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SUSTAINABILITY IN A PROJECT: CONCEPTUALISING FOR SUSTAINABILITY INDICATORS

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Abstract

The concept in this paper builds upon basic principles of sustainability to address the problem of how a sustainable project must contribute to economic and social welfare without depleting natural resources, destroying the environment or harming human health.. With this understanding, a systems approach was used in a study that conceptualised a paradigm shift in project management system for sustainability incorporating Environmental Impact Assessment (EIA), Cause-effect Chain and the Socio-economic Resource models. Using a multi evidence research methodology of four project case studies in Tanzania, sustainability of the project was assessed at different phases of project life cycle. The paper presents a conceptual framework that integrates concepts of sustainability and project life cycle assessment to assess the sustainability of projects using indicators.

Key words: Sustainability; Indicator; Project Life cycle; Project Management

Introduction

The concept of sustainability is still evolving and is indeed the subject of continued debate, although common threads underlying the contending conceptions could be identified. Based on the concept of Sustainable Development (WCED, 1987) a number of writings have been published on what is sustainability. Some authors (Elkington, 1999; Carter, 2005; Munier, 2005 and Juafari, 2007) regard sustainability as a philosophy based on human goals and on the understanding of the long-term impact of man's activities on the environment and on other species in absolute and static term. Others think of it as a buzzword to the man in the street and highly publicised by politicians, developers, researchers and conservationists, but the least understood word in the common vocabulary, at this point of time. To many (Pronk and Haq, 1992, Howarth, 2007; Lubin and Esty, 2010; Anderies *et al.*, 2013) sustainability is simplified into environmental conservation taking a relative approach that a society must maintain "an appropriately defined stock of capital including the initial endowment of resources intact and that its consumption can be interpreted as the interest on that patrimony" as specified by Solow (1986).

The field of sustainability is thus confusing enough before one tries to understand all of the definitions, jargon, complex ideas and numerous strategies that go along with it. Simply defining sustainability can be difficult, even at which level to define it. It gets even more complicated when one considers all the dimensions required to achieve sustainability for both people and planet, namely the social, the environmental, and the economic. By the time one has mastered one element, he might have completely forgotten about another, or, perhaps, even why he started. Sustainability is thus a new research area.

To the project management discipline the principle of sustainability is a challenge. The challenge is how to integrate the environmental considerations with other project management activities at the earliest possible time to ensure that planning and decisions reflect environmental values, and avert potential conflicts with society needs.

The objective of this paper is to present the results of a study that used the concepts of sustainability to develop sustainability model based on interdisciplinary integration. Interdisciplinary integration concept as the basis for the development of the sustainability model, presupposes a holistic view, which goes beyond the project site. What happens at the project site is a reflection of what is taking place outside it. It includes concepts from economic theories of development that guide policy formulation to ecological laws that determine the eco-existence of life in nature.

Existing Project Management Approaches to Sustainability

Projects, however, small in size and complexity, have significant impacts on the environment and society. For a balanced ecosystem, a project endeavours to maintain nature's stability and hence sustainability. Sustainability in this context deals with the equilibrium in supply and demand, now and in the future (Slootweg *et el.*, 1999; Carpenter, 2008).

From literature, attempt to define sustainability in the context of project management, has proved to be quite futile – there are too many variables sprouting from the particular applications and implementations of the term. Part of what makes defining sustainability controversial is that the issue actually brings ecological problems from the realm of pure science to the everyday life of people. Defining sustainability connects abstract environmental issues (ecological dimension) with people's personal (social dimension) and commercial interests (economic dimension). As a result, sustainability becomes one of those terms, which is easier to understand, than to explain.

The attempts towards sustainability in project life cycle which includes ISO 14000 standards, provides a mechanism that links the concept of sustainable development with the project management processes. This dates back to the 1990s which saw the development of Environmental Management Systems (EMS) designed to provide a framework for organisations that were trying to incorporate environmental objectives into their decision-making. Principle 17 of the Rio Declaration on Environment and development of Agenda 21 states: *'Environmental Impact Assessment (EIA), as a national instrument shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority'*.

However, EIA is based on the condition that an environmental organisational component, in a project, must have defined processes to assess, design for, and implement environmental requirements on a real time basis as the mission of the project/facility is being performed. EIA has is also criticised for its lack of consideration of cumulative impacts, bias and lack of independence, scientific credibility and objectivity, the accuracy of their findings and predictions, and problems incurred in rationalising environmental with economical evaluations (Wright and Smith, 1992). Cost-benefit analysis and EIA remain relatively separate and unrelated processes in many jurisdictions despite the evident importance of linking them (Sadler, 1996). EIA also tends to be poorly adapted to the realities of project planning and design, in general, and to feasibility and engineering studies that define proposals, in particular. In Botswana, for example, the applications of EIA during the planning and design stage depend on individual initiatives, and very little on a planned path, when researching on sustainable construction practices (Rwelamila *et al*., 1999).

Previous attempts to operationalise the notion of sustainable development were limited to parts of cause-effect chains only, and particularly to their economic facets (Bergh van den, 1991). Shaw *et al.* (1991), for example, formulated holistic conceptual models of the socio-environmental system, which we live in. Recently a supply-demand relationship explaining the interactions taking place in the ecosystem has been advocated as a holistic approach to project impacts. The cause-effect framework focuses on improving environmental performance by taking strategies that significantly reduce environmental damage. However, the question of improving social performance is again not addressed. The framework also suggests that the various strategies should be integrated with a corporate environmental management strategy, which many construction companies may see it as a cost burden as they have had with ISO 9000 Standards (Love and Li, 1999), affecting the overall economic objectives of the companies.

