Sustainability Analysis of Social Interactions Achieved by Collaborative learning Resulted from NPTEL SWAYAM Mentor Scheme

Vinay Kulkarni[1], Jaya Wakode[2], Ashwini Patil[3], Mrinalini N[4], Rutuja Deshmukh[5], P Malathi[6]
[1,2,3,5,6] D Y Patil College of Engineering, Akurdi, Pune,
[4]ALIET Vijayawada, Andhra Pradesh ,
[1]vakulkarni@dypcoeakurdi.ac.in, [2]jswakode@dypcoeakurdi.ac.in, [3]arpatil@dypcoeakurdi.ac.in.
[4]mrinalini.nunna@gmail.com, [5]rdeshmukh@dypcoeakurdi.ac.in,
[6]pjmalathi@dypcoeakurdi.ac.in

***Abstract*—The NPTEL SWAYAM mentor scheme is an innovative initiative aimed at enhancing educational experience through collaborative learning and mentorship. This study conducts an impact analysis of social interactions facilitated by the scheme, focusing on its effectiveness fostering collaborative learning environments and improving student outcomes in higher education relevant to SDG 4.**

The research combines quantitative data from student performance metrics with qualitative insights from surveys and interviews conducted with participants, including mentors and mentees. The study evaluates how structured mentorship and peer interactions withing the scheme contribute to academic performance, social skills development and overall student engagement. Primary findings suggest that the mentor scheme significantly enhances collaborative learning by providing a structured environment where students can engage in meaningful interactions with peers and mentors. These interactions are shown to improve abilities of problem solving, critical thinking and communication skills amongst students. Furthermore, the sense of community and support fostered by the mentor scheme contributes to increased motivation and a positive learning experience. The research identifies key factors that influence the success of the collaborative learning process, such as the quality of mentor-mentee relationships, the effectiveness of communication channels, and the availability of resources on the SWAYAM platform. Challenges such as varying levels of mentor engagement and the need for continuous mentor training are also discussed.

The research concludes with recommendations for optimizing schemes, including strategies for sustaining mentor training, improving digital tools for collaborations, and integrating feedback mechanisms to continuously refine the mentorship process. The findings underscore the potential of mentorship and collaborative learning frameworks in transforming educational practices and highlight the broader implications for integrating such schemes into digital learning platforms globally.

***Keywords*—Sustainability Index, Mentor Dynamics, Digital Divide, Mentorship, SDG4**

I. INTRODUCTION

In the ever developing landscape of quality education, integration of mentoring programs with digital platforms like MOOCs had become crucial in enhancing students learning experiences. The NPTEL SWAYAM mentor scheme is a focusing idea to harness the power of collaboration in learning and mentorship to improve educational outcomes. Students from Tier-II or Tier-I colleges learn at par with IIT standards is the major advantage of NPTEL SWAYAM courses. Furthermore, the mentor scheme of NPTEL (NPTEL SWAYAM) creates meaningful interactions with a structured environment with peers and mentors, fostering an enriched learning ecosystem. The importance of collaborative learning in 2024 eco system needs well documentation with numerous studies highlighting benefits like critical thinking, problem solving abilities and communication skills. Accumulation of all these skills to enhanced employability is of paramount importance to technical institutes. However, it is also observed that success of these mentorship schemes largely depends upon quality of mentorship and the effectiveness of the interactions facilitated by the institute as well as mentor. Even though the scheme aims to address the factors providing a structured platform, it must demonstrate how academic performance, and social skills are increased amongst the students to achieve Sustainable Development Goal (SDG4). In real world applications, like industry recruitment tests, multiple choice questions (MCQs) are a major part of the process, which students will have to adhere to. Since major rejections are observed during preliminary examinations like MCQs, practicing NPTEL/SWAYAM pattern will be an added advantage to the students. Therefore, the research is needed to present a sustainability analysis of the social interactions achieved through the NPTEL mentor scheme, focusing on its role in fostering collaborative learning environment that contributes by considering mentor-mentee relationships, communication channels and resource availability on the SWAYAM platform.

Apart from positiveness, challenges are also needed to be addressed to optimize the effectiveness, like varying levels of mentor engagement, ongoing mentor training in transformative educational practices. Also, its broader implications for integrating such models into digital platforms on a global scale.

Vinay Kulkarni
D Y Patil College of Engineering, Akurdi, Pune, Sector 29 Nigdi Pradhikaran, Akurdi, Pune 411044
vakulkarni@dypcoeakurdi.ac.in

II. LITERATURE REVIEW

Considerable academic research is conducted on the role of mentorship and collaborative learning for educational outcomes. NPTEL mentor scheme, with a structured mentorship initiative, builds on principles of mentorship, collaborative learning processes integrated with digital learning platforms. Why students choose mentor forms the basis on which studies can built upon to overcome the hurdles. Konyeha et al. (2021)found problems like gender bias contributing significantly and recommends development of mentoring forums. Martínez Oquendo et al. (2022) examines critical thinking and improved communication skills impacts amongst the learners. As demonstrated by Harvey & Uren (2019). structured mentorship program provides perceived evidence with quasi-experimental methods like focused discussions, intervention questionnaires and qualitative findings like beliefs and cohesiveness. Coates (2012) mentioned advantages of mentorship such as guidance and support, encouragement which are essential in addressing complexities of academic life. Mentors helps students to build confidence, establish professional networks, discuss amongst peers. However, mentor-mentee relationships largely depend on structure and objectives of the initiative as observed by Kardash (2000). Not just leveraging on structured ecosystems but also active participation of both mentor and mentee to achieve outcomes is essential as advocated by Santhanamari et al. (2022). The cooperative learning indicated by Dorigo & Gambardella (1997), promotes individual and group accountability, resolve conflicts, act critically and develop positive interdependence and interpersonal skills. Social interactions in learning is underlined by Kreijns et al. (2003), by the way in which students constructs knowledge through dialogue and cooperation amongst the peers. Lee & Matusovich (2016) recommends the use of social interactions for co-curricular support for greater academic retention as compared to traditional learning methods. Phan et al. (2016) concluded that active engagement, moderate prior knowledge and self-motivation significantly contributes to learners' success in MOOC's environment along with digital storytelling. Prior knowledge acts as predictor of success in learning environments, which can be termed as quality circle. Pursuit of formal certifications, personal interests and insights of professional developments contributes extensively as observed by Fransson (2010). Prior knowledge also helps in identifying the gaps to be covered by an activity and helps in gauging success. An analysis of intrinsic and extrinsic motivation was carried out by Botham (2018) indicating is readiness of learner to dive deeper into course material for improved performance. Behavioural traits incorporating adaptive learning technologies enhances learners' engagements as observed by Paul & Wa-Mbaleka (2023). Digital storytelling is comprehensively analyzed by Robin (2008) and how it can used is presented. Its impact on creating engagement, narratives resonating with audiences are notified. Rahdar et al. (2020) examines effect of online mentorship and recommends using own formulated best practices with flexible and personalized modalities. The self-regulation aspects of mentorship is of paramount importance in mediums like social media platforms or discussion forums by Gonibeed & Saqib (2023) and recommends to consider factors like enacting inauthentic selves, experimenting with identify boundaries, previously failed relevant identity experiments and motivation to build self-esteem.

Mentorship is anchored for success and quick wins propagate faster. Hubbard Murdoch et al. (2021) demonstrated that perceived success translates to organizational commitment and autonomy of creativity. The researcher also recommends a mixed method approach to be followed. The important factor of coachability of students is researched by Kuratko et al. (2021) and relevant venture outcomes as per relevant entrepreneurial traits.

Based on many more researchers, it is observed that more comprehensive analysis is required, and research framework as shown in fig 1, is identified to work on further.

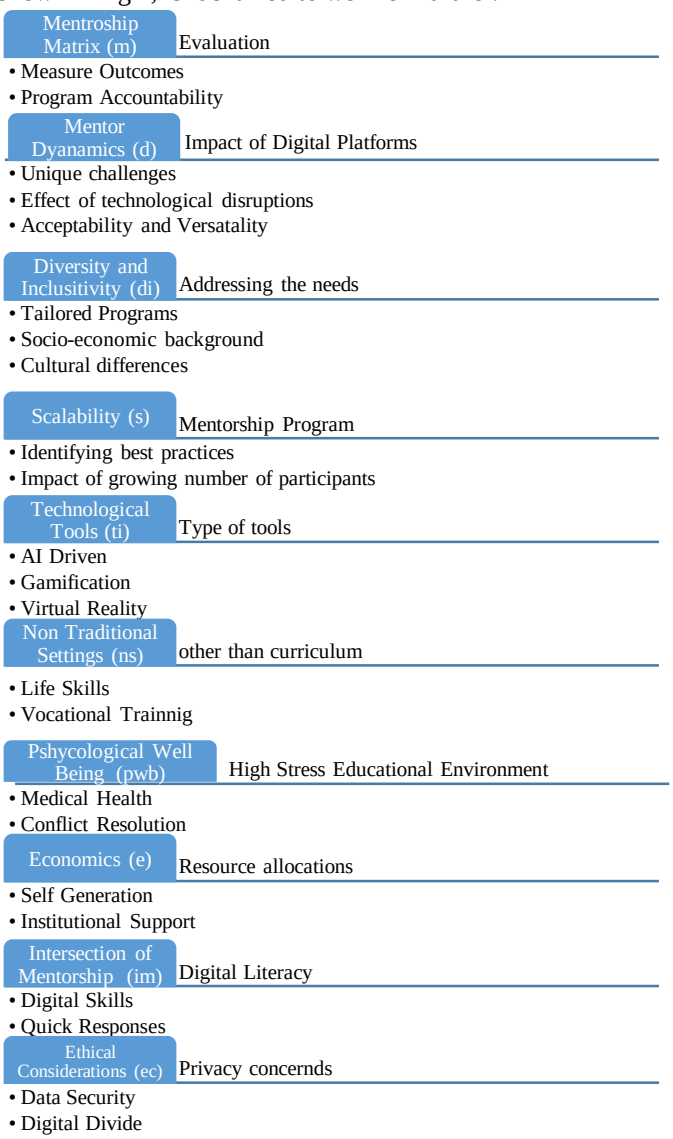

Fig. 1. Research framework

The research gap indicated in fig 1, outlines the critical areas to be worked upon for building research on mentorship and collaborative learning integrated with digital platforms like NPTEL. Measurable outcomes and program accountability is much needed for evaluating mentorship programs. The unique challenges presented emphasize the need for inclusivity in mentorship by considering socio-economic backgrounds and

scalability of program. Cultural differences will affect the acceptability of mentorship. Technological tools like AI, Virtual reality and gamification needs to be researched to enhance mentorship impact while addressing the challenges like stress during education, time bound targets and psychological well-being. Ethical considerations such as digital divide and data security poses additional problems ensuring that programs are inclusive and responsible. The success of mentorship programs is complex and needs sustainable efforts to achieve intended outcomes.

III. SUSTAINABILITY FRAMEWORK

In context of mentorship, sustainability will refer to the program's ability to maintain its relevance, impact and effectiveness over the time, addressing the needs to stakeholders. Mentors act as facilitators and guides, provide support to learners like clarifying doubts, assisting learners in comprehending complexity of course. They play a crucial role of encouraging and motivating students to complete the course, participate in discussions and effectively utilize available resources. In addition, mentors provide positive constructed feedback on all assignments and learnings students undertake, helping them to learn and improve performance. The mentor's expertise ensures that students remain on track with their learning goals while addressing individual needs in order to enhance the mentorship ecosystem. Continuous evaluation, measurement of outcomes effectively, and accountability of mentees are the key parameters. Scalability of mentorship programs and ability to adapt technological disruptions and their acceptance by users will ensure that user-friendliness can prolong sustainability over time. Apart from other factors, inclusiveness, equity in opportunities, use of technologies ethically and effectively coupled with long term fitness, mentorship programs can sustain for longer periods of time.

A mathematical model is created to measure, predict and optimize the sustainability of the mentorship program is worked out as per following.

