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Assessing the Indicator Based Sustainability: A Pragmatic Approach

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Abstract:
Sustainability is the derivation of the status of capacity to maintain, in any scale from individual to population, and sometimes non-living natural resources. Sustainability is a term which not only indicates the quality of life or expectancy, rather in modern day research it has evolved as a quantitative approach towards the estimation of well-being. Thus, it has definitive conflict with the developmental processes, which usually attempt to fulfill the concern of the people only. There are various methods to measure sustainability and ever comply with the variation in natural ecosystem and dynamic situations therein. But these methods have their own shortcomings in application for sustainability assessment as a whole as they are based mainly on few certain criteria and most of the outputs are qualitative in nature. The experimentation with the sustainability has the potential to accommodate this kind of variations. This study has also an attempt to accommodate the variables in natural system and a more refined process to quantify the sustainability.A new approach for sustainability scoring has been developed considering interrelation of the systems resilience, threats and adaptive capacity. The proposed methodology is more quantitative and flexible to any natural system.

1. Introduction

Sustainability is a term, which means capacity to maintain. Sustainability represents the highest level of activities to make progress towards sustainable development (Galvic and Lukman, 2007). The concept of sustainability is the basis of Sustainable Development (SD) which was first defined in the Brundtland Commission's Report in 1987 as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987). Both sustainability and its developmental context have been defined variously in different literatures (Solow, 1991; McMichael et.al, 2003; Vitalis, 2004, Hopwood et al, 2005).

The term 'Sustainability' or 'sustainable development' was popularized by the World Commission on Environment and Development report Our Common Future in 1987 but it is generally recognized that notions of sustainability were promoted in 'limits to growth' and 'green' discourses in the early 1970s (Lumley and Armstrong, 2004). In 1980s the liberalization of market, less government intervention resulted in higher level of trade and international investment and stakeholder pressure intensified in 1990s. Criticism of the negative environmental and social impact of multinational enterprises has increased since the 1990s (Kolk, 2003). The concept of sustainability emerged in response to concern about environmental degradation resulting from poor resource management. As the environment became increasingly important as a world issue, sustainability was adopted as a common political goal (McKenzie, 2004). Sustainability is increasingly viewed as a desired goal of development and environmental management. This term has been used in numerous disciplines and in a variety of contexts to the vision of a sustainable society with a steady-state economy. The meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic, or ecological perspective (Brown et al, 1987). Although the essence of the concept of sustainability is clear enough, the exact definition of sustainability has caused strong discussions. Difficulties related to the definition of sustainability show that it is a complex and multidimensional issue (Ciegis et al, 2009). To human population sustainability means the living condition with maximum support for security, wellbeing and health (McMichael et al., 2003). The ecological definition of sustainability focuses on natural biological processes and the continued productivity and functioning of ecosystems (Brown et al, 1987). From developmental view, sustainability, the concept behind sustainable and economic development is the integration of economy and environment and also promoting the intra- and intergenerational equity (Quaddas and Siddique, 2001). The Brundtland commission's definition of sustainable development has a major focus on intergenerational equity (Kates et al, 2005). Again a social definition of sustainability might include the continued satisfaction of basic human needs as well as higher level social and cultural necessities such as security, freedom, education, employment, and recreation (Maslow, 1970). Most of the definitions of sustainability ignore the temporal and spatial scale factor in sustainability study. Clark (1985) has identified many problems regarding confusion of different time and space scales in the study of environmental futures. Sustainability may have a different definition and different measures, depending on the scale of concern but all these studies have common theme of continued support of human life on earth, maintenance of biological resources and productivity, stable human population (Brown et al, 2005).Since sustainability has been used in multi- disciplinary concepts, it needs a proper integrated methodology for assessment of sustainability.

