A FRAMEWORK FOR ENVIRONMENTAL RATING SCHEMES FOR INFRASTRUCTURE PROJECTS

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ABSTRACT

Infrastructure plays a vital role in a country's socioeconomic development and there is a growing demand for infrastructure in developing countries. However, infrastructure development impacts the natural environment significantly. Therefore, it is important to consider the environmental sustainability of infrastructure projects. In the built environment sector, Environmental Rating Schemes (ERS) play an important role in evaluating and encouraging the implementation of sustainability at the project level. While ERSs have gained widespread attention worldwide, less attention has been paid to infrastructure, and it has tended to focus on the building sector. Furthermore, no ERSs for infrastructure are found in developing countries so far. It is important for an ERS to be type-specific and many building rating schemes have considered this. However, no type-specific ERS for infrastructure has been published so far. Moreover, the existing ERSs have been criticized for the absence of any theoretical bases. To address these gaps, this study aims to propose a theoretical framework for infrastructure ERSs in developing countries. The literature on environmental sustainability was reviewed to identify the important aspects which should be applied at the project level to achieve environmental sustainability in those countries. The factors were analyzed using Analytic Hierarchy Process (AHP). Results show the highest importance for minimising impacts of waste disposal and non-renewable energy sources followed by avoiding corruption. The study provides a theoretical basis for developing ERSs for infrastructure projects and a path for developing sector-specific ERSs.

Keywords: *Developing Countries; Environmental Rating Schemes (ERSs); Infrastructure Projects.*

1. INTRODUCTION

Infrastructure projects play a vital role in the economic and social development of a country. Urbanization and implementation of the country's development plans lead to growing demand for infrastructure. Organisation for Economic Co-operation and Development (OECD, 2006) reported that nearly half of the international financial institutions' lending to developing countries goes to infrastructure and it is likely to rise from the current $700 billion a year to $1 trillion a year by 2030.

However, there is also a dark side of infrastructure development. Such projects normally spread over wide geographical areas, utilize a large volume of natural resources, take a long time to construct (OECD, 2006) and significantly impact the natural environment. With the increasing demand for infrastructure, more attention should be paid to reduce the adverse environmental impacts of infrastructure development.

In achieving Environmental Sustainability (ES) in the built environment, environmental assessment methods play an important role by evaluating and measuring the environmental performance of projects. Crawley and Aho (1999) categorized these environmental assessment methods under Life-Cycle Assessment methods (LCA), Environmental Impact Assessments (EIA) and Environmental Rating Schemes (ERS**)** such as Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED). LCA methods consider buildings as products and assess life cycle impacts and are known as non-site specific assessments. EIA methods consider broad environmental impacts (Crawley and Aho, 1999).

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Among these assessment methods, ERSs have gained widespread attention since the launch of BREEAM in the United Kingdom in 1990. These schemes have been applied extensively in the construction industry. For example, BREEAM schemes have certified 15,000 projects since 1990 and the Building Construction Authority's (BCA) Green Mark schemes have certified 1180 building projects in Singapore since 2009. ERSs have gained wide attention in the developing countries as well. For example, in India, GRIHA has been used to certify 290 projects since 2008 and Green Building Index in Malaysia has been applied to certify over 26 million square feet of buildings since 2009. In Sri Lanka, the first green building rating scheme was launched in 2011. Some of these rating schemes have been specified and recognized by public agencies and by banking, financial and insurance companies as well (Cole, 2005). For example, some versions of the BCA Green Mark in Singapore are mandatory. If used effectively, ERSs can play an important role in evaluating and encouraging the implementation of sustainability principles at the project level.

2. KNOWLEDGE GAP AND RESEARCH PROBLEM

Not much attention has been paid to ERSs for infrastructure projects as they have tended to focus on buildings (Wong, 2010). There are many ERSs for assessing buildings in both developed and developing countries, but only a few of infrastructure ERSs have been published worldwide so far. These are: Civil Engineering Environmental Quality Assessment and Awards Scheme (CEEQUAL) in the United Kingdom (2003), the Building and Construction Authority (BCA) Green Mark for Infrastructure in Singapore (2009), Zofnass Rating System for Sustainable Infrastructure housed at Harvard University's Graduate School of Design (2011) and Australian Green Infrastructure Council rating system (2012).

CEEQUAL is specific to the United Kingdom and Ireland and the BCA Green Mark has been developed for application in the Singaporean context. All these countries have specified environmental standards and involved different contexts when compared with developing countries. An international version of CEEQUAL has been launched recently. However, no single infrastructure ERS is found in developing countries so far.