The integrated cause-effect chain approach also only allows for the identification of likely biophysical changes. Field observations and detailed information on the proposed interventions are needed to determine the actual magnitude. Therefore, in order to address these issues, another conceptual model was developed, which is primarily an improved version of the resources model of the World3-model (Meadows *et al*, 1972; and 1992). World3 is used in many nations' planning and policy making. It is a tool to think about and plan for the future based on *Growth* and *Beyond the Limits*. The assumptions in the World3 model are about rates of growth and interactions between global phenomena. These fundamental assumptions gave birth to another model, the socio-economic resource model.

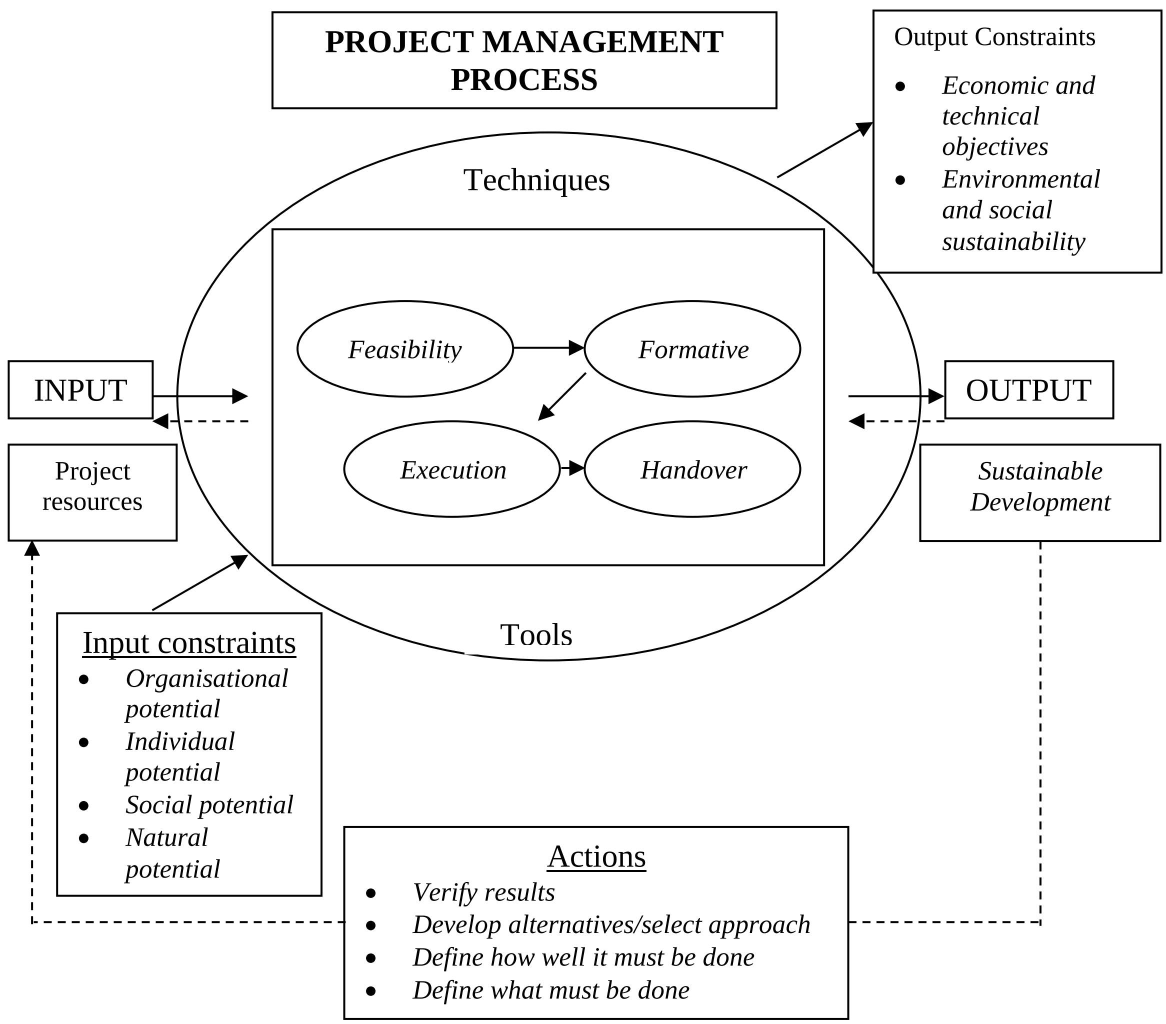
A key element in the socio-economic resource model is its integrated system dynamics perspective. The model is divided into pressure, state and impact models as a result of project development. The model was developed from the stress-response framework which was applied by Friend and Rapport (1979) to ecosystem. This framework is used by OCED, SCOPE (Scientific Committee on Problems of the Environment) and some other organisations working in the field. Although this approach is systematic and widely applied to sustainable development problems, it neglects the systematic and dynamic nature of processes, and their embedding in a larger total system containing many feedback loops (Rotmans, 1994). Representation of impact chains by isolated PSIR-chains will usually not be permissible, and will often not even be adequate approximation, because impacts in one chain can be pressures, and in another can be states and vice versa. Using these frameworks, multiple pressures and impacts are neither considered nor are the resulting nonlinear relationships between the different components of a chain accounted for.

Some project sustainability definitions have used the axiomatic approach (Griffiths, 2007; Lock, 2007; and Silvius, *et al, 2010)* and have focused on describing the conditions that a system has to comply with to achieve sustainability by way of sustainability models. The axiomatic approach is widely used in abstract sciences such as mathematics or logic and result in many productive applications, even though at first sight it may seem that it leads to cyclic definitions. Deciding about the necessary conditions for sustainability instead of defining it, may serve as a basis for building function relationships between various variables that adequately define the characteristics operationally in a way making clear the common ideas that sustainability necessary implies.

Defining Project Management Processes in Sustainability Perspective

Borrowing from current models that attempt to address project sustainability, the traditional project management framework (Figure 1), as a system, can be evaluated for sustainability as a subsystem of the total system. In the project management system, comprising of a combination of living and non-living resources and their interactions, the performed functions (project activities) in providing goods and services, which are used by each society, are recorded. At the input side of the project management system, the extent of impact to the environment, in order to produce the desired economic function, is determined based on sustainability of the natural system (project resource).

Figure 1: Traditional Project Management Process Framework for Sustainability



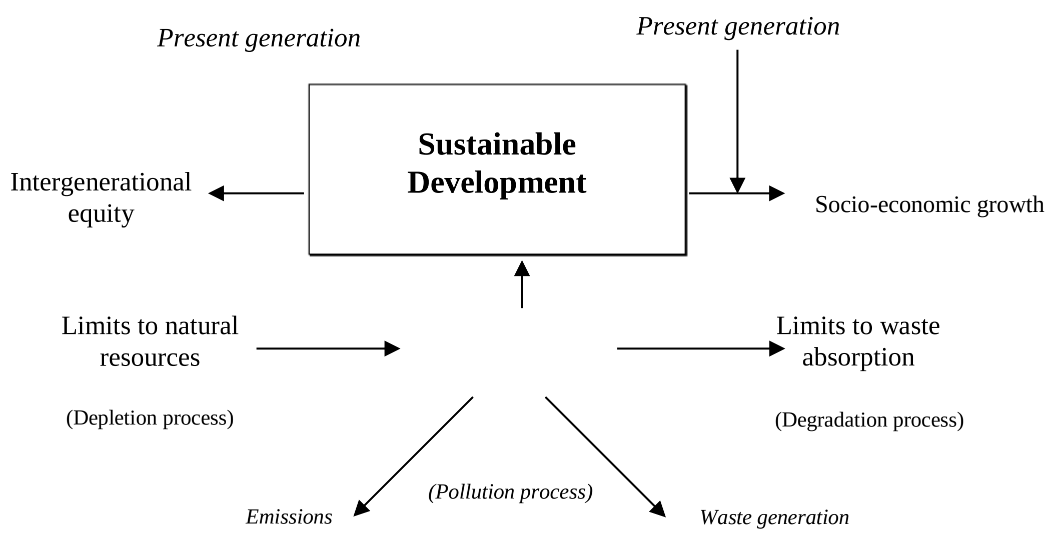
The output of the project, comprising of the economic and social values derived from the project management system, to a large extent, depends on the societal context, differing between cultures, and also differing for different groups within a society. The extent of the resulting social benefit/cost is determined based on established economic and social sustainability indicators (output constraints). There is also the regulatory environment, which addresses the institutional setting (input constraints). For every physical setting there exists institutional arrangements (authorities, legal framework, traditional laws and regulations), management practices (in construction of such as physical structures e.g. buildings, roads, etc.), policy instruments (permits, subsidies, quota, etc.), and the use of persuasion by governments or agencies in an attempt to change people's beliefs or behaviour.

Conceptualising Sustainability in Project Life Cycle

A project, in the context of this paper, is defined as a process of selection and reduction of ideas and perspective of those involved into a set of clearly defined objectives, key success criteria and evaluated risks and environmental interfaces. A project is initiated for various reasons, which include, but not limited, to solving human being socio-economic problems (development issues) such as taking up an economic or business opportunity or requirements. The central theme of all this is that management generally must make a decision about how to respond. The end result (objective) must be sustainable development or simply improving the quality of life within environmental limits.

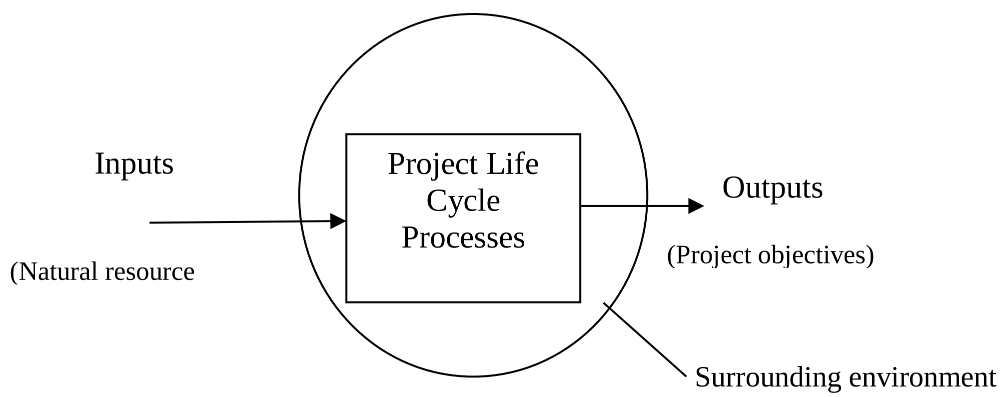
This requires defining some project development criteria, and in each and every decision, an option that tends toward sustainability. It also requires that the project idea to be Attainable, Timely, Relevant and Important (ATRI). Developing a project idea helps to identify the best project management processes to address the issue, and attract relevance. The assumption here is that achieving this goal depends on society fundamentally changing their project management practices, by moving from overuse of natural resources' system and unchecked disposal of waste, which have significant negative socio-environmental impacts, toward a more benign "cradle-to-cradle stewardship" system (Figure 2).

Figure 2: Conceptualising Sustainability in Project Development



Using the system approach, a project can be evaluated from the context of its environment, which would affect the project processes. A process (Figure 2), in the context of this article, is a series of activities on inputs bringing about an output(s) and has been defined as a time-dependent relation, changing the state of a system (Ackoff, 1971). The implication as represented in Figure 3 is that the success of the project is dependent much on the threshold of the surrounding environment i.e. to measure project performance one has to look at the resources, budget, methods and tools supporting the project.

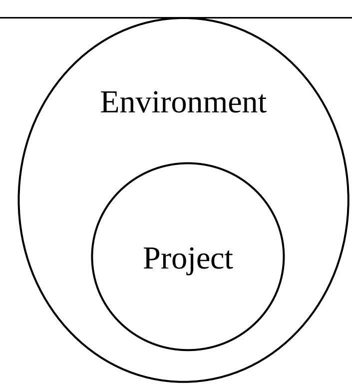
Figure 3: Conceptual System of Project Process



Therefore, to achieve sustainable development, the project's surrounding environment should form the basis for selecting tools and techniques of project management. We need therefore to consider a fundamental link of project management system as an integral part of the surrounding environment (Labuschangne and Bent, 2006). This can be depicted in the simple yet powerful scheme of the 'egg of sustainability" (Figure 4).

Figure 4: Egg of Sustainability

A project is an integral part of the surrounding environment like the yolk of an egg within the white. A project can only be sustainable if and only if it is developed in a surrounding environment whose conditions are good or improving i.e. sustainable.



Source: Modified from Hardi and Zdan, 1997

This fundamental link, however, gives rise to constant conflicts, which exist between the needs of the project, on one hand, and surrounding system on the other. These conflicts, which are basically constraints to project management, must be addressed for developing environmental sustainability indicators for decision making. A fundamental principle is that project primary objectives, which are cost, time and quality are part of and linked to the diversity, productivity and quality of the ecosystem, throughout the life cycle of the project. The project lifecycle, therefore, need to be planned and managed in consideration of internal and external constraints, as represented in Figure 3.

Within the project management system, processes are taking place that are externally influenced by other total systems components. The total systems components comprise of the natural system, human system and the supporting system. The natural system provides sustainability conditions for project inputs, defined by the 1st ecological law – limits to natural resource (renewable and non-renewable). The human system sets out sustainability conditions for a sustainable human development as defined by the 2nd ecological – limits to waste absorption which is associated with the sustainability of the ecosystem and consequently the human health and socio-economic development. Above all is the support system, which sets out conditions for proper functioning of the other two systems (natural and human systems) through policies, regulations, standards and practices. Essentially sustainability of projects entails the integrated project management systems functioning as a component of the total system.

Under these interrelationships, based on the total systems theory, the viability and performance of the project management system must be contained in the states (stocks of the natural system) and the rates of change (flows) taking place in the other three systems. By a viable system it is meant that the system in question is able to survive, be healthy and develop in its particular system environment. To achieve environmental sustainability project life cycle has to reflect both the requirements of project management processes and their properties on one hand, and with the properties of the other systems on the other.

Developing Environmental Sustainability Indicators

Methodological issues

With the view of integrating sustainable development dimensions into project management processes, emphasis is placed on issues of environmental sustainability. Using a systems approach and as conceptualised above, the following conditions must be fulfilled:

(a) The system does not cause harm to other systems, both in space and time;
(b) Within the system life-support ecological components are maintained at levels of current conditions, or better; and
(c) The system maintains living standards at a level that does not cause physical discomfort or social discontent to the human component.

The first condition presupposes an evaluation of the kind of project management system in place to oversee the fulfilment of a management action which primarily is a moral issue (reflected in the organisation's behaviour and practice) that leads to studies of intergenerational equity and justice (Glasser *et al.*, 1994; Agyeman, 2002; Agyeman *et al*., 2003; Grosseries, 2008; Smith *et al.*, 2013; and Summers and Smith, 2014). Spatially the systems have more obvious bi-directional feedbacks and respond to mismanagement in quite remote locations.

The second condition for sustainability is for the biotic, ecological component of the system. It is important to identify the signals of the ecosystem that would communicate its 'content' or "comfort" for the given state of the ecosystem. On the one hand the current conditions of the system are an important factor in deciding whether the system should be sustained or not. On the other hand the property of the system sustainability depends upon the current conditions of the system. In this sustainability condition, the basis of the score is on the impacts of current operational practices on the environment. The scores can be derived using the intensively developed concept of ecosystem health (Constanza *et al.*, 1992). The ecosystem health notion was used to identify system sustainability.

The third sustainability condition parallels to the second in that if the system is to be sustained, the living conditions in the project site must continuously suit the people living there. If it ceases to suit the community it results in social tension that eventually reorganises the social and economic components of the system. The condition to sustain human life within the project primary objectives, should not occur in the form of gradual depopulation (emigration or die-off), or sharp conflicts that would provide changes both population numbers and system structure. In any case, if the system changes to its initial design, it fails the sustainability test. Important is the mode of change. In sustainable systems the change takes place as a result of actions accepted by the society and not causing conflict (discomfort and discontent). The same events occurring against the societal choice make the system unsustainable.