2. Overview of Sustainability Assessment Methodologies

Developmental work in all sphere of activities are going on at a maximum pace in the recent world. The present ways of development do not support a sustainable condition (Kates et al. 2000) as; it attempts alterations of the environment that includes global warming, land transformation, unequal wealth distribution. Meeting fundamental human needs will require a progress in a transition toward sustainability (Kates et al. 2000). Sustainability is now rapidly moving from a concept to a measureable state of human- ecological dynamic system (Myers, 2008). Several methodologies had been put forward to assess sustainability (Hartwick, 1977; Daly, 1991; Azar et al. 1996, Krajnc and Galvic, 2005, Gibson, 2006, Ridaura et al. 2002, Cendrero et al. 2003). Sustainability assessment is an integrating approach, while many approaches tried to assess sustainability separately for social, economic and environmental sector and as a result failed to integrate properly (Gibson, 2006). The major problem with its assessment is the paucity of a perfectly sustainable condition in the environmental system as a reference (Hannon et al., 1993). Different approaches have been taken by practitioners and researchers to promote sustainability principles. For the purpose of this paper few assessment procedures have been reviewed.

The Pressure State Response (PSR) framework is based on the following concept of human activities exert 'pressures' on the environment and change its quality and the quantity of natural resources (the 'state'). Society responds to these changes through environmental, general economic and sectored policies (the 'societal response'). The latter forms a feedback loop to pressures through human activities (OECD, 1998). Later, PSR was expanded into framework known as DPSIR (driving- pressure- state- impact- response). The drivers produce certain amount of positive and negative pressure, which change the quality and quantity of natural resources. Based on the impacts generated by this pressure, society must react by developing policies to prevent and mitigate the impact (Poveda & Lipsett, 2011; Jorge et al., 2002). Based on driving force- state- response approach, the United Nations Commission on Sustainable Development (UNCSD) was established a framework for the selection of sustainability development indicators which initially include 134 indicators from social, environmental, economic, and institutional aspects (UNCSD, 2001). The World Conservation Union or International Union for Conservation of Nature and Natural Resources (IUCN) sponsored the development of the 'Wellbeing Assessment' that was published in The Wellbeing of Nations: A Country-by-Country Index of Quality of Life and the Environment (Prescott-Allen, 2001). The Wellbeing Index is a composite of 88 indicators for 180 countries and the indicators are aggregated into two sub-indices viz. human wellbeing and ecosystem wellbeing. Regarding the most and least sustainable concept used in this index, it can be said that for sustainability of any system, all the components should be sustainable by them. Precisely, a system remains sustainable, till no deterioration is observed in any of its components. If a system is sustainable it can't be most sustainable or least sustainable but can be sustainable for higher time span or lesser time span. The extent of non-sustainability can vary from high to low. The World Economic Forum's Environmental Sustainability Index is also composite index derived from 68 indicators for 148 countries (WEF, 2002). The ESI, based upon a set of 68 basic indicators which are aggregated to construct 21 core indicators, is quite similar to Wellbeing Index (Singh et al, 2009). Composite sustainability index and Multi- criteria analysis are increasingly recognized as an important tool for sustainability assessment which introduces issues such as selection of data, normalization of data, weighting and aggregation methods (Krajnc and Glavic, 2005; Sheppard & Meitner, 2005; Ridaura, 2002).

Another assessment index ecological footprint (Wackernagel and Rees, 1997) measures the total land area that is required to maintain the food, water, energy and waste-disposal demands per person, per product or per city. As it is based on consumption data, it relies on normalization and mainly constructed for managing the use of croplands, grazing lands, forests, fisheries, infrastructure, and fossil fuels. The Human Development Index (HDI) is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. This includes the average value which sometime ignores the reality.

An impressive number of sustainability indices have been developed (Mayer. 2008, Singh et al. 2009, Mori & Christodoulou, 2012). But these indices have their own shortcomings in application for sustainability assessment as a whole as they are based mainly on few certain criteria and most of the index calculated on averaging method resulting deviation from the reality. It is evident from the above discussions, there is no particularly universally accepted approach of sustainability measurement, and economists, sociologists and ecologists perceive the matter from their individual viewpoints. Thus, several modifications in the sustainability assessment or index preparation are reported in literatures. In this present study too, based on previous concepts and approaches a few necessary modifications have been made to have an operational sustainability assessment methodology, which include both socio- economic and ecological perspectives.

