	0.57	0.6667	0.7802	0.55	0.96969697

After formulation of the normalized data series, the next step is to calculate the deviation data series with respect to the normalized sequence with the help of the second step of analysis. The calculated deviation data series of the decision matrix is presented in Table 6.

Table 6 Deviation sequence

B1	1	0.7398	0.46156	0.875	1
B2	0.8	0.6666	0.70329	0.6125	0.71717
B3	0.22	0.9024	0.2197	0.4375	0.62626
B4	0.53	0.2520	0.40659	0.675	0.54545
B5	0.59	0.97560	0.92307	0.2	0.23232
B6	0.66	0.78048	0.58241	1	0.31313
B7	0.91	0	0.6703	0.7875	0.51515
B8	0.47	1	0.36263	0.7625	0.11111
B9	0.71	0.61789	1	0.275	0.42424
B10	0.1	0.29268	0.0989	0.9875	0.47474
B11	0	0.21951	0	0.9125	0
B12	0.42	0.39837	0.37362	0	0.13131
B13	0.21	0.47154	0.52747	0.55	0.30303
B14	0.43	0.3333	0.21978	0.45	0.03030

Further, the grey relational coefficients among all the comparability sequences and the reference sequence are evaluated by using the third step of the GRA approach. The calculated grey relational coefficient of the decision matrix is presented in Table 7.

Table 7 Grey relational coefficients

B1	0.3333	0.40327	0.52	0.3636	0.3333
B2	0.3846	0.42857	0.41552	0.4494	0.4107
B3	0.6944	0.35652	0.6946	0.5333	0.4439
B4	0.4854	0.66486	0.5515	0.4255	0.4782
B5	0.4587	0.33884	0.3513	0.7142	0.6827
B6	0.4310	0.3904	0.4619	0.3333	0.6149
B7	0.3546	1	0.4272	0.3883	0.4925
B8	0.5154	0.3333	0.5796	0.39603	0.8181
B9	0.4132	0.4472	0.3333	0.6451	0.5409
B10	0.8333	0.6307	0.8348	0.33613	0.5129
B11	1	0.6949	1	0.3539	1
B12	0.5435	0.5565	0.5723	1	0.792
B13	0.7042	0.5146	0.48663	0.4761	0.6226
B14	0.5376	0.6	0.6946	0.5263	0.9428

By using the last step of the GRA approach, i.e. the grey relational grade among the deviation data and normalized data is calculated and presented in Table 8.

Table 8 Grey relational grade and ranking among GLSS barriers

S. No.	GLSS barriers	Grey relational grade	Rank
1.	Linking GLSS to institution strategy (B1)	0.390716344	14
2.	Customer focus (B2)	0.417787702	13
3.	Management commitment and resources (B3)	0.544580439	6
4.	Leadership and vision (B4)	0.521121939	9
5.	Selection of the ought human resources (B5)	0.509190852	10
6.	Effective communication to all levels of the organization (B6)	0.446335955	12
7.	Identification of 3R opportunities (B7)	0.532545361	7
8.	Developing organizational readiness (B8)	0.528527301	8
9.	Project selection and prioritization (B9)	0.47599482	11
10.	Resources and skills to facilitate implements (B10)	0.629610554	4
11.	Training and education (B11)	0.809779511	1
12.	Continuous assessment of SDG (B12)	0.692873278	2
13.	Assessment of satisfaction and welfare of the employee (B13)	0.560866541	5
14.	Organizational culture (B14)	0.660292766	3

The maximum grey rational grade the first will be the preference, so for that reason because of this evaluated grey relational grade, prioritizing all the GLSS barriers in perspective of HEIs is shown in Figure 3.