Sustainability Index (SI) quantifies sustainability of mentorship program. Weighted sum of various sub-indices represents components as per following.

$$SI = w_1 \times SI_m + w2 \times SI_d + w_3 \times SI_{di} + w_4 \times SI_s + w_5 \times SI_{ti} + w_6 \times SI_{ns} + w_7 \times SI_{pwb} + w_8 \times SI_e + w_9 \times SI_{im} + w_{10} \times SI_{ec} \quad (1)$$

Every sub index SIi can be competed using specific metrics related to component that it consists of. The equation (1) represents a weighted sum model where the sustainability (SI) is computed as a combination of multiple factors with associated (w_i) and sub-indices (SIx) representing different dimensions. The theoretical framework for equation (1) typically falls within multi-criteria decision-making (MCDM) or sustainability assessment frameworks.

$$SI_m = \alpha_1 \times EE + \alpha_2 \times QMA + \alpha_3 \times AC \quad (2)$$

Where, EE is evaluation effectiveness, OMA is correlation between predicted and actual outcomes while AC is percentage of participants meeting their commitments.

$$SI_d = \beta_1 \times DPU + \beta_2 \times CRR + \beta_3 \times TA \quad (3)$$

Where DPU is the percentage of participants effectively using digital tools, CRR is the rate at which unique challenges are addressed, and TA is rate of adaptation to technological changes.

$$SI_I = \gamma_1 \times TPSR + \gamma_2 \times SEI + \gamma_3 \times CC \quad (4)$$

Where, TPSR is tailored programs success rate, SEI is Socio-Economic Inclusivity (SEI) and CC is cultural competence.

$$SIs = \delta_1 \times BPI + \delta_2 \times GM \quad (5)$$

Where, BPL is best practices implementation and GM is growth management

$$SI_T = \varepsilon_1 \times AIS + \varepsilon_2 \times GE + \varepsilon_3 \times VRU \quad (6)$$

Where, AIS is AI integration success (AIS), Gamification Engagement (GE) and Virtual Reality Utilization (VRU).

$$SI_n = \zeta_1 \times LSD + \zeta_2 \times VTS \quad (7)$$

LSD is the effectiveness of life skills training provided through mentorship and VTS is the success rate of vocational training programs integrated into mentorship

$$SI_{pwb} = n_1 \times SME + n_2 \times HAS + n_3 \times CRS \quad (8)$$

$$SI_E = \theta_1 \times RAE + \theta_2 \times ISS \quad (9)$$

Where, RAE is resource allocation efficiency and ISS is the level of consistency of support from the institution backing the mentorship program.

$$SI_{im} = k_1 \times DL + k_2 \times DSE + k_3 \times RTE \quad (10)$$

Where, DL is digital literacy level of mentees, DSE is effectiveness of the program enhancing participant's digital skills, RTE is response time efficiency indicating Speed and Efficiency of responses to mentorship related queries or issues.

$$SI_{ec} = \lambda_1 \times PP + \lambda_2 \times DS + \lambda_3 \times DDM \quad (11)$$

Where, PP is privacy protection, DS is data security and DDM is digital divide mitigation

Overall Sustainability SI computed as a weighted sum of all the sub-indices

The weights w_1, w_2, w_3…….w_{10} reflect relative importance of every sub-index in the overall sustainability of the mentorship program. These can be adjusted based on strategic priorities. Factors such as α_i, β_i, γ_i, δ_i, εi, ζ_i, n_i, θi, k_i, and λi are coefficients represent the relative importance of different metrics within each sub-index.

Three different scenarios are simulated by varying the weights assigned to each sub-index in the Sustainability Index (SI) model as shown in Figure 2.

Scenario 1 Baseline consists of weights focusing on balanced importance across all sub-indices with mean SI 0.748 and standard deviation is 0.027. Scenario 2 focuses on mentorship matrix and scalability with higher weights on mentorship matrix and scalability with mean 0.748 and standard deviation of 0.028. Scenario 3 focuses on diversity and inclusivity with higher emphasis on diversity and inclusivity, mean SI is 0.748 and standard deviation of 0.027. All scenarios yield similar mean SI values of approximately 0.748 indicating that the mentorship's program's overall sustainability is robust across different strategic focuses. Scenario 2, focusing on mentorship matrix and scalability, indicating higher variability with standard deviation of 0.028, depicting that these areas will introduce more fluctuations in the sustainability outcomes. The choice of different weight scenarios does not drastically change in the overall sustainability score but might influence the variability in outcomes. This guides decision-makers to prioritize areas depending on whether they seek stability or can

accommodate more fluctuations in pursuit of higher impact on specific domains. The resulting simulation helps in creating potential tradeoffs, while adjusting focus of the mentorship programs and optimizing sustainability as shown in Figure 3.

The simulation involved varying each of the 10 sub-indices in the sustainability index model by ±10% to simulate their impact on the overall SI.

SI increased 1 represents 10% in SI_m mentorship matrix with Mean SI of 0.756 and standard deviation of 0.027. SI decreased 1 represents a 10% decrease in SIm with mean SI 0.741 and standard deviation of 0.026 SI increased 2 represents 10% increase in mentor dynamics upto 10 cases.

Increase in any of the sub-indices by 10% generally leads to an increase in overall SI with mentor dynamics showing a strong impact. Conversely, decreasing any sub index by 10% overall SI, most notable drops observed again in mentor dynamics. The standard deviation across scenarios remains lower (0.026 to 0.027), depicting consistency in performance with reasonable variability. The mentor dynamics impacts stronger effect, making it critical for mentorship sustainability.

IV. Case study

Sustainability of a mentorship program across 10 sub-indices is carried out as per following.

Scenario 1 (Balanced Weights)

Weights = [0.1,0.15,0.1,0.1,0.05,0.1,0.1,0.1,0.1]

Sub Index Scores =

[0.75,0.8,0.72,0.78,0.7,0.68,0.77,0.73,0.75,0.76]

Overall SI

SI = (0.1x0.75)+(0.15x0.8) + (0.1 x 0.72) + (0.1 x 0.78) + (0.1x0.7) + (0.5 x 0.68) + (0.1 x 0.77) + (0.05 x 0.73) + (0.1 x 0.75) + (0.1 x 0.76)

Scenario 2 (Focus on Mentor Dynamics)

SI = 0.75

Weights = [0.1, 0.25, 0.1,0.05,0.1,0.05,0.1,0.05,0.1,0.1]

Scores = [0.75,0.82,0.72,0.78,0.7,0.68,0.77,0.73,0.75,0.76]

Overall SI

SI = 0.7595

V. Results and Discussion

The overall SI is 0.75 for scenario 1, with balanced weights indicating that the program has balanced sustainability across all areas with no particular focus. The overall SI with slightly higher at 0.7595, showing more emphasis on mentor dynamics, the programs sustainability is increased. By adjusting weights, overall sustainability index changes, reflecting importance of mentor dynamics domain. Depending on the goals, weights can be applied to optimize outcomes such as diversity or technological tools etc.

Simulation run of 1000 iterations, distributions indicating how overall sustainability index varies in different conditions. The distributions reveal a tradeoff between stability and improvement.

The sustainability analysis of NPTEL SWAYAM mentor scheme, conducted through a series of simulations and evaluations, key insights into the program's effectiveness in fostering collaborative learning environments to improve student's outcomes. The sustainability index was computed by aggregating sub-indices and simulations demonstrated that SI remained robust across different scenarios, indicating programs sustainability. The sensitivity analysis showed that increasing or decreasing specific sub-indices by 10% increase, importance of maintaining strong mentor-mentee relationships and effective communication channels. The stronger impact of mentor dynamics on the overall SI underscores the critical role of effective mentor-mentee relationships in sustaining the success of the programs. The findings suggest that investing in mentor training, improving communication channels and ensuring consistent mentor engagement are critical in maintaining high level of support to students and group learning with collaboration.

The simulation results suggest that while focusing on specific areas, scalability yields improvements in SI, sustainability remains robustness. Balanced approach in key areas is suggested to sustain the success of the program.

Inclusion of technological tools offers considerable opportunities for increasing learning outcomes. However, ethical and inclusiveness is recommended to address the potential challenges of digital divide.