Sustainability indicator conceptual framework

To ensure effective integration, and therefore to improve project management process and bring about environmental and social sustainability while maintaining the projects primary economic objective, it was necessary to determine the key sustainability indicators. Indicators are taken as representative of pressure, state or the effect on a system, for project management. Here, an indicator ideally is a means devised to reduce a large quantity of data to its simplest form, retaining essential meaning for the questions that are being asked of the data (Otto, 1978). Despite the apparent vagueness of the term, indicators have been widely used for monitoring and assessment of numerous environmental impacts of operations, and are increasingly used in social and economic arenas (UNCED, 1992; OECD, 1993; Hardi, 1997; Basel, 1999). In the study, an indicator was defined as a characteristic of the status and dynamic behaviour of the system under concern. From the systems-based definition of an indicator, it follows that an indicator is a one-dimensional systems description, which may consist of a single variable (absolute indicator) or a set of variables (relative indicator). In general, indicators describe complex phenomena in a quantitative way by simplifying them in such a way that communication is possible with specific target groups.

The question was to determine the quantitative, spatially explicit and dynamic linkages between project activities and the ecosystem sustainability. Sustainability indicators that meet sustainability requirements must fulfil the three systems conditions at the same time integrating the dimensions of sustainable development. To address this question, the analysis was built on the sustainable development requirements based on projected/determined changes to the following five broad requirements of sustainability below, derived from company's vision, business objectives and strategies:

i) Integration of conservation and development;
ii) Satisfaction of basic human needs;
iii) Achievement of equity and social justice;

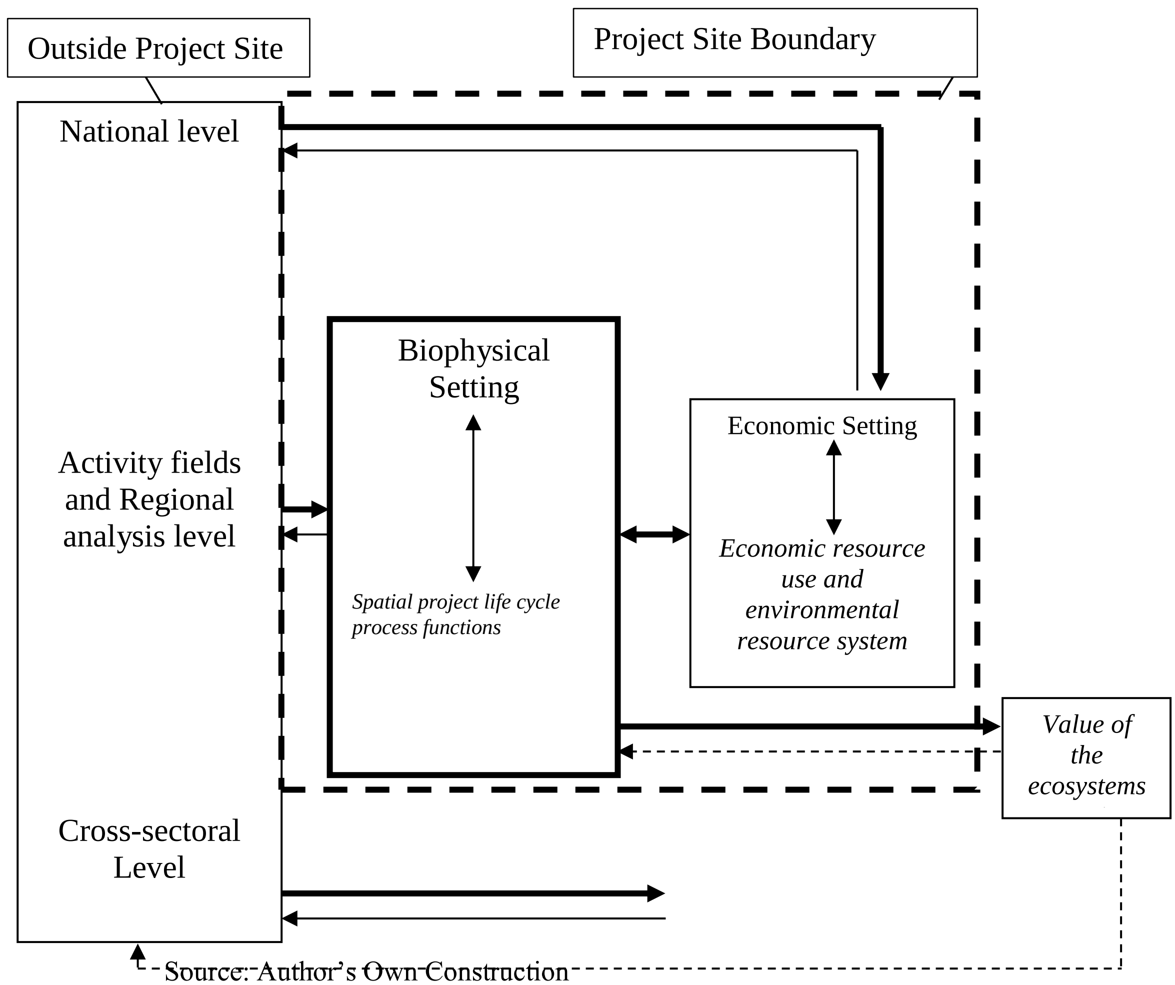
iv) Provision of social self-determination and cultural diversity; and
v) Maintenance of ecological integrity.