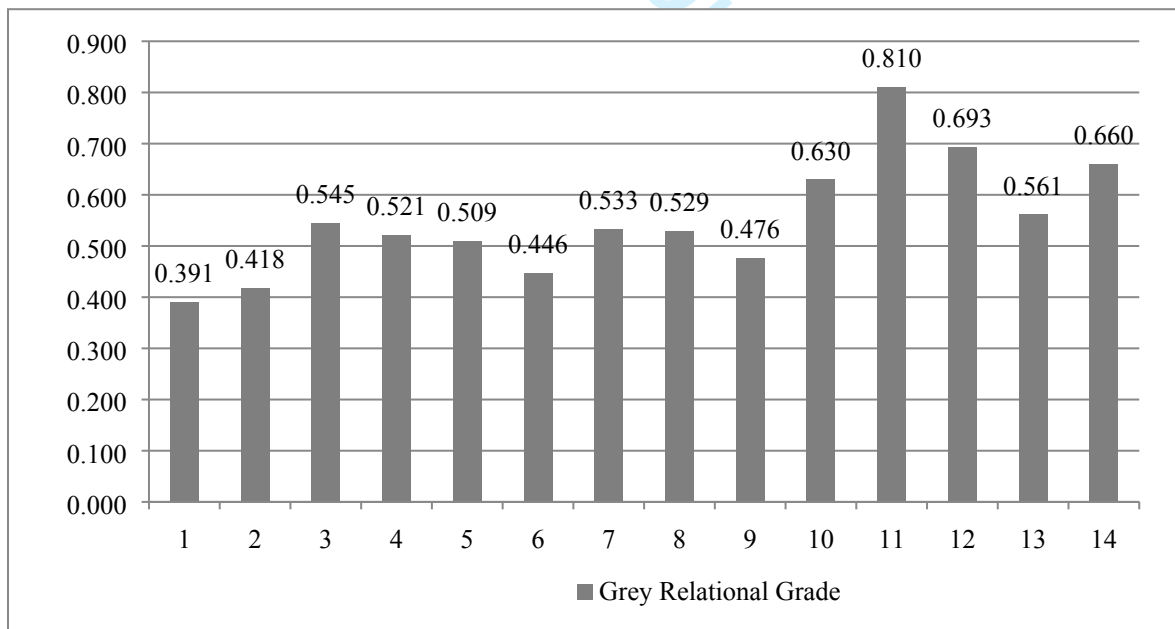


Figure 4: Grey relational grade of all the GLSS Barriers

Barriers are the challenges that occur during the implementation of any method in any sector or field. The essential qualities of a tool or technology that prevent it from fulfilling the organization's goals are its barriers (Kaswan et al., 2020). The term "GLSS barriers" in the context of TQM refers to obstacles that could prevent an organization from effectively implementing TQM principles. Goals, Leadership, Systems, and Skills, or GLSS, are essential elements of TQM. For the implementation of TQM to be successful, GLSS obstacles must be removed. The identified GLSS barriers in HEIs can be overcome by taking the following resolutions by linking GLSS to institution strategy at every stage, we can resolve institution strategy-related barriers to get the solutions. The resolution to all GLSS fourteen barriers is presented in tabular form in Table 9. Table 9 has been made to suggest mitigation actions for the removal of Green Lean Six Sigma barriers for effective execution of this strategy in Higher education institutions. This table has been made from the literature review and to consult with academicians in this field. The demographic background of these respondents includes Director, Principal, Associate Professor, Assistant Professor, and Senior Instructor etc. to explain the resolution of GLSS barriers better. Overall, overcoming GLSS hurdles necessitates an all-encompassing strategy that includes precise goal-setting, committed leadership, clearly defined procedures, and continual skill development. Organizations can improve the efficiency of TQM and promote continual improvement in quality and performance by tackling these challenges.

Table 9: Resolution of GLSS barriers

S.N.	Barriers	Resolution of GLSS barriers
1	Linking GLSS to institution strategy	By linking GLSS to institution strategy at every stage we can resolve this barrier.
2	Customer focus	Customer focus should be shifted due to good education.
3	Management commitment and resources	Management should be serious about its implementation.
4	Leadership and vision	Leadership should be strong and vision is focused on its implementation.
5	Selection of the ought human resources	Human resources selection should be proper according to requirements.
6	Effective communication to all levels of an organization	There should be no communication gap between organization persons.
7	Identification of 3R opportunities	Everyone should know about 3R and its importance.
8	Developing organizational readiness	Organizational persons should be active and ready to take action at any time.

9	Project selection and prioritization	Project selection is also an important parameter of GLSS implementation in which we have to prioritize the most important and least important barriers.
10	Resources and skills to facilitate implements	Resources and skills are available related to GLSS implementation.
11	Training and Education	Training and education must be required for the proper implementation of the GLSS strategy.
12	Continuous assessment of SDG	There should be continuous assessment of sustainable development goals.
13	Assessment of satisfaction and welfare of the employee	Satisfaction of employees is also an important parameter, and employees' welfare is also considered.
14	Organizational culture	Organizational culture should be satisfactory and focus on GLSS implementation.

The order of identified GLSS barriers for the execution of Green Lean Six Sigma in HEIs is B11>B12>B14>B10>B13>B3>B7>B8>B4>B5>B9>B6>B2>B1. As per the results obtained from Table 8 and Figure 4, B11 (Training and Education), B12 (continuous assessment of sustainable development goals), B14 (Organizational culture), and B10 (Resources and skills to facilitate implements) stood first four positions, which revealed that these four key barriers have played an important role for execution of Green Lean Six Sigma in HEIs. Subsequently, ranks are taken by B13 (Assessment of satisfaction and welfare of the employee), B3 (Management commitment and resources), B7 (Identification of 3R opportunities), B8 (Developing organizational readiness), B4 (Leadership and vision), B5 (Selection of the ought human resources), B9 (Project selection and prioritization), B6 (Effective communication to all levels of the organization), B2 (Customer focus) and B1 (Linking GLSS to institution strategy). Moreover, it helps to successfully execute GLSS a comprehensive approach in HEIs.