Conclusion

The sustainability analysis demonstrates that the program is well-positioned to maintain impact, relevance and effectiveness over time relevant to SDG4. The consistent performance across various scenarios and the strong influence of mentor dynamics signifies strategic focus and continuous improvement in key domains. The findings also underline the potential of mentorship and collaborative learning in transforming educational practices and offer guidance for optimization. The regular training ensures that mentos are equipped with the latest strategies to provide high quality guidance and support their mentees. The study also recommends continuous improvement in monitoring and adjustments of the focus areas. Future research can be conducted for sustainability analysis that includes empathy and conflict resolution with predictive analytics to identify students proactively pairing with mentors.

APPENDIX

```
# Let's create a high-quality graph for the simulation of the Sustainability Index (SI) for all 10 sub-indic

# Define colors for the plots

colors = ['#1f77b4', '#ff7f0e', '#2ca02c', '#d62728', '#9467bd', '#8c564b', '#e377c2', '#7f7f7f', '#bcbd2
'#17becf']

# Plot the results for all scenarios with increased and decreased values

plt.figure(figsize=(16, 10))

# Plot increased scenarios

for i in range(10):

    plt.hist(scenarios[f'SI_increased_{i+1}'], bins=30, alpha=0.5, label=f'Increased SI_{i+1}', color=colors

# Plot decreased scenarios

for i in range(10):

    plt.hist(scenarios[f'SI_decreased_{i+1}'], bins=30, alpha=0.5, linestyle='dashed', label=f'Decreased
SI_{i+1}', color=colors[i])

plt.title('Sustainability Index (SI) Distribution for Variations in All 10 Sub-Indices', fontsize=16)

plt.xlabel('Sustainability Index (SI)', fontsize=14)

plt.ylabel('Frequency', fontsize=14)

plt.legend(loc='upper left', bbox_to_anchor=(1, 1), fontsize=12)

plt.grid(True)

plt.show()
```

APPENDIX

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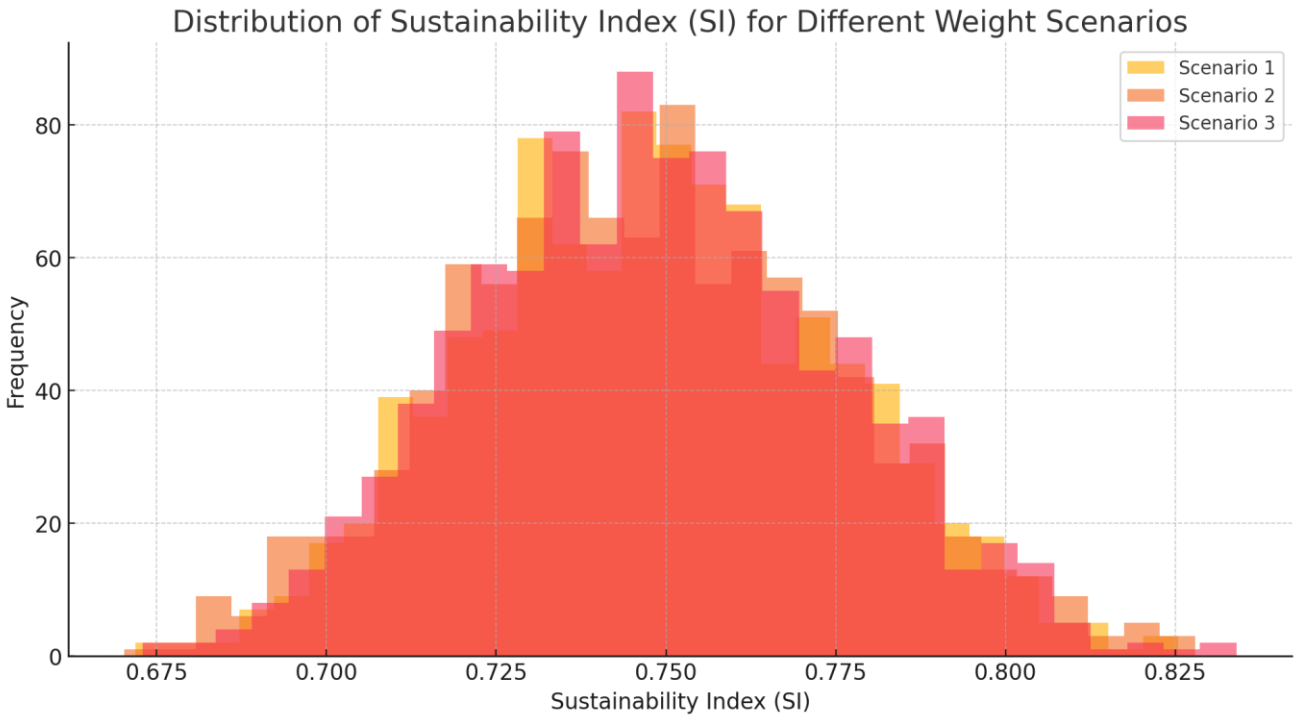