Each of these criteria was considered as a goal in itself and a condition for achieving the others, thus underlining the interdependence of the different dimensions of sustainability and the need for an integrated, interdisciplinary approach to achieve sustainable development.
This approach proved to be complex and difficult to assemble all the indicators that form the backbone of the sustainability model, along with its requisite calibration data sets and scenario analyses. Hence several features were added to the data collected to develop the sustainability functional relationship that made the sustainability model much more effective as both a scientific and a management tool. Specific indicators, which were considered important, leading to sustainability, were derived from analysis of data generated from economic objectives of the project or organisation in relation to the levels of natural resource use and their effects to achieving the project's functional performance. This necessitated the establishment of the quantitative effects of various combinations of natural and project stressors on economic objectives (spelled out in the company's vision) and how these effects do change with time.

Research protocols

The ecosystem functions and parameters were assumed to be dictated by the project sustainability rules including resource use, production efficiency factors (low levels of emissions and waste generation) and management actions towards maintenance of a balanced ecosystem. The study was therefore set out to test the sustainability characteristics at various phases of the project within the national economic, social and political systems in Tanzania using four case studies namely Songo Songo Gas Project, Lower Kihansi Hydropower Project (LKHP), Tanga Cement Manufacturing Company and Kibo Match Manufacturing Company. While Songo Songo Gas Project, at the time of the study, was still in construction phase during 1998-2001, LKHP had just been commissioned. Both Kibo Match and Tanga Cement were already in operation. In order to collect the necessary data that defines the problem, inquiry of sustainability issues into practice, at project site, was broken into three stages of the research process.
The first stage involved sustainability analysis external to the project which was done using two scenarios: outside the project site at different institutional levels where policies, regulations and standards are set and decision-making takes place; and at the project site for internal factors. Outside the project site the institutional levels analysed were: the national level; activity fields and regional analysis level; and cross-sectoral level. Outside project site scenario is represented by the box on the left side of Figure 5. The goal was to create a reference level for the analyses relating to project sites and regions, and also to integrate these analyses.
The second stage was analysis of project sustainability at the project site. The project site area of study in Figure 5 is represented by the central box with thick dotted lines. The study variables were derived from the italicised information. The objective in considering the individual project sites was to identify and analyse existing sustainability deficits using the indicators identified at national level, supplemented by indicators specific to the project site, as from existing practices. Subsequently, project site-specific goals were formulated, taking into account the goals proposed for the national level.

Figure 5: The Research Process Adopted for This Study



Source: Author's Own Construction

Against this background, the third stage was to evaluate the specific potentials for efficiency, consistency and sufficiency and investigate various options for mitigation measures and instruments in terms of their effectiveness for reaching the goals and the conditions for implementation. Ultimately, this yielded project site-specific sub-strategies, which were analysed for their interaction with other project sites environmental requirements and integrated into an overall strategy, again at national level. Moreover, the intention was to carry out exemplary investigations into specific aspects (opportunities, limits, requirements, conflicts of use etc.) of implementing the project at regional level.

Results and Findings

The first sustainability factor which was analysed was the integration factor. The sustainability integration factor explains variability of project sustainability from the company's vision, business objectives and strategies in the project life cycle to meet stakeholders' needs and expectations defined by the dimensions of sustainable development. Each case study was tested in reference to the level of integrating sustainable development requirements (economic, environmental and social) into project development. The test was

done based on the 5 key sustainability indicators that form a linkage between project stakeholders' needs and demands to project sustainability requirements. The data revealed a consistency in the overall level of integration for each case study. The higher the score meant that the dimensions of sustainable development are ideally integrated in project development (Figure 6)
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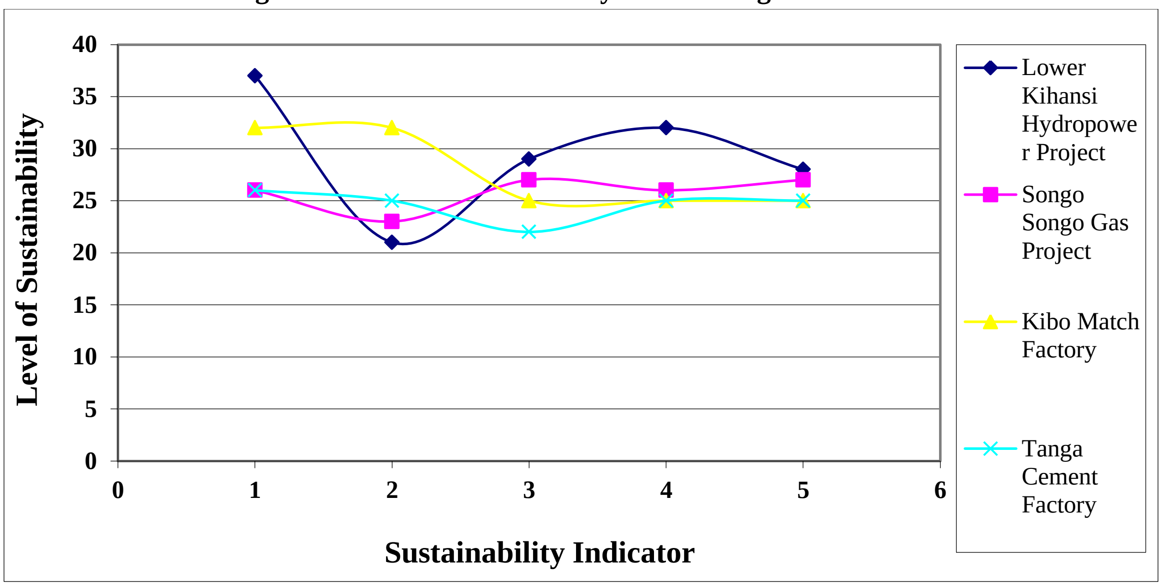
Figure 6: Level of Sustainability for the Integration Factor