Moreover, many ERSs for assessing building projects have considered different types of buildings separately such as residential, commercial and so on. Also, project scale (Abdalla *et al*., 2011) and project type (Haapio and Viitaniemi, 2008) have been identified as important factors in categorizing assessment tools because different types of projects cause different environmental impacts. However, the published infrastructure ERSs are general to all types, and no type-specific infrastructure ERS has been published so far. This is a critical gap as, again, different types of infrastructure cause significantly different environmental impacts.

Despite the popularity gained and the wide application of existing ERSs in the built environment, these are not without criticisms. These include lack of overall transparency (Inbuilt, 2010 cited by Alyami and Rezgui, 2012), failure to cover some important criteria (Haapio and Viitaniemi, 2008; Abdalla *et al*., 2011) and lack of a clear path towards establishing type-specific and regional ERSs (Alyami and Rezgui, 2012). Also, no theoretical base has been established for ERSs in general (Cole, 1998; Retzlaff, 2009). Thus, in this area, theory lags behind practice. Crawley and Aho (1999) identified methodological transparency as an important requirement in developing ERSs, from both a philosophical and a practical point of view. However, previous studies have followed a process of listing sustainability criteria and sub-criteria under broad categories and ranking them with expert evaluation. Evaluating the project's impact on the natural environment (Crawley and Aho, 1999) is a primary objective of environmental assessment schemes. ERSs reward efforts to minimise such impacts and in some instances the efforts to enhance the natural environment as well. Therefore, the basis of ERSs should demonstrate the potential impacts of development activities on the natural environment. However, such a basis for ERSs has not been established so far.

3. AIM AND OBJECTIVES

The above review of works on ERSs and related studies shows that studies relating to infrastructure ERSs are lacking. Moreover, the absence of a theoretical base for the selection of the assessment criteria in these ERSs, and the weighting system is a cause of many shortcomings of existing ERSs. Motivated by these gaps, the research question addressed in the study was, “How can the criteria and weights in ERSs for infrastructure projects in Sri Lanka be determined?”

Following the research question, the aim of this study is to develop a framework as the basis for determining criteria and weighing of ERSs for infrastructure projects in Sri Lanka. The specific objectives of the study are to:

- identify the important factors for assessing environmental sustainability (ES) of infrastructure projects,
- propose a theoretical framework for ERSs in infrastructure sector, and
- make recommendations for further applications of the framework.

4. SCOPE OF THE STUDY

This study was carried out in Sri Lanka which was the geographical territory selected to represent developing countries with rapidly increasing demand for infrastructure development.

5. METHOD OF THE STUDY

The literature on Sustainable Development (SD) was reviewed to identify the relevant aspects which should be applied at the project level. This review directed attention towards Environmental Sustainability (ES) and the importance of the natural environmental for everything else to be sustained. Therefore, the literature on Environmental Economics was reviewed to identify the interactions between the economic system and ecological systems which are the root causes of environmental issues and should be considered in assessing the environmental performance of development activities, and hence of infrastructure projects as well. Other aspects that should be considered to ensure ES efforts with particular reference to developing countries which otherwise would be barriers to such efforts were also reviewed.

These identified factors were adopted as the factors to be considered in assessing the environmental performance of infrastructure projects in Sri Lanka. A cross-sectional survey was carried out using questionnaires, to measure the importance of the factors. A pair-wise comparison was employed and data were analyzed using the Analytic Hierarchy Process (AHP).

6. LITERATURE REVIEW

6.1. SUSTAINABLE DEVELOPMENT (SD)

SD is often presented as comprising three sectors; economic, environmental and social and often presented as shown in Figure 1.a. Giddings *et al*. (2002) pointed out several weaknesses of this ring model which shows three rings in a symmetrical interconnection that leads one to assume that the three sectors are separate or even autonomous from each other. Furthermore, Giddings *et al*. (2002) claimed that the model shows possible trade-offs that can be made among the three sectors, similar to that of the concept of “weak sustainability” which assumes that man-made capital can be used to replace or substituted for natural resources and systems (Neumayer, 1999 cited in Giddings *et al*., 2002; Daly, 1994) which is far beyond the reality within real physical environmental limits.

In reality, the economic system depends on society and the environment and ultimately both the economic system and society depend on the natural environment. The natural environment is the core of any economy, and economies cannot be sustained without environmental goods and services.

Therefore, ES is a necessary condition for economic sustainability (Thampapillai, 2002). Thus, the separation in the ring model underplays the fundamental connections between the economy, society and the environment (Giddings *et al*., 2002) and it is suggested that the nested model (Figure 1.b.) represents the reality of the relationships between three sectors better than the ring model (Giddings *et al*., 2002).It has been realized today that the term "economic" does not just mean the happenings in the flow of money but also changes in human well-being which comprise not only monetