Developing Framework for the Computer Application in Sustainable Development

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ABSTRACT: *Sustainable development is a major theme that has been given significance in the last couple of decades. It is possible to achieve with the help of support from many quarters out of which the support of computing is more important. The UN Millennium Goals from 2000 and Agenda make it clear that a society with the sustainable development is required to achieve the UN goals. Hence, many are interested to develop framework both for the implementation and evaluation. Likewise, we also in this research put forward an application of computing to achieve the Millennium Goals.*

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1. Introduction

Leading international and global governing bodies of UN, gradually took sustainable 17 goals agenda as it prime outcome for 2030, which started formally as the 7^{th} out of 8 UN Millennium Goals in 2002. It seems to be that under the umbrella of sustainable agenda are similar as previous 7 Millennium goals, and other 10 spanned sustainable goals agenda into more detailed manner. Previously recognized as only one out of seven, now sustainability is one standing out for all 17 goals at global agenda. Therefore, assessment and evaluation of sustainability has become an increasingly important issue. In this paper we will give a brief overview of the term sustainability itself and a review of numerous methods of sustainability assessments, followed by development and presentation of our assessment software application for sustainability measurement.

In 1994, John Elkington coined the term *triple bottom line*. There was no single eureka moment, but rather synergetic impact of ideas and work on SustainAbility (a think – tank found in 1987), Brundtland report in 1987 with social and economic dimensions of the agenda among other things [1]. In the simplest terms, the Triple Bottom Line (TBL) agenda focuses on corporations – not just on the economic value that they add, but also on the environmental and social value that they add or destroy [2]. Therefore, sustainability is an intersection and integration of three factors: social, environmental and economic, and is often presented as three circles, as shown in Figure 1.

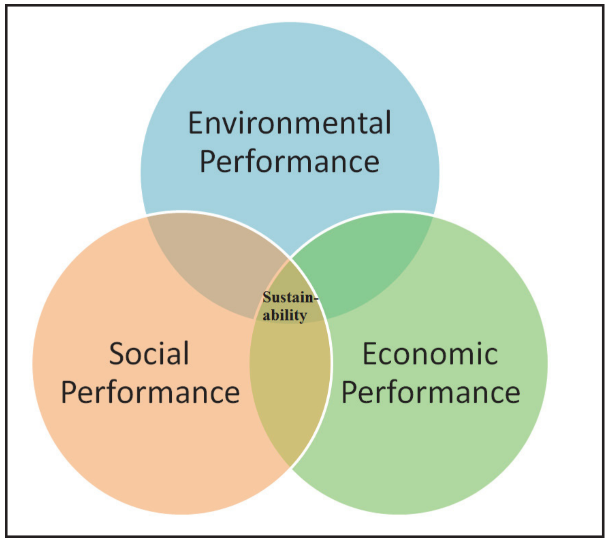

Figure 1. Triple Bottom Line

From 1960 to the present, three great waves of public pressure have shaped the environmental agenda. The roles and responsibilities of governments and the public sector have mutated in response to each of these three waves – and will continue to do so. Although each wave of activism has been followed by a down-wave of falling public concern, each successive wave has significantly expanded the agendas of politics and business [2]. Wave 1 brought an understanding that environmental impacts and natural resource demands have to be limited, resulting in an initial outpouring of environmental legislation. The business response was defensive, focusing on compliance, at best. Wave 2 brought a wider realization that new kinds of production technologies and new kinds of products are needed, culminating in the insight that development processes have to become sustainable – and a sense that business would often have to take the lead. The business response began to be more competitive. Wave 3 focuses on the growing recognition that sustainable development will require profound changes in the governance of corporations and in the whole process of globalization, putting a renewed focus – on government and on civil society. Now, in addition to the compliance and competitive dimensions, the business response will need to focus on market creation.

Pearce [3] says: "Recognizing that people's actions toward nature and each other are the source of growing damage to the environment and resources needed to meet human needs and ensure survival and development, I PLEDGE to act to the best of my ability to help make the Earth a secure and hospitable home for present and future generations."

Daly [4] questioned: "What is it that is supposed to be sustained in "sustainable" development?" Two broad answers have been given. First, utility should be sustained; that is, the utility of future generations is to be non-declining. The future should be at least as well off as the present in terms of its utility or happiness as experienced by itself. Utility here refers to average per capita utility of members of a generation. Second, physical throughput should be sustained, that is, the entropic physical flow from nature's sources through the economy and back to nature's sinks, is to be non-declining.

In the supply chain management domain, lessons about strategic importance of competitiveness brought by sustainability had been implemented by Carter and Rogers [5] along with the measurements of ranking of sustainable practice by intersection and integration of social, economic and environmental aspects of sustainable supply chain management practice.

Sustainability has definitely become a global agenda; therefore various sustainability assessment methods have been developed. We will describe some of them in the next section.

2. Sustainability Assessment

Vinouh et al. [6] developed a computer-based decision support system for the assessment of the sustainability level of a manufacturing organization. Their system was developed designated as fuzzy-logic-based sustainability evaluation. Decision support system is taking into consideration various factors needed for insuring sustainability. The system calculates the fuzzy logic sustainability index, Euclidean distance, and fuzzy performance importance index. This model should help the companies to analyze various aspects of sustainability within their organization and work toward further improvement of it.

Benedetto and Klemeš [7] improved the Life Cycle Assessment (LCA), a well-known tool for analyzing environmental impacts on a wide perspective with reference to a product system and the related environmental and economic impacts. They stressed a need for a novel approach that complements environmental and financial considerations and introduced a new graphical representation: the Environmental Performance Strategy Map. It allows one to combine the main environmental indicators (footprints) with the additional dimension of cost. Their study defined the Sustainable Environmental Performance Indicator as a single measure for sustainability of a given option. Comparison of different options for strategic decision-making purposes can be enhanced and facilitated by the use of this indicator.

Calderón [8] aimed at presenting a model, in the form of a template and a set of operating instructions, produced by the European Commission for the appraisal of sustainability of projects requesting financial support under the Urban Pilot Projects scheme. The proposed appraisal scheme should jointly take into consideration the three main components of the sustainability concept, namely economic, social, and environmental, subjectively weighted to produce a single index. Evaluation of a single index was handed over to a panel of external evaluators for them to reach consistent decisions across the European Union (EU).

Munda [9] argued that sustainability assessment needs a set of multi-dimensional indicators and how could such indicators be aggregated. Like in a classical conflictual situation, studied in multi-criteria decision theory, some indicators improve while others deteriorate. For instance, when incomes grow, SO_2 might go down while CO_2 increases.

Ticehurst et al. [10] explored coastal lakes as ecosystems of significant value generating many ecological, social and economic benefits. Clearly, integration and intersection of ecological, social and economic issues are in the domain of sustainability thought. Like in [9], conflicts, for example between lake users and upstream communities, are present in multi-criteria decision theory. There are many techniques that can be used to integrate the variables involved in such conflicts including system dynamics, meta-modelling and coupled component models, but many of these techniques are too complex for catchment managers to employ on a routine basis. The overall result is the potential to compromise the sustainability of these important ecosystems. In their paper, they present research to address this problem. Development of an integrated model framework based on a Bayesian network (Bn) was presented. Bns are used to assess the sustainability of eight coastal lake-catchment systems, located on the coast of New South Wales (NSW), Australia. Their paper described the potential advantages in the use of Bns and the methods used to develop their frameworks. A case study application for the Cudgen Lake of northern NSW is presented to illustrate the techniques.

Tseng et al. [11] examined sustainable production indicators (SPIs). SPIs is a complex concept for which determining multiple qualitative criteria is not trivial. Thus, they developed a generalized quantitative evaluation model, which considers both the interdependence relation between criteria and the fuzziness of subjective perception concurrently. They evaluated the performance of synthetic SPIs by adopting fuzzy measure and analytical network process (ANP) method in a multi-nation original equipment manufacturing firm.

Jayal et al. [12] developed improved models, metrics, scoring methods, predictive models for sustainability evaluation and optimization techniques at the product, process and system levels to achieve sustainability in manufacturing. They used a holistic view, spanning not just the product and the manufacturing processes involved in its fabrication, but also the entire supply chain, including the manufacturing systems across multiple product life-cycles. Their paper presents an overview of recent trends and new concepts in the development of sustainable products, processes and systems with examples focusing on dry, near-dry and cryogenic machining.

Gunasekaran and Spalanzani [13] stated that today it is not enough to be successful in business, it is becoming imperative to safeguard the environment, safety and welfare of those alive today and prepare for those yet to come. Various stakeholders have realized that the future of the earth, and therefore that of future generations, is at stake. They provided classification and critical review of the available SBD literature and developed a framework for SBD and suggest future research directions, along with the tools, techniques and some performance measures and metrics for SBD.

Cucek et al. [14] presented an overview of footprints as defined indicators that can be used to measure sustainability. Many definitions, units of measurement in its single instance of social, economic and environmental dimensions are unclear. Even more, footprints could be composite of two and more individual composites are also assessed. These composite combinations have multi-objective optimization problem for which authors presented several tools for optimizations, calculations, graph based and mathematical programming based.

Bond et al. [15] draw mainly on theoretical papers along with the few case study examples published to date (from England, Western Australia, South Africa and Canada). Their paper outlines what might be considered state-of-the-artsustainability assessment. Such processes must: (i) address sustainability imperatives with positive progress towards sustainability; (ii) establish a workable concept of sustainability in the context of individual decisions/assessments; (iii) adopt formal mechanisms for managing unavoidable trade-offs in an open, participative and accountable manner; (iv) embrace the pluralistic inevitabilities of sustainability assessment; and (v) engender learning throughout. They postulated that sustainability assessment may be at the beginning of a phase of expansion not seen since environmental impact assessment was adopted worldwide.

3. Our Approach

Our basic idea is as follows: there are many questions/indicators, and each of them can be 'placed' in only 1 of 7 possible areas, as each question/indicator deals with:

1. Only the economic aspects or
2. Only the environmental aspects or
3. Only the social aspects or
4. Both the economic and environmental aspects or
5. Both the economic and social aspects or
6. Both the environmental and social aspects or
7. All three aspects

For example, the question 'Are the workers motivated?' regards both the social and economic aspects. Taking care of the workers' motivation basically belongs to the social aspect, but their motivation directly influences their efficiency, which will increase/decrease the company's profits. Therefore, this indicator also deals with the economic aspects. It is not easy to properly define which question belongs to which area, therefore experts' job is to define the questions/indicators for the evaluated entity (firm, company, organization, etc.) and categorize them to one of the seven areas. In such system each of the seven areas is important for the sustainability, not only the center where the three circles intersect. If any of the areas is neglected, it will negatively influence the sustainability.

Since various questions/indicators can be more or less important than other questions/indicators, each can have a proper weight, which is expressed as a positive number – the greater the weight, the greater the importance. When evaluating, each question/indicator can have 5 values, from 1 to 5. Then for each of the 7 areas an average value may be calculated according to Eq. (1). Here n is the number of questions/indicators for that particular area and w_i and v_i are the proper weights and values for each of them.

$$ave = \frac{\sum_{i=1}^{n} w_i v_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

The obtained average value for each of the areas is a number between 1 and 5. We can convert that number into a proper shade of grey, with 1 being the darkest (black) and 5 being the lightest (white). If we color each of the 7 areas with the proper shade of grey, we can immediately derive interesting conclusions, such as:

1. Which area is the darkest, therefore which aspect is the most important to focus on, in order to increase sustainability.

2. How 'close' are all the areas to the color white, which gives a sense of how sustainable the evaluated system is.

In the remainder of this section we will describe the application we have developed. It basically has two parts: manipulation of the questions/indicators and assessment. Clicking the button 'Manipulate questions/indicators' selects the first part, which is shown in Figure 2. The user can enter a new question/indicator or delete an existing one, as well as change the text, weight or area for any of the questions. Clicking the 'Save' button saves the changes.

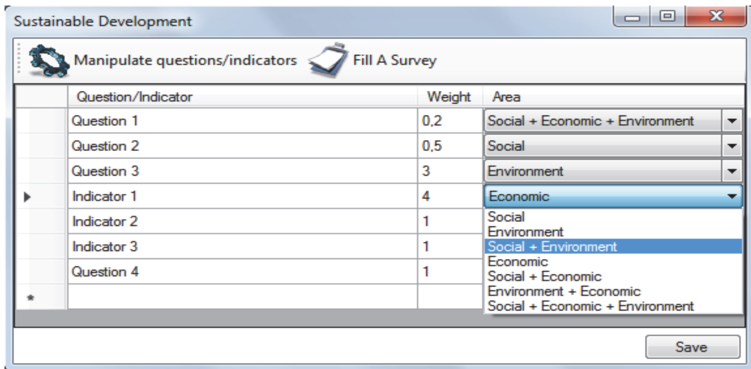

Figure 2. Manipulating questions/indicators - Changing the area

Clicking the 'Fill a Survey' button starts the evaluation. For each of the questions/indicators the user should select a value from 1 to 5, as shown in Fig. 3. After all the questions are answered the user can click the 'Submit' button and the application will show the results, as can be seen in Figure 4. The left part of the window shows the seven colored areas. We can see in the shown case that the economic aspect is great, while work needs to be done on the social and environmental aspects. The most important part in this particular case is the part that deals with both social and environmental aspects, as that area is the darkest. The user can click on any of the seven areas, and the results for that area will be shown in the right part of the window. There we can see the proper questions/indicators for the selected area with their weights and values. The calculated average value is shown at the bottom. Clicking on some other area gives the results for that area.

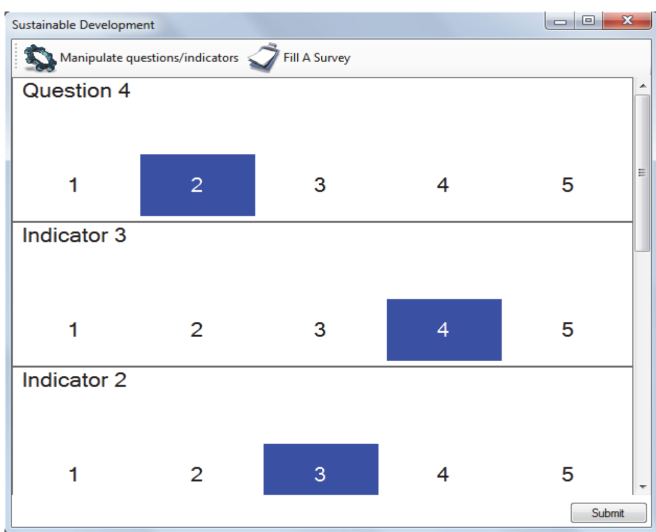

Figure 3. Filling the survey

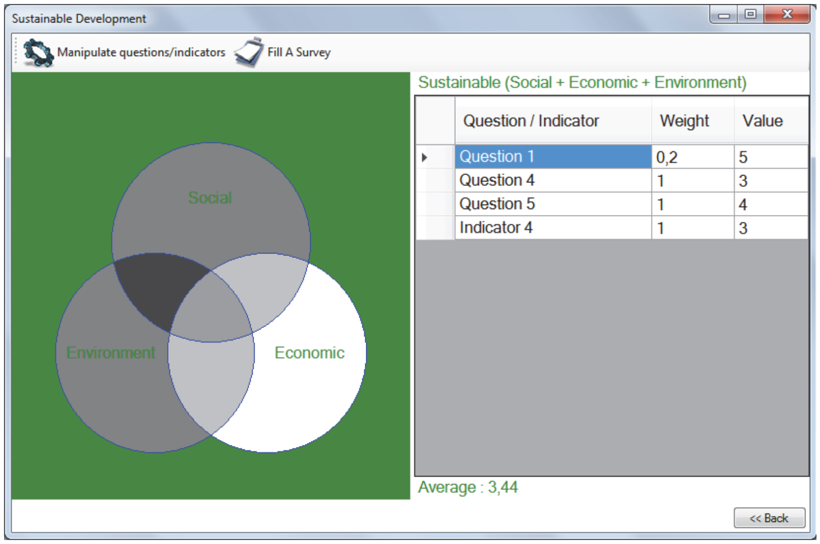

Figure 4. Results

As can be seen, the application is easy to use and gives a simple sustainability assessment, which may be valuable as a first level evaluation. Another merit of our approach is that it gives a different view, compared to existing models.

In future work we may enrich our model with some more complex evaluations.

4. Conclusion

Previously being only one out of seven goals, sustainability is now standing out for all 17 goals at global agenda. Therefore, sustainability assessment/evaluation has become an increasingly important issue. In this paper we gave a review of several methods of sustainability assessment, and described our simple computer application for first level sustainability assessment. The application is easy to use and gives a different approach, compared to existing models.

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