The results presented in Figure 6 does not answer the hypothesis that integrating dimensions of sustainable development into the project life cycle can improve project management process to bring about environmental sustainability while maintaining the projects primary economic objective. Hence, several features were added to the data collected to develop the sustainability functional relationship that can make sustainability model much more effective as both a scientific and a management tool. Specific indicators, which were considered important, leading to sustainability, were derived from project/organisation economic objectives in relation to the levels of natural resource use and the resulting socio-economic situation (of value to the society).

The dependent variables for determining the project integration sustainability factor were correlated, using the bivariate Kendall's correlations, to establish their relationship (Table 1) at 0.05 and 0.01 significant levels. The results in Table 1 show that the correlation is significant between satisfactions of basic human needs with provision of social self-determination; between cultural diversity with maintenance of ecological integrity; between achievements of equity with social justice; between social responsibilities with provision of social self-determination; and between cultural diversity with maintenance of ecological integrity, at 0.05 significant levels. The correlation also indicates that a significant relationship exists between maintenance of ecological integrity with provision of social self-determination and cultural diversity at 0.01 significant levels. The implication here is that project sustainability is dependent on satisfaction of human needs and ecological integrity. However, the satisfaction of human needs is highly influenced by the social factors (self-determination and cultural diversity). At the same time the social aspects influence the ecological integrity. This means that developing a project without regard to these factors would negatively influence its sustainability.

Table 1: Nonparametric Kendall's Correlations of Project Sustainability Indicators outside the Project Boundary

Variable		Integration of conservation and development	Satisfaction of basic human needs	Achievement of equity, social justice and social responsibility	Provision of social self-determination and cultural diversity	Maintenance of ecological integrity
Integration of conservation and development	Correlation Coefficient	1.000	-.183	.548	.400	.400
	Sig. (1-tailed)		.359	.139	.222	.222
Satisfaction of basic human needs	Correlation Coefficient	-.183	1.000	-.667	-.913	-.913
	Sig. (1-tailed)	.359		.087	.035	.035
Achievement of equity, social justice and social responsibility	Correlation Coefficient	.548	-.667	1.000	.913	.913
	Sig. (1-tailed)	.139	.087		.035	.035
Provision of social self-determination and cultural diversity	Correlation Coefficient	.400	-.913	.913	1.000	1.000
	Sig. (1-tailed)	.222	.035	.035		
Maintenance of ecological integrity	Correlation Coefficient	.400	-.913	.913	1.000	1.000
	Sig. (1-tailed)	.222	.035	.035		

It was further necessary to determine the useful ways to measure changes in the total value of resources at a project site including both marketed and non-marketed (provided by the natural and social systems) components and determine the effective alternative management approaches (strategies, policy options and practices) towards increasing this value. In other words understanding how the social system and ecosystem function and how they are affected by human activity (driven by economic objectives), for example, it is possible to determine human uses and human interventions affects the ecosystems, and how these are affected, among other things, by the ecosystem's characteristics and regulatory paradigms.

Furthermore, the study determined methods that can be used to measure the values of the services provided by the ecosystem to society or methods for improving ecosystem valuation that are required to produce a given economic value. Based on these set of study issues a number of statistical method were employed to analyse data related to project sustainability within the project boundary i.e. whether the project management activities were planned and executed in consideration to environmental sustainability indicators. In the study the issue was addressed by determining the environmental significance impact factor.

In deriving the environmental significance impact factor, use was made of a combination of EIA and ASSIPAC sustainability assessment study, within the project site. A combination of interviews, questionnaires and direct observation, including data sample testing and analysis were employed. Three sets of data matrix were tabulate based on severity of impact, frequency of occurrence and control measure put in place. The weighting factor for the severity of the impact from each activity and frequency of occurrence was taken as the sum of the average of the respondents' judgements and the average of the respondents' judgements. The respondent's judgement was weighted to the available international/national/local standards, which provide a basis for the criticality of the impact. A summary of the collected and interpreted data is presented in Table 2.

Table 2: Environmental Sustainability Factor

Significance Impact Indicator	***Case Study***			
	LKHP	***Songo Songo***	***Kibo Match***	***Tanga Cement***
Resource use R_u	10	9	7	4
Ecological limits, W_a	10	15	13	7
Regulatory limits and standards, company image or social acceptability L_e	32	16	28	14
Environmental Sustainability Factor, $\boldsymbol{N_c}$	**17**	**13**	**16**	**8**

In general terms, from Table 2 Kibo Match operations and LKHP activities were found to be environmentally better than the other two. As for LKHP, the high level of environmental sustainability explained the fact that many mitigation measures and recommendations were made in favour of the development of the project in Kihansi area as per recommendations from EIA findings. The EIA activities included a review of project and institutional setting, review of pre-project situation and establishment of baseline conditions, identification of significant project impacts, impact significance, mitigation and compensation possibilities and formulation of recommendations for mitigation measures. These included public health, protection of the Kihansi catchments, biodiversity issues and social-economic aspects. In the context of the study the concern was sustainability practices by Kihansi management in ensuring that mitigation measures are being taken to ensure lasting power generation within the limits of the ecosystem and sustenance of human life within and around the project site.