3. Discussion and Conclusion

Indicators and composite indicators are increasingly recognized as a useful tool for policy making and public communication in conveying information on countries performance in fields such as environment, economy, society or technological development (Singh et al. 2009). The opportunity of the indicator based approach is that it can fit easily to any ongoing system. It can be context specific. Each and every driving force which is functioning at that system can be included into it. This besides, condition can be assessed by choosing specific components from that system according to the nature of the work. It is difficult to get perfect indicators and hence, their development in a general case involves methodological alterations taking care of technical feasibility, public availability to use, and systemic consistency of data (Ciegis et al, 2009). Selection of indicator can be done following some guiding principles (UNCSD, 2001; DESA, 2007) and under social, economy and environmental criteria to cover the three major node of sustainability. Indicators will be measured by the suitable parameters to get the actual condition of ongoing system.

Baseline Parameters can be categorized as those who have some standard value i.e. reference. These parameters are measured in one timeframe. These parameters may show the deviations from the standard value either negative or in positive directions. For example malnutrition can be measured in one time frame and can differ from the established standard value. However, for the baseline parameters few have no standard value for which a standard value can be set for this study on the basis of suggestions available in literatures. On the other hand Variable Parameters are those which are changing with time. These parameters may have positive or negative impacts or trends depending on their characteristics. If the parameters have negative impact or it is changing in negative way then it can be identified as the threat to the system. On the contrary if the parameters have positive impact or it is changing in positive direction it is said as the adaptive capacity. This adaptive capacity will help the system to fight back the threats. Adaptive capacity will reduce the extent of risk of the system. Resilience of system is the capability to cope with the threat and this depends on the baseline condition of the system. Risk depends on the exposure of the system to threat. The sustainability or the non- sustainability of the system depends on whether residual threat exceeds the adaptive capacity of the system or not. Now the vulnerable condition and baseline condition together will be measured to find out the sustainability status of the system. The ''indicators approach'' has acquired huge importance in the environmental and ecological economics literature (Diaz- Balteiro& Romero, 2004) as several papers have adopted this strategy (Rennings and Wiggering, 1997). However, it is also known that for sustainability of any system, all the components should be sustainable themselves. It is suggested that, in the perspective of complex problem of ecological economics the aggregation of different indicators or components into an index or assessment of sustainability of each of the components may give the measure of sustainability as a whole (Azar et al., 1996 & Common and Perrings, 1992).

4. Normalization Methods

Baseline parameters will have some optimum value. This optimum value represents a maximum value if the indicator is of the type ''more is better'' or a minimum value when the indicator is of the type ''less is better'' (Diaz- Balteiro & Romero, 2004). Baseline parameters value will show the actual condition of the system and their deviations from the standard value reflect the sustenance of the system. The main problem of aggregation of parameters value is that they may be expressed in different units. So normalization of parameters is important. Each baseline parameter value should have to normalize to integrate for Im th indicators baseline value. For integration of composite parameters, Krajnc and Galvic (2005) proposed the following formula:

Normalized value = (actual- minimum) / (max- minimum)

It is then modified by Diaz- Balteiro & Romero (2004) for "more is better" and "less is better" parameters.

For "more is better" parameters-

Normalized value = 1- {(optimum value- actual value) / (optimum value- worst value)}

For "less is better" parameters-

Normalized value = 1- {(actual value- optimum value) / (worst value – optimum value)}

Base line Parameters are normalized according to Diaz- Balteiro & Romero (2004) where normalization done separately for parameters having 'more than better' value and 'less than better' value. E.g. lesser value is better for Gini Index and higher value is better for Adult Literacy Rate.

After normalization of each baseline parameter aggregate baseline value for m^{th} indicator (I_m) will calculated.

$B_j = \sum j$ where j = 1, 2…..n baseline parameterof I_m thindicator.

Variable parameters need not to be normalized as they do not have any maximum or minimum threshold. Variable parameters will show positive and negative values, are mainly driving forces. Here positive values are considered as adaptive measures which will protect the system and negative parameters are considered as threats. Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity. The concepts of adaptation, adaptive capacity, vulnerability, resilience, exposure and sensitivity are interrelated and have wide application to global change science (Smit & Wandel, 2006). Here the positive parameters are depending on the system adaptive capacity, infrastructure development, and resilience. Threats are depending upon the exposure of the system to the threat and lack of adaptation. Now whether the systems condition is sustainable or vulnerable will depend on the aggregation of these parameters.

Variable parameters are considering the driving forces of the system while the baseline parameters are denoting the actual condition of the system. So the impact of driving forces on baseline situation will measure the system's sustainability or vulnerability. Here, this measurement will be done for each indicator. But as the three pillars of sustainability are interconnected so the parameters are also interlinked. Variable parameters being the driving force can impact on more than one indicator. So for the impact of variable parameters can be measured as -

$I_{jk} = f \mid B_j, V_k \mid$

Where, $K=k_1, k_2,\ldots\ldots\ldots\ldots k_n$ variable parameters for all indicators.

Here an interactive matrix is used to identify the impact of variables on the indicators. And variables may have positive or negative impact. So to get the total impact of variable parameters on Ith indicator summation of negative variable parameters (k-) value is subtracted from summation of positive parameters value (k+) to get the sustainability or vulnerability of variable parameters.

$V_k = \sum(k+) - \sum(k-)$

This is followed from operational index suggested by Hayati and Karami (1996) to measure agricultural sustainability trend in farm level by subtracting the total score of parameters leading to non-sustainability from the total score of parameters leading to sustainability. We consider the relative score of B_j under V_k^{th} impact. Ratio between B and V is being assessed to measure the rate of impact. Ratio is to be calculated dividing Min(B_j, V_k) by Max(B_j, V_k) to get the range of value within 0 to 1. Putting weightage to the component is very difficult as it involves complex interactions between indicators. Several weighting techniques are being used for valuation of parameters (Saaty, 2008; Brandon & Lombardi, 2011; Handfield et al., 2002). Weighting techniques can be qualitative or quantitative. Each weighting methods have their own pros and cons. Analytic Hierarchy Process (AHP) consists of hierarchy criteria with a goal, decision criteria and alternatives (Saaty, 2008). An advanced approache of AHP is Analytic Network Process. This approach allows interaction and feedback between clusters and also scaling the indicators according to priorities (Brandon & Lombardi, 2011). In this methodology weighting has been done on the basis of AHP, with a few modifications to fit in the situation and local set up. Matrix is used to calculate total interaction between indicators. Weighting of each indicator is depending on the scoring of number of interaction upon whole interaction.

	Indicator 1	**Indicator 2**	**Indicator 3**	**Indicator 4**	**Indicator n**
Indicator 1		X		X	
Indicator 2	X				X
Indicator 3	X	X			X
Indicator 4			X		X
Indicator n	X				

Table 1

From the above matrix, the number of interactions among the components can be calculated. Now, if the whole of the interactions are considered to be 1 then, each component will have a relative score varying from 0 to 1.

C_n= (total score of the nth component/ total number of linkages)

Next Weighted category score is calculated by multiplying component score and number of linkage of that indicator.

$$W_i = C_n * \text{No. of linkage}$$

Now, the weighted value of indicators is being multiplied by the I_{jk}^{th} value of each indicators.

$$IS_{jk} = W_i * I_{jk}$$

Then the sustainability can be calculated by aggregating IS_{jk} for social, economic and environmental sectors

i.e., $S = (\sum W_i * I_{jk}) / n$ **or** $(\sum IS_{SocEcoEnv})/n$, where n= no of indicators

In this study a new approach towards quantification of sustainability score has been developed, considering the driving forces and actual condition prevailing in this system. Driving forces create impactseither in positive or negative way, depending upon the adaptive capacity and exposure to threat of the system. This methodology will help to assess the resilience of the system according to the actual condition and residual risk, measured through baseline and variable parameters. Also, this methodology has the potential to calculate system sustainability or non- sustainability considering all the impacts and generate some specific quantification rather than qualitative approach as in other assessment methodologies. On the other hand this is primarily a flexible and content specific methodology, where every system can fit. Thus, this can be used as a more efficient and accurate tool for assessing the sustainability score of any system.

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