

Simplifying Strategic Frugal Innovation and Sustainability Formulation and Evaluation: An SDG-Maslowian Approach: A Review and Proposed Framework

Chien-Sing Lee[1,2(✉)]

[1] Faculty of Engineering and Technology, Sunway University, Selangor, Malaysia
[2] IEEE, Piscataway, NJ, USA
csleester@gmail.com

Abstract. The 17 United Nations SDGs are aspirations towards a greater society/world. But not all countries have the capacity or capability to follow. Model-based expected results are sometimes not realized. Possible reasons are first, sometimes, multi-stakeholder macro-micro economic and cultural/lifestyle challenges, require coordinated will and effort, to reach and benefit the people. Second, there may be too many evaluation metrics. Third, localization and harmonization are needed. Hence, we should reduce complexity in requirements and evaluation while augmenting human centricity, towards more needs-based requirements/solutions. Framed within the UNEP's intrinsic, instrumental, cultural values and the Balanced Scorecard, this pilot grounded theory study first maps the UN SDGs to Maslow's hierarchy of needs to determine the centrality of design. Next, the 2024 top 5 global SDG countries and the top 5 Southeast Asian countries' dashboard performances are compared, and contrasted with their respective World Happiness Report ranking, to identify two key ground factors and the baseline. An example of localization, based on intersection of union of global-local SDG-Maslow, Computational Thinking, and the Sustainable Awareness Framework is then presented. Hopefully, as hypotheses emerge, broader and deeper understanding and investigation will develop, not only with regards to the states of progress, but also foci, strategies, outcomes, and subsequently, suitable reference points, pivots to related possibilities and possibly, room for collaboration, based on dynamic weighted criteria analyses. The findings, however, are preliminary thus (not generalizable) due to the small sample size.

Keywords: UN SDG · Maslow · UN Environmental Program · World Happiness Report · Balanced Scorecard · Knowledge Management · agile · grounded theory · baseline · centrality of design · pivot

1 Introduction

Model-driven paradigms/architectures are known to increase effectiveness, efficiency, and performance, as they promote structured instantiations/differentiation to suit the local contexts. The United Nations' (UN) 17 Sustainable Development Goals (SDGs)

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2026
O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15895, pp. 157–174, 2026.
https://doi.org/10.1007/978-3-031-97651-3_11

is exemplary in coordinating efforts towards a society/world worth working towards, by developing better policies and more effective/efficient distribution and use of resources. Furthermore, Sachs (2016) in his capacity as the President of the Sustainable Development Solutions Network (SDSN) and a key member of the World Happiness Report (WHR), has stressed on well-being and happiness for all ages during his keynote address at the London School of Economics.

The UN's 2024 SDG dashboard (Sachs, Lafortune & Fuller, 2024) indicates that 12/17 of the world's SDGs are stagnating (Fig. 1a), while 4/17 have improved moderately. The four SDGs, which have evidenced moderate improvements are good health and well-being (SDG 3), gender equality (SDG 5), affordable and clean energy (SDG 7), and industry, innovation and infrastructure(SDG 9) (Fig. 1b). Figures 2a and 2b highlight the comparative gaps, and room for collaboration.

1.1 Problems and Research Questions

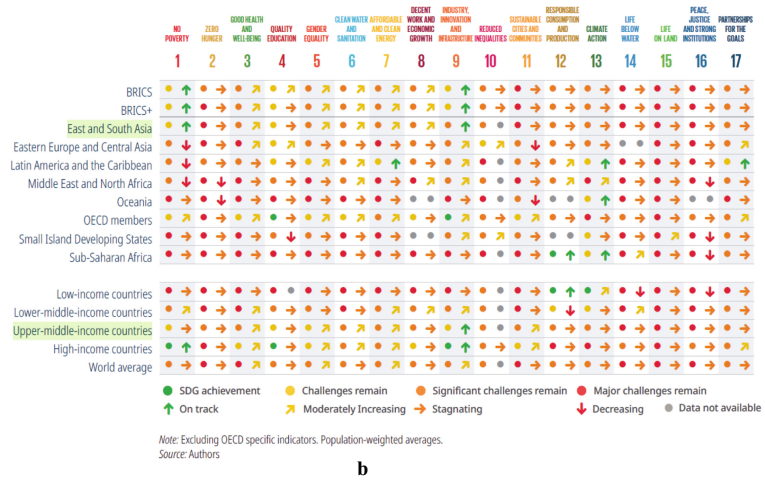
This study explores the problem of overwhelming complexity. First, there may be too many evaluation metrics, that countries are overwhelmed. Since many evaluation metrics are comprehensive, Sigurdarson, Papalambros and Eifler (2023) have suggested three levels, i.e., informal evaluation, opportunistic evaluation, and exhaustive evaluation. For informal evaluation, updated objective functions are assessed for possible redesign at a specific point in the design's objective function space, and outcomes are contrasted with the initial design's Pareto set. At the opportunistic level, the focus shifts to the degree to which design changes affect crucial Pareto optimal activity. The changes to the Pareto-set may be local or global. At the highest level, whole Pareto-sets are considered. Sigurdarson et al. Point out that decision makers should decide how many levels of evaluation are necessary, based on their respective objectives and expected outcomes.

Another way to reduce complexity, is by reusing information e.g. activities, constraints, trade-offs, insights (model-based approach) during configuration redesign, to the relevant part(s) of the Pareto-set. Sometimes, however, model-based expected results are not realized, as multi-stakeholder macro-micro economic and cultural/ lifestyle challenges, require coordinated will and effort, to reach and benefit the people. Optimization/localization should thus be encouraged. This would require assessing the viability of including new or less explored elements of the model. For instance, Tan and Gong (2024) note that in China, supply and demand of labor algorithms adapts to various circumstances, e.g. more time is given to delivery workers, if traffic is heavy. In Europe, large companies are regulated more strictly, while smaller ones are given more space/support to grow. Hence, *identifying the baseline amidst multiple factors, is necessary, to align global-localization initiatives and outcomes.*

Furthermore, the Gaussian distribution partly enables resources to be more optimally designed/developed and leveraged across the population. The general rule with regards to normal (Gaussian) distribution, indicates that 68.2% of the observations will be within ± one standard deviation of the mean; 95.4% within ± two standard deviations; and 99.7% ± three standard deviations (Chen, 2024). Interestingly, as exemplified by Figs. 3a, 3b, whether the poles balancing/holding the top form a triangle or vertical pillars, there are usually, two (adjustable) poles. Hence, *can we reduce complexity by identifying what the two/three key ground/baseline factors are?*



a

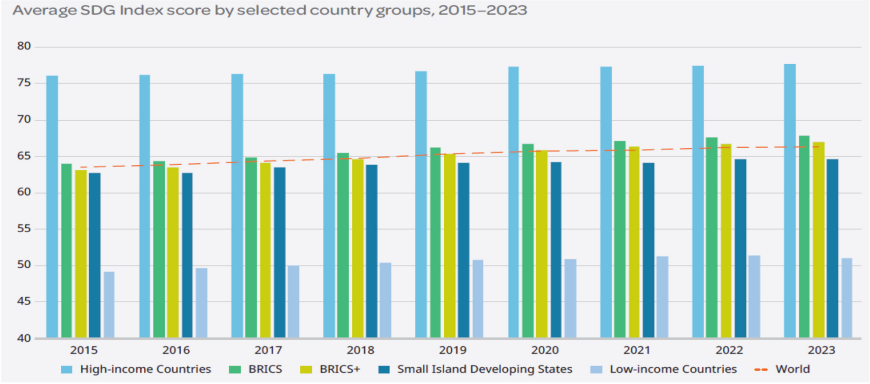


b

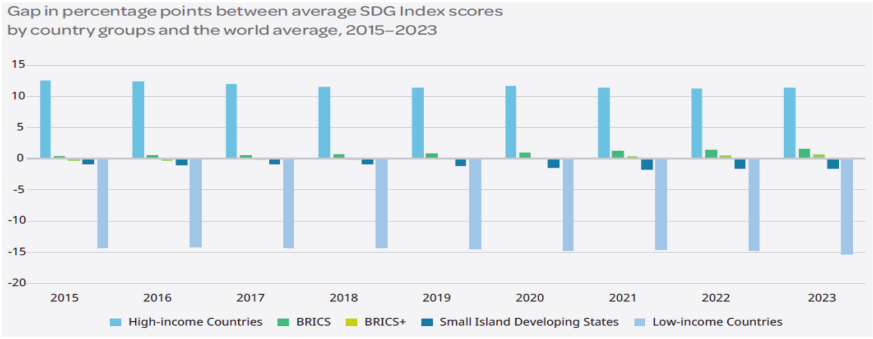


c

Fig. 1. **a.** Sachs, Lafortune and Fuller's 2024 World SDG dashboard. **b.** Sachs, Lafortune and Fuller's (2024) region-income levels dashboard. **c.** Sachs, Lafortune and Fuller's (2024) levels and trends in Southeast Asia



a



b

Fig. 2. **a.** Sachs, Lafortune and Fuller's (2024) SDG index comparison (2015–2023). **b.** Sachs, Lafortune & Fuller's (2024) comparison in percentage points (2015–2023)

Furthermore, *mapping may also reduce complexity*. However, mapping based on equivalence relations may not be equivalent in human contexts. As such, *will intersection of union reduce complexity meaningfully?*

1.2 Objectives

The objectives for this study are:

a) to identify the baseline and the two key ground factors,
b) to enable more effective/efficient reflection (Lee & Wong, 2022), and refactoring.

The subobjectives are:

1) to map the SDGs to Maslow's (1962) hierarchy of needs (Fig. 3c) (Sect. 4.1),
2) to review the 2024 SDG dashboards, and formulate hypotheses with regards to the baseline and two key ground factors (Sect. 4.2),

3) to develop an intersection of union global-local SDG-Maslow example (Sect. 4.3).



Figs. 3. a, b. Gaussian and Pareto principles, **c.** Maslow's (1962) hierarchy of needs, **d.** Resnick's (2007) creative-KM society

2 Methodology

This study is a pilot based on grounded theory (Glasser & Strauss, 1967). The sample size is scoped to the top 5 SDG countries and top 5 low-income developing countries reported in Sachs, Lafortune and Fuller's (2024) global dashboard and their respective World Happiness Report rankings. From their SDG achievements, a hypothetical baseline and two key ground factors are formulated. Subsequently, SDGs are mapped to Maslow's (1962) hierarchy of needs, to simplify knowledge engineering. Next, an example of localized centrality of design based on the intersection of union of global-local SDG-Maslow is developed.

3 Related Work

3.1 International Requirements Engineering Board's (IREB) Requirements Engineering (RE) Framework

The IREB's Requirements Engineering framework (Fig. 4) parallels the Software Development Lifecycle's (SDLC) planning, analysis, design, development and evaluation phases. Planning parallels with the RE context, where the target users are profiled (subject facet), behavioral patterns (usage facet) and the user's usage infrastructure and devices (IT system facet) identified. This phase corresponds with design thinking's empathy.

Furthermore, Broy and Rumpe (2023) highlight that semantics modeling and intelligent adaptations are usually object-oriented (attributes and methods). Considering the huge potential of the Semantic Web (Krippendorff, 2006), if structural, behavioral, functional and non-functional requirements, are adequately, accurately, significantly and semantically modelled, instantiation/adaptations and pre-post requirements tracing via UML would be more accurate. To validate hypotheses, prototyping, and alpha-beta user testing are carried out.

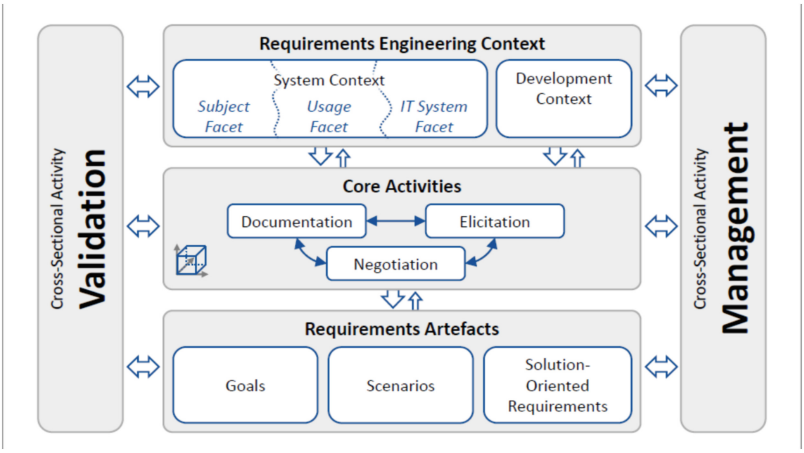


Fig. 4. IREB RE framework

3.2 The Balanced Scorecard (BSC) and the Kano Model

Figure 5a presents Gamble, Peteraf and Thomson's (2023) view of the macro/external factors influencing the organization's development. These are multi-variate and can be complex. In terms of RE context (Fig. 4a), Kaplan and Norton (1992) aim to improve organizational strategies holistically, by understanding the customers' needs, perspectives, and usage, leading to elicitation, negotiation, documentation (RE core activities), and requirements artefacts (goals, scenarios, and proposed context-specific solutions). Then, organizations improve internal processes, and chart learning paths (up/re-skilling), to increase financial gains. By defining a strategy as a set of hypotheses representing possible causes and effects based on the body of knowledge, the BSC also aligns with design thinking (Dym, Agogino, Eris, Frey, & Leifer, 2005).

Furthermore, Meier (2015) highlights that SCRUM-based RE assumes prioritization of requirements in the product backlog. This will enable more effective assignment of requirements to sprint releases. McKinsey's Aghina, Handscomb, Salo, and Thaker (2021) add that Agile methodologies, reduce time-to-market by up to 40% and improve team productivity by 25%. Scrum methodology reports a 50% reduction in defects. The Kano model is chosen for this study, as it aims at customer satisfaction through agile principles, and has an inherent tendency towards Gaussian distributions (Miyamura & Kano, 2006). Product roadmaps are charted through four quadrants, i.e., from in-different to must-have to performance to delighter functions. Improvements are charted as sine curves, decrements cosine curves, consistency as regression (Fig. 5b).

3.3 Circular Economy Design Factors, Sustainability Awareness Framework

Medkova and Fifield (2016) have proposed designing for a circular economy based on people, planet and profit, with systems thinking at the core, and communication as mediator to create awareness and persuade mental shifts. TU Delft (2016) points out that these will be enablers only if there is trust, above other factors (Fig. 6a). Venkatesh,

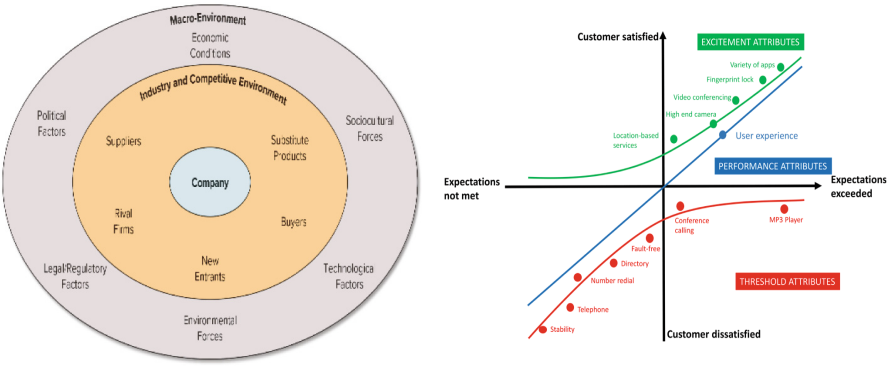


Fig. 5. **a.** Gamble et al.'s (2023) external influences to organizational strategies. **b.** Sample Kano model (Seeburger's Trends and Innovations)

Speier-Pero, and Schuetz (2022) further highlight how individual psychological factors e.g. risk, quality, congruence, value consciousness and enjoyment influence decisions and behavioral change during online shopping. These three complement each other especially with regards to congruence and value consciousness.

Penzenstadler, Duboc, Kocak, Becker, Betz, Chitchyan, Easterbrook, Leifler, Porras, Seyff, & Venters' (2020) Sustainability Awareness Framework (SusAF) aims to predict the impacts of technological products and services during the SDLC's planning phase. The impacts related to five sustainability dimensions (social, individual, environmental, economic, and technical). Three types/degrees of impact, i.e., direct/immediate, indirect/enabling, and systemic/structural, cater to different stakeholders (Fig. 6b).

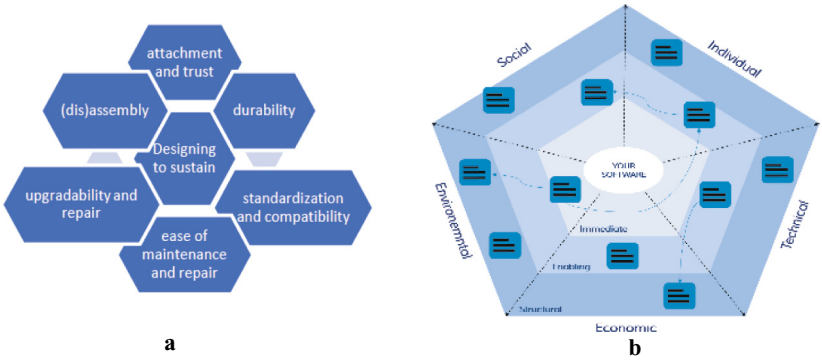


Fig. 6. **a.** TU Delft's circular economy building blocks. **b.** Sustainable Awareness Framework's Immediate, enabling and structural impacts

3.4 Triangulated Evaluation Metrics (Emulating Gaussian-Mixture Models Enabling Fuzzy Logic)

Grover and Pea (2013) highlight that different Computational Thinking (CT) assessments scaffold differently. Hence, they have suggested triangulating. Triangulating evaluation metrics reduces complexity and enables development of information gain-like hierarchies, through ranking of averages. Lee and Jiang's (2019) Scratch fractal CT-HCI scaffolds study and subsequent studies, have utilized mapping and triangulation, and confirm this.

Figures 7a, b further present comparisons between single (CSUQ) and triangulated usability evaluation metrics (CSUQ, HE, UEX) outcomes. All findings concur with Liang and Kleeman's (2005) information flow – that information quality, and ser experience (dynamic system components) across interrelated channels, sustain flow.

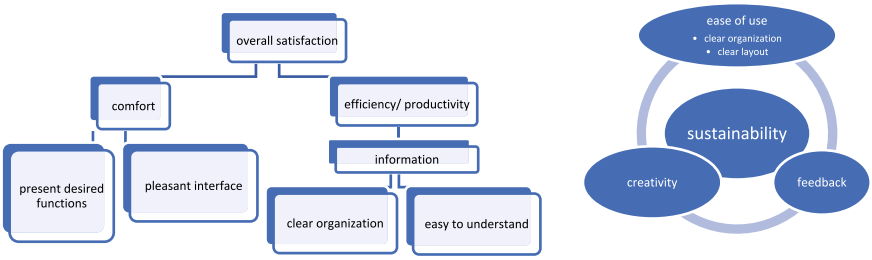


Fig. 7. **(a)** Inferred hierarchy of factors contributing to overall satisfaction/attractiveness based on CSUQ and **(b)** highlights from CSUQ-HE-UEQ**,** with information as the bridge, and derived three key factors, as mediators and moderators, over time (from Lee, 2023)

While averaging emulates Sigurdarson et al.'s (1996) informal evaluation, weighted criteria analysis (Valacich, George & Hoffer, 2016) and triangulated evaluation correspond to opportunistic evaluation, with derivation of meaningful/creative insights.

3.5 Determining Significant Factors, Ranking and Optimizing

Determining the initial design's Pareto set in past research has been at a much simpler level, i.e., first, via derivation of averages (due to its inherent Gaussian implication) and ranking, second, via Valacich, George and Hoffer's (2015) weighted criteria analysis, and at a higher level, via triangulated evaluation metrics. WCA involves identifying criteria (projected benefits/requirements, and constraints) based on past and current data-trends, to predict and strategize/prioritize product roadmaps. Constraints are usually related to resource costs (hardware/software, human resource, operations), environment and partnerships. Valacich, George and Hoffer (2015) have recommended the total weights for the requirements criteria to be at 50 and for constraints at 50.

In terms of differentiation, it may be easier to determine a percentage as baseline across all criteria, and subsequently, adjust the percentages per criterion, to suit different contexts. This brings us back to Sigurdarson, Papalambros and Eifler's (2023) three levels of evaluation, and Valacich, et al.'s (2015) weighted criteria analysis. By adjusting either criteria and/or weights, and/or ratio between requirements and constraints, an optimistic or pessimistic approach similar to Project Management's critical path analysis can be developed.

At an advanced level of global-local path optimization, Li, Wang, Qi, Zhang, Liu, Wu, and Jia's (2020) exponential counterfactual regret minimization (ECFR) provides an example of a pessimistic approach, as actions with a higher regret value are assigned larger probability. ECFR starts with a small negative regret value in the initial phase and compares the next best strategy in the next iteration with the current alternatives. More optimistic/game-like, Xue and Ye's (2020) DCFR considers only positive regret and prunes nodes based on discounted utility.

4 Findings

4.1 Subobjective 1: Map the UN SDGs to Maslow's Hierarchy of Needs

With regards to design thinking, this study proposes mapping the UN SDGS to Maslow's (1943) hierarchy of needs motivational theory (Fig. 8 left). Mapping is based on respective definitions and nearest/best fit. Basic needs (physiological and safety), and emotional needs (love and belonging, and self-esteem), lead to higher likelihood of self-actualization. The italicized needs in Fig. 8 (right), are from Maslow's (1962) extended hierarchy. They highlight how cognitive and aesthetic needs are mediated by advancements in technology, and how the SDGs are also Gaussian, with the base grounded on **s**ocial/**g**overnance factors, the top 3 bands on decent work and economic growth, and one band on **e**nvironment factors. The increments are iterative. A curriculum should be designed likewise.



Fig. 8. Maslow's original and extended hierarchy (italics) mapped to the UN SDGs within the BSC-KM-IREB RE framework

4.2 Subobjective 2: Review the 2024 SDG Dashboards, and Develop Hypotheses with Regards to the Baseline and Two Key Ground Factors

The top 5 countries, i.e., Finland, Sweden, Denmark, Germany, and France, have 8–11 moderately improving SDGs (Figs. 9a-e). Finland, Sweden, Denmark and France have achieved no poverty and interestingly, affordable energy goals. Denmark's additional achievements are gender equality, reduced inequalities. Germany, has achieved sustainable cities and communities, while the United Kingdom (Fig. 9f), industry, innovation and infrastructure.

Moreover, Finland, Sweden and Denmark are the top 3 countries in the WHR since it was first published in 2012. The WHR defines happiness as a measure of social progress and public policy. It is quantified by GDP per capita, social support, healthy life expectancy, freedom, generosity, and corruption. From Figs. 9a-f and Figs. 10a-h, when SDG1 drops or stagnates, it implies that the corresponding supportive SDG e.g. SDG 10 has dropped or stagnated. In addition, when SDG 8 stagnates, SDG 10 also stagnates, the country's WHR drops compared to the previous years', and challenges in achieving higher levels of Maslow's hierarchy increase. However, when SDGs 9 and 11 moderately improves, the country's WHR improves compared to the previous years'.

The top 5 SouthEast Asian (SEA) countries, e.g. Korea Dem. Rep., Thailand, Vietnam, Singapore, China (Figs. 10a-e) evidence similar correlations between SDGs 9 and 11, except for Vietnam, as its SDG 8 stagnates. Hence, for the top 5 developed countries, the baseline is tripartite, between SDGs 8, leading to SDG 1, with SDGs 9 and 11 as the enablers, and SDG 7 as the enabler to SDGs 9 and 11. For the top 5 SEA countries, SDGs 4 and 8 and thus SDG 1 are enablers for SDGs 9 and 11 and ultimately, SDG 3.

From Fig. 1c, Southeast Asian countries and upper middle-income countries have achieved their targets for industry, innovation and infrastructure. All Southeast Asian countries are working hard to create jobs (SDG 8), with India, Indonesia, South Korea, Myanmar, Philippines and Singapore making moderate improvements in SDG8.

Malaysia, an upper middle-income developing country, is a part of Southeast Asia (SEA). Sustainable cities and communities is prioritized higher than making cities smart. Hence, Malaysia has achieved SDG 1 (no poverty) and SDG 11 (sustainable cities and communities) targets (Fig. 10g), and is making improvements in SDG 3 (good health and well-being), SDG6 (clean water and sanitation) and SDG 9 (industry, innovation and infrastructure).

Bigger and more diverse countries face broader multi-variate challenges. China, for example, has successfully prioritized SDG 1 (no poverty) and SDG 9 (industry, innovation and infrastructure). Similarly, India and Indonesia have exhibited good governance over time. The enabler is mainly SDG 4 (quality education), the fundamental psychology of becoming (Maslow's hierarchy).

As each country strives to improve and rise to higher heights above constraints, possibly, the SDGs should be illustrated corresponding to Maslow's needs hierarchy for BSC prioritization, stratification and assessment, corresponding to relevant body of knowledge e.g. Gamble et al.'s (2023) macro-micro external-internal factors (Fig. 5a), and Knowledge Management's thrust The comparison is summarized in Table 1.

4.3 Subobjective 3: Develop an Example of Localization to SDG-Maslow's Extended Hierarchy

An example of circular economy strategies based on SusAF's immediate, enabling and structural impacts (Fig. 6b), and lean RE is presented in Table 2. Transcendence implies that the respective SDGs (criteria) permeate/apply across all needs as shown in Table 1 above. Hence, these SDGs should be given higher weights. Subsequently, the relevant motivators/communicators should be given their respective sub-weights.

The third column shows Intersection of Union between SDGs and transcendent SDGs. These may become the center of design, depending on multi-stakeholder consensus. The most interesting finding is that redesign matches all transcendent SDGs.

5 Implications

These findings echo design thinking, Knowledge Management, Project Management literature, Kano, Grover and Pea (2013), and Maliehe and Grobbelaar's (2022) studies, that sustainability is broad, and there is a need to progress incrementally, based on strategic local core needs. Examples are Lazada's frugal innovations play on (needs



Fig. 9. **a.** Finland No. 1. (SDG), No. 1/143 WHR, 10 moderately improving SDGs. **b.** Sweden No. 2. (SDG), No. 4/143 WHR, 11 moderately improving SDGs. **c.** Denmark No. 3. (SDG), No. 2/143 WHR, 10 moderately improving SDGs. **d.** Germany No. 4. (SDG), No. 24/143 WHR, 8 moderately improving SDGs. **e.** France No. 5. (SDG), No. 27/143 WHR, 10 moderately improving SDGs. **f.** UK No. 9 (SDG), No. 20/143 WHR, 10 moderately improving SDGs



c



d



e



f

Fig. 9. (*continued*)

(multi-purpose designs (price (gamification, (material))), which lead to similar search, personalized recommendations, via multi-feedback channels (e.g. likes, comments, and post-delivery survey). Empathy and understanding of local cultures have led to customization for average and below average income customers. Including artificial intelligence into such designs, e.g. ambient or cultural computing, in line with the UNEP's



Fig. 10. **a.** Korea Dem. Rep. No. 33/167 (SDG), No. 52/143 WHR. **b.** Thailand No. 45/167 (SDG), No. 58/143 WHR. **c.** Vietnam No. 54/167 (SDG), No. 54/143 WHR. **d.** Singapore No. 65/167 (SDG), No. 30/143 WHR. **e.** China No. 68/167 (SDG), No. 60/143 WHR. **f.** Indonesia No. 78/167 (SDG), No. 80/143 WHR. **g.** Malaysia No. 79/167 (SDG), No. 59/143 WHR. **h.** India No. 109/167 (SDG), No. 126/143 WHR

intrinsic, instrumental and cultural values, may be the next trend interconnecting the core SDGs to other SDGs, for job creation and broader markets.

Table 1. Localized needs-based centrality of design among the top 5 SDG global ranked countries and top 5 SEA ranked countries

World SDG ranking	No. of MI	A&I	A&M	SEA SDG ranking	No. of MI	A&I	A&M
No. 1. Finland	10/17	SDG 1	SDG 7	No. 1. Korea DR	4/17	SDG 13	SDG 12
No. 2. Sweden	11/17	SDGs 1, 5	SDG 7	No. 2. Thailand	4/17		SDGs 1, 4
No. 3. Denmark	10/17	SDGs 5, 10	SDGs 1, 7	No. 3. Vietnam	6/17		SDG 1
No. 4. Germany	08/17			No. 4. Singapore	9/17	SDG 9	
No. 5. France	10/17	SDG 1	SDG 7	No. 5. China	6/17		SDGs 1, 4

MI = moderately improving, A&I = Achieved & improving, A&M = Achieved & maintaining.

Moreover, semantics and behavior (the Semantic Web) enable retrieval and aggregation in intelligent systems, based on the universal body of knowledge/ schematics and transformative rules relevant to the specific contexts or areas of perceptual interests. Bever's (1970) associations to arrays of semantic possibilities and behaviors amid (un)supervised learning of transformative rules, progression from shallow to deeper refinement of knowledge, and feedback, are thus keys to discovering more relevant and accurate data augmentation and system refinement.

Moreover, to Rudas, Pap and Fodor (2013), in fuzzy logic, the conjunctive aggregation forms a triangle (a t-norm) in rule-based systems. The t-conorm can refactor with t-norms and h-norms (symmetrical). As such, identifying the t-conorm may be richer than a Gaussian distribution, due to probabilistic mixtures, applicable to different utilities, managed by upper and lower bounds.

Having defined the upper and lower bounds, pivots to related fixed transformation points determined by universal approximators which are differentiable (Tar, Rudas, Kozłowski, 2007) are less complex. To determine the pivot, dynamic human-machine transformative metaverse possibilities can be triggered by information aggregation. The resulting information aggregation will lead to defuzzification. This process can be applied as the intelligent pivot(s) in socially-driven interactions and lesser structured environments, e.g. in metaverses and noSQL.

This study thus conjectures that Maslow's hierarchy of needs is not meant to be a single triangle but multiple triangles, consisting of the three chosen foci and strategies, similar to Rudas et al.'s (2013). As such, Bever's (1970) and Rudas et al.'s (2013) research and global-local optimization algorithms which factor in Gamble et al.'s (2023) macro-micro factors, Knowledge Management and Project Management principles and dynamic weighted criteria analyses, can complement retrieval, augmentation/generation, with minimal regrets and thus, refine business models (customer value propositions and constraints) for best (not necessarily optimal) fits.

Table 2. Sample circular economy strategies and differentiated motivators/communicators based on SusAF's immediate, enabling and structural impacts, IREB, and Venkatesh, Speier-Pero and Schuetz's (2022) congruence and value consciousness. Intersection of Union is shown in the rightmost column.

Problem	Objectives	Maslow
Goal: Improve internal processes, Scenario: Assessment, SusAF impact: Immediate		
• Many citizens are aware of the importance of sustainability, due to flash floods, and the damage/loss of lives/ livelihood. However, companies/governments require lots of investments, to start on the sustainability journey and in uncertain economic times, it may not be easy to persuade developing countries with low and middle income, to adopt sustainability initiatives, if it costs more	• refine/consolidate BSC, Maslow, RE-SCRUM, strategic group map, Kano model, WCA, SusAF	Transcendence (SDG 3, 4, **8**, 9, 11, **17**), Differentiated motivators/ communicators: Physiological (SDG 2, 6), Safety & Security (SDG 12); Self-esteem (SDG **8**)
Goal: Improve customer satisfaction, internal processes, Scenario: Redesign, SuSAF impact: Enabling		
• Citizens are asked to separate our waste but even if this study do, there are few or no recycling bins in neighborhoods • Also, the garbage truck which comes to collect our wastes is designed to enable easier lifting of garbage, but there are no compartments for each type of waste. So even if citizens separate wastes, the wastes remain "unseparated" and go to the landfill. It is not easy to send the unseparated wastes for resource/material recovery to the relevant up/downstream organizations	• more recycling bins, organizations innovate in each neighborhood • redesign garbage trucks to cater for those who separate wastes /do not • extend/refine supply chains/ business models, to operate in parallel, incrementally	Transcendence (SDG **3, 4**, **8**, **9**, **11, 17**), Differentiated motivators/ communicators: Love and belonging (SDG **3, 4**), TU's attachment and trust SDG **9, 11**: Medkova and Fifield's (2016) **redesign**

(*continued*)

Table 2. (*continued*)

Problem	Objectives	Maslow
Goal: Improve customer satisfaction, internal processes, Scenario: Derive/adopt/adapt local/global best practices/citizen ideas/feedback, SuSAF impact: Structural		
• Need a more systemic supply chain approach, and better balance between requirements-constraints, to suit the economic situation • Companies which have spearheaded waste management in Malaysia and overseas have tested global and local industry-government models and derived best practices	• adopt/adapt local/ overseas best practices, collaborate & incentive households, companies • make aware avenues for feedback/ideas from the public & incentivize	Transcendence (SDG **3, 4**, **8,** 9, 11, **17**) Differentiated motivators/ communicators: Safety and security (SDG **3, 4,** 12, **9, 8**, **16, 17**)

Above all, localization from best practices is critical. Thus, the SDGs should be illustrated corresponding to Maslow's needs hierarchy, possibly, in tripartite, for BSC prioritization, customization, assessment and open feedback, and corresponding to diverse relevant body of knowledge.

6 Conclusion

Design factors and their corresponding epistemological orientations and weightage for each discipline differ slightly, e.g. in education and in computing/engineering. Hence, context is partly defined by the design scope, design space and the discipline. The SDGs can be categorized and prioritized to fit different contexts, and hierarchy of needs, resulting in different centralities in design. Evaluation of relevant requirements with due consideration for corresponding constraints will create balance and reduce risks.

UNEP's three values, i.e., intrinsic, cultural and instrumental are applicable across contexts. Semi-automating weighted criteria analysis and global-local optimizations based on past and current trends and intersection of union among market, product, impact and constraints, will enable dynamic prediction/(re)prioritization/recommend-ation of future trends/strategies/technologies within a Maslow-grounded SDG-UNEP-BSC-CT-Kano-SusAF product roadmap.

Acknowledgements. The author wishes to express her deepest thanks to Prof. T. Bever and Prof. I. Rudas for their inspiring research, which have greatly increased the significance of this study and enlightened many possibilities on the way forward. Thanks also to foundational mentors Prof. Hean-Teik Chuah, Prof. Hong-Tat Ewe, Prof. Yashwant Prasad Singh, Prof. R. Koper (IJCELL), Prof. Janet L. Kolodner, Prof. Ashok K. Goel (Fulbright), the IEEE, ACM, esteemed collaborators Dr. K. Daniel Wong (design thinking US/SG), Dr. John H. Hughes, Prof. Bo Jiang (and his China NSF). The views in this paper are the author's own perspectives, not of the University's, as

hypotheses based on grounded theory are emergent and the sample size reviewed is small. This study is mainly funded by the author's past Fulbright Visiting Scholar Fellowship.

Disclosure of Interests. The author has no competing interests.

References

Aghina, W., Handscomb, C., Salo, O., Thaker, S.: The impact of agility: how to shape your organization to compete. McKinsey Comp. **25** (2021)

Bever, T.G.: The cognitive basis for linguistic structures. In: Hayes, R. (ed.) Cognition and Language Development, pp. 279–362. Wiley, NY (1970)

Brennan, K., Resnick, M.: New Frameworks for Studying and Assessing the Development of Computational Thinking. American Educational Research Association (2012)

Broy, M., Rumpe, B.: Development use cases for semantics-driven modeling languages. Commun. ACM **66**(5), 62–71 (2023)

Chen, K.: Normal Distribution: What it is, Uses, and Formula. Investopedia (2024)

Deloitte Insights.: Leading the social enterprise: Reinvent with a human focus. (2019). https://www2.deloitte.com/content/dam/insights/us/articles/5136_HC-Trends-2019/DI_HCTrends-2019.pdf

Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D., Leifer, L.J.: Engineering design thinking, teaching, and learning. J. Eng. Educ. **94**(1), 103–120 (2005)

Gamble, J.E., Peteraf, M.A., Thompson, A.A.: Essentials of Strategic Management: The Quest For Competitive Advantage. McGraw-Hill (2023)

Glaser, B., Strauss, A.: The Discovery of Grounded Theory: Strategies for Qualitative Research. Aldine, Chicago (1967)

Grover, S., Pea, R.: Computational thinking in K–12. a review of the state of the field. Educ. Res. **42**(1), 38–43 (2013)

Kaplan, R.S., Norton, D.P.: Linking-the-BSC-to-strategy. Calif. Manage. Rev. **39**(1), 53–79 (1996)

Kano, N., Seraku, N., Takahashi, F., Tsuji, S.: Attractive quality and must-be quality. J. Jpn. Soc. Qual. Control **14**(2), 147–156 (1984)

Krippendorff, K.: The Semantic Turn: A New Foundation for Design. CRC (2006)

Lee, C.S., Kolodner, J.L., Goel, A.K.: Creative design: scaffolding creative reasoning and meaningful learning. Educ. Technol. Soc. **14**(1), 1–2 (2011)

Lee, C.S. Jiang, B.: Assessment of Computational Thinking (CT) in Scratch fractal projects: towards CT-HCI scaffolds for analogical-fractal thinking. International Conference on Computer-Supported Education, Crete, May 2–4, 2019, Greece, 2019, pp. 192–199 (2019)

Lee, C.S., Wong, K.D.: Towards self-adaptive/reflective co-managed open generativity to augment absorptive-multiplicative-relational capabilities/capacities. In: EEE International Conference on Industrial Engineering and Engineering Management, Malaysia, 2022, pp. 52–56 (2022)

Lee, C.S.: Developing a knowledge-requirements engineering framework towards trans-formative (eco)systems/metaverses/ecologies. In: IEEE International Conference on Intelligent Systems and Knowledge Engineering, China, November 17–19, 2023, pp. 1–8 (2023)

Li, H., et al.: Solving imperfect-information games via exponential counterfactual regret minimization. J. IEEE Intell. Syst. 1–10 (2020)

Liang, X.S., Kleeman, R.: Information transfer between dynamical system components. Phys. Rev. Lett. **95** (2005)

Maliehe, T., Grobbelaar, S.: Evaluating the drivers of frugal innovation and its relation to sustainability- a systematic literature review. In: IEEE International Conference on Engineering, Technology and Innovation & 31st International Association for Management of Technology Joint Conference, Nancy, France, 1–7 (2022)

Maslow, A.H.: Toward a Psychology of Being. D. Van Nostrand Co., Princeton (1962)
Medkova, K., Fifield, B.: Circular design – Design for circular economy. Lahti University of Applied Sciences (2016)
Miyamura, M., Kano, Y.: Robust Gaussian graphical modelling. J. Multi- variate Anal. **97**, 1525–1550 (2006)
Penzenstadler, B., et al.: The SusA workshop - improving sustainability awareness to inform future business process and systems design. Zenodo (2020)
Resnick, M.: Sowing the seeds for a more creative society: lifelong kindergarten. Learn. Lead. Technol. **35** (2007)
Rudas, I.J., Pap, E., Fodor, J.: Information aggregation in intelligent systems: an application-oriented approach. Knowl.-Based Syst. **38**, 3–13 (2013)
Sachs, J.D., Lafortune, G., Fuller, G.: The SDGs and the UN Summit of the Future. Sustainable Development Report 2024. Dublin University Press Dublin, Ireland (2024)
Savage, S., Jarrahi, M.H.: Solidarity and A.I. for transitioning to crowd work during COVID-19. In: Association for the Advancement of Artificial Intelligence (2020)
Sigurdarson, N.S., Papalambros, P.Y., Eifler, T.: Managing functional trade-offs in the mechanical design of integrated products using multi objective monotonicity analysis. In: International Conference on Engineering Design. Bordeaux, France, 24–28 July 2023 (2023)
Tan, J.E., Gong, R.: Algorithmic Management and Societal Relations-The Plight of Platform Workers in Southeast Asia. Khazanah Research Institute (2024). https://www.krinstitute.org/Discussion_Papers-@Algorithmic_Management_and_Societal_Relations-The_Plight_of_Platform_Workers_in_Southeast_Asia.aspx
Tar, J.K., Rudas, I.J., Kozłowski, K.R.: Fixed point transformations-based approach in adaptive control of smooth systems. Robot Motion Control 157–166 (2007)
TU Delft. Circular Product Design. The Netherlands. (2016). https://www.ellenmacarthurfoundation.org/circular-economy/buildingblocks
United Nations Environment Program (2024). https://www.unep.org/
Valacich, J., George, J., Hoffer, J.: Essentials of Systems Analysis and Design. Pearson, New York (2015)
Venkatesh, V., Speier-Pero, C., Schuetz, S.W.: Why do people shop online? A comprehensive framework of consumers' online shopping intentions and behaviors. Inf. Technol. People **35**(5), 1590–1620 (2022)
Wing, J.: Computational thinking. Commun. ACM **49**(3), 33–35 (2006)
Xue, X., Ye, M.: Interactive complex ontology matching with local and global similarity deviations. Electron. Res. Archive **31**(9), 5732–5748 (2020)