This research work identifies GLSS barriers in the context of HEIs for the execution of the GLSS approach. An SLR helped to identify a total of fourteen impediments, which were then verified for greater relevance by the professional judgment of industrial personnel. Furthermore, GRA has been used to prioritize the identified GLSS barriers. The result of this study reveals that Training and education, continuous assessment of SDG, organizational culture, resources and skills to facilitate implementation and assessment of satisfaction and welfare of the employee are the most significant barriers to implementing the GLSS approach. The results of this study can also assist educational institutions to have a complete understanding of these barriers so that they can carry out the GLSS approach in the academic curriculum (Bumjaid and Malik, (2019). The ranking of these barriers can also help higher educational institutions in sharing belongings

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3 associated with completing the visionary objectives (Luthra et al., 2016). The present study
4 investigated a total of fourteen GLSS barriers to the execution of GLSS from the perspective of
5 Indian HEIs. The identified GLSS barrier Training and education (B11) is the most important
6 feature while executing GLSS in HEIs. It suggests that concerns related to training and education
7 must be required for the proper implementation of the GLSS strategy. In implementing any type
8 of initiative proper training and education are very crucial (Mangla et al., 2022). Continuous
9 assessment of sustainable development goals (B12), positioned at second rank is also important as
10 the first GLSS barrier. There should be a continuous assessment of sustainable development goals
11 for organizing educational goals (Tsai et al., 2021). Alternatively, one more important GLSS
12 barrier 'Organizational culture' (B14) is positioned as third and equally significant as the first two
13 barriers while implementing GLSS in higher educational institutions. It recommends that proper
14 organizational culture initiative would result in a more positive faculty attitude toward loyalty and
15 the importance of nature in personal growth and job engagement (Soni et al., 2022).

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17 The result of this study helped to get a wide understanding of the GLSS barriers and
18 prompts the improvement of better execution of the GLSS approach in higher educational institutes
19 (Kaswan et al., 2022; Cudney et al., 2020). The successful identification of GLSS barriers will
20 lead to improvement in GLSS implementation in educational institutes by reducing the hindrance
21 (Vijaya Sunder 2016; Sunder and Mahalingam, 2018; Haerizadeh and Sunder, 2019). The
22 knowledge of prioritization of GLSS barriers will enhance academic performance, environmental
23 sustainability, and achievements (Gholami et al., 2021; Rathi et al., 2022; Antony and Thomson,
24 2020).

41 ***4.1 Theoretical implication***

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43 The SLR signifies that research on green lean six-sigma concerted mainly on frameworks of GLSS,
44 its application in manufacturing organizations, technical and social dimensions, and sustainability,
45 but very less research articles have pointed out the barriers of GLSS in higher education of
46 institutions. Accordingly, the present research work considered SLR and GRA methodology to
47 identify and prioritize the GLSS barriers for higher educational institutions. Furthermore, the
48 previous articles have focused on GLSS in the context of manufacturing organizations only. The
49 absence of GLSS barriers in the education sector in the past articles; therefore, the present research
50 article makes a precious theoretical contribution to the learning of GLSS in higher education
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3 institutes that relates to sustainability and the barriers of GLSS using SLR and GRA methodology
4 approach.
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11 ***4.2 Practical implication***

12 The results presented in this paper give multiple managerial contributions. The ranking of GLSS
13 barriers gives top officials of higher education institutes a very clear view to effectively and
14 efficiently implementing GLSS initiatives. This study's results indicate the most contributing
15 barriers and how they are linked with one another. The outcomes also show training and education,
16 sustainable development goals, and organizational culture as critical barriers. The findings of this
17 study provide an impetus for managers, policymakers, and consultants to embrace the GLSS
18 strategy through a wide-ranging understanding and exploring these barriers.
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25 In this study, the present study has its limitations. The expert's judgment is completely
26 reliant on the GRA technique. Other mathematical model methods could be used to further validate
27 the statistical validity of the relationship model between these barriers.
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32 ***4.3 Societal implication***