Songo Songo Gas Project scored low due to the fact that gas exploration, as a new investment venture in the country, was not well known for the project stakeholders to be able to determine the impacts of various factors. The low environmental sustainability factor value of Tanga Cement Company is explained by the fact that cement-manufacturing process is associated with significant environmental factors. The fact that the company is certified to ISO 14001 specifications in cement production, has made the company manage to put in place an environmental management system that is changing the operation to an appreciable level of sustainability, than had it not.

The results presented in Table 2 were then statistically tested to determine if there was any relationship (causal or correlational) between sustainability indicators. The correlation of these parameters was done using a One Way ANOVA (Table 3) by the Pearson correlation. The Pearson Correlation was preferred here because the correlation coefficient, as a measure of linear association, would provide an indication to the significance of environmental regulations/standards in project development. The assumption suggests a unique requirement for addressing environmental sustainability issues at various stages of a project, which need to be integrated in the management processes.

Table 3: One Way ANOVA Correlation

Type	***Resource use***	***Ecological limits***	***Environmental regulations/standards***
Pearson Correlation	.811	.507	.904
Sig. (2-tailed)	.189	.493	.096

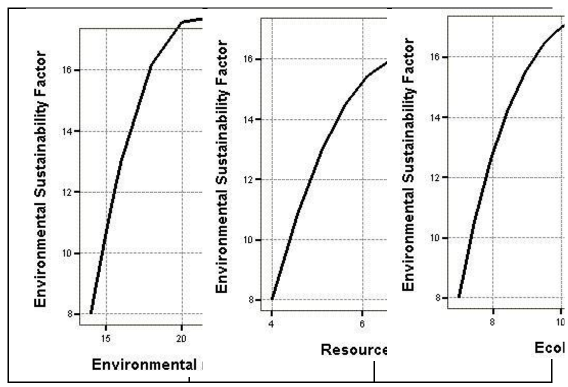
The results (Table 3) suggests that the ecosystem's functions and parameters are dictated by human activities and include resource use, production efficiency factors (e.g. low levels of emissions and waste generation) and management actions towards maintenance of a balanced ecosystem. This condition can be described in terms of limits to resource use, pollution and waste absorption, and regulations/ environmental standards that protect biodiversity and productivity systems.

The analysis above indicates that in order to achieve economic objectives project sustainability depends on its environmental performance simplified as follows: $N_c = f(R_u, W_a, L_e)$

Where: N_c = Environmental Sustainability Factor
R_u = Resource use (production efficiency)
W_a = Levels of emissions and waste production
L_e = Conformance to limits spelled out by environmental legislation, regulations or standards

The mathematical formula was tested and the resulting empirical evidence is graphically presented in Figure 7.

Figure 7: Relationship between Environmental Sustainability factors



The relationships represented in Figure 7 suggest that the biological diversity and productivity of natural systems depend on environmental regulations and standards for protection and their effectiveness contributes to high environmental sustainability. A sinusoidal relationship reflects the complex nature of natural resources influenced by depletion rate and renewable rate. Also a normal distribution relationship proves existence of different limits to: dispersion, absorption, and recycling levels specific to a project site. However, to measure project sustainability or closely related issues focus should not on a single indicator. Sustainability includes social aspects and the supportive system, the institutional structures and processes.

Conclusion

In the study it was established that for a balanced ecosystem, a project should endeavour to maintain nature's stability and hence sustainability. Interdisciplinary integration, the basis for the development of the sustainability model presupposes a holistic view, which goes beyond the project site. What happens at the project site is a reflection of what is taking place outside it, which includes economic theories of development, that guide policy formulation, and ecological laws that determine the eco-existence of life in nature. The research findings and cross synthesis of the results conclusively indicate that:

- The manner in which ecosystem sustainability conditions have to be integrated into the project life cycle depends on the kind of environmental and socio-cultural values requirements and patterns as well as a combination of these. The interdisciplinary integration can be accomplished by deriving the relationship between the factors that influence the level of project sustainability.
- To ensure effective integration, and therefore to improve project life cycle and bring about environmental sustainability while maintaining the projects primary economic objective, it is necessary to determine the key sustainability indicators. These are resource use efficiency, levels of emissions and waste production and conformance to limits spelled out by environmental legislation, regulations or standards. The mechanism that should be developed at each individual project site and specific to the project and organisation can be determined using the environmental sustainability factor formula.
- 'Sustainability' as a concept of 'project management' offers potential benefits and uses in project development as follows:

  – Provision of key information related to project development and monitoring of the effects of project development decisions;
  – Highlight of strength and weaknesses of project management system and support for project implementation;
  – Assistance in assessing investment priorities, project selection and follow up; and
  – Provision of an appropriate framework for identifying the main asymmetries between different projects and locations.

- The level of sustainability would be dictated by technology used to achieve the primary project/production objectives, management style (environmental and social responsibility) and commitment of the project team/workforce.

The findings of this study suggest a notion of a common socio-ecological system for analysis. In order to achieve the sustainable dynamics, the desirable behaviour produced by the social values system has to be matched with what is possible on the ecological part. There are always certain limits to the adaptability of the ecological component and it should not be overstrained. In a certain way this can be considered as a dynamic stability, which can be achieved by both managing the ecological subsystem and moulding the social goals in an adaptive way.

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