Fig. 2. Simulation of Sustainability Index

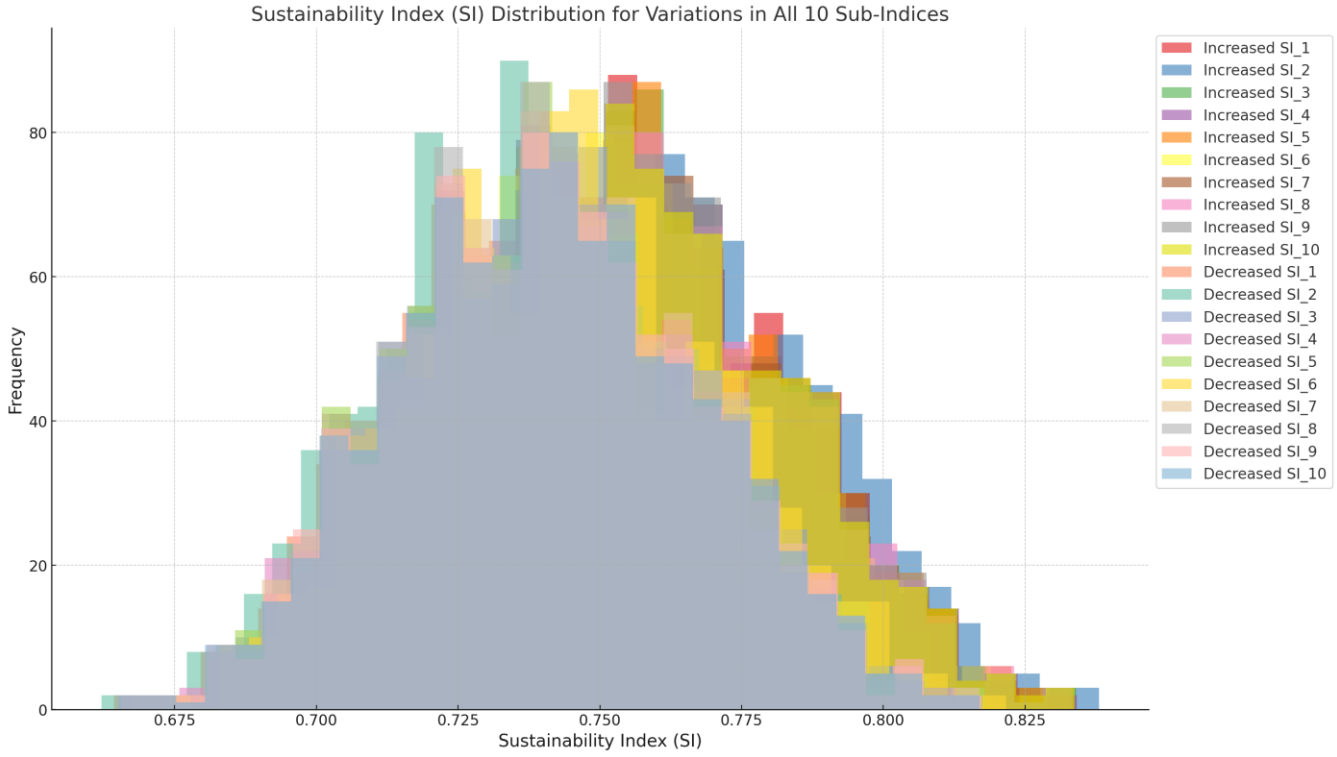

Fig. 3. Sustainability Index for all sub-indices