33 The GLSS barriers in HEIs may significantly affect the society. HEIs can lessen their
34 environmental effect by using GLSS practices, which can support sustainability initiatives and
35 foster social responsibility. Taking steps to lessen environmental effect can benefit society as a
36 whole. This may benefit the local and reduce the institution's operations' negative effects on the
37 environment. GLSS techniques in HEIs can also result in increased operational effectiveness and
38 cost savings, which can free up resources to be employed in other areas, like boosting student
39 services and improving educational programs. By improving the educational experience and
40 expanding access to higher education, this can help students and the larger community. However,
41 failing to implement GLSS procedures in HEIs could have societal repercussions as well. For
42 instance, a lack of sustainability initiatives and eco-friendly practices may be a factor in climate
43 change, environmental deterioration, and detrimental effects on human health. Additionally, a lack
44 of operational efficiency might raise the institution's expenditures, which could translate into
45 higher student tuition fees or less resources for programs and services that support education. As
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3 a result, it's critical for HEIs to identify and remove GLSS obstacles in order to advance
4 sustainability, social responsibility, and operational effectiveness. By doing this, HEIs can have a
5 good impact on society and lessen any potential negative effects.
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11 **5. Conclusions, contributions, and future directions**

12 The GLSS is a crucial instrument for understanding the ecological effect and resources utilized
13 during a product's whole life cycle (Sonnemann and Margni 2015). It includes all environmental
14 considerations, from product procurement to disposal. Throughout the past 20 years, there has
15 been a major methodological advancement in the GLSS discipline. The GLSS has been used in a
16 variety of industrial contexts, including corporate decision-making, supply chain management,
17 process optimization, and strategic marketing decisions (Butt et al. 2019; Lin et al., 2020; Shuhui
18 et al., 2020). Yet GLSS implementation requires a lot of work, and restrictions known as
19 bottlenecks prevent this sustainability assessment tool from working as intended. The current study
20 pinpoints and looks at the obstacles to GLSS implementation in India's higher education
21 institutions. Critical hindrances to the implementation of GLSS at Indian HEIs have been
22 discovered in this study by a comprehensive literature review (PRISMA-2020) and subsequently
23 validated through expert questionnaires (staff of educators and academics). The GRA technique
24 was used to prioritize the impediments. The most major obstacle to GLSS execution in HEIs has
25 been identified as "Training and education." The management gives the educational staff thorough
26 training on environmental indicators, the kind of data set needed, and how to evaluate it. It means
27 to implement GLSS at every stage of the institution proper training and education must be required.
28 Continuous assessment of sustainable development goals (B12), positioned at second rank is also
29 important as the first GLSS barrier. There should be a continuous assessment of sustainable
30 development goals for organizing educational goals (Tsai et al., 2021). Everyone can gain the
31 values, competencies, skills, and knowledge required to contribute to the creation of a more
32 sustainable society through education for sustainable development goals. Organizational culture
33 (B14) is positioned as third and equally significant as the first two barriers while implementing
34 GLSS in higher educational institutions. By fusing academic goals with a fresh strategy and
35 fostering a culture of learning, organizational culture is essential for the adoption of a sustainable
36 development approach (Luthra et al. 2016). Building a culture of sustainability in educational
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3 institutions is made possible by inclusive management responsibility, abundant financial
4 resources, and rigorous employee training (Mangla et al., 2017). Linking GLSS to institution
5 strategy is the least important barrier according to the current study which means we can
6 implement GLSS to institution strategy up to a certain level.
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Questionnaire

SECTION –A

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38 1. Organization Name: _____
- 39 2. Location: _____
- 40 3. Name of the Authority _____
- 41 4. Designation _____
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SECTION-B

Barriers of Green Lean Six Sigma in Higher Education Institutions

46 Green Lean Six Sigma (GLSS) is one of the approaches that minimizes the wastes generation through the
47 reduction in process variation and using Green concepts of 3'R (recycle, reuse, reduce). This concept also
48 mitigates negative environmental effects and at the same time delivers high specification products. The
49 responses provided by the Higher Education Institutions personnel will facilitate higher education sector
50 indirectly in the run for the effective implementation of environmentally concerned GLSS approach.
51 Please provide your useful insights in the table appended below to identify significant GLSS barriers
52 pertaining to the HEIs.

53 Please tick mark at appropriate place against each barrier according to the label provided corresponding to
54 each barrier.

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3 **1: Very Weak**
4 **2: Weak**
5 **3: Neutral**
6 **4: Strong**
7 **5: The Strongest**
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S.N.	Label of barriers	Barriers	Score of barriers				
			1	2	3	4	5
1	'B1'	Linking GLSS to institution strategy					
2	'B2'	Customer focus					
3	'B3'	Management commitment and resources					
4	'B4'	Leadership and vision					
5	'B5'	Selection of the ought human resources					
6	'B6'	Effective communication to all levels of organization					
7	'B7'	Identification of 3R opportunities					
8	'B8'	Developing organizational readiness					
9	'B9'	Project selection and prioritization					
10	'B10'	Resources and skills to facilitate implements					
11	'B11'	Training and Education					
12	'B12'	Continuous assessment of SDG					
13	'B13'	Assessment of satisfaction and welfare of the employee					
14	'B14'	Organization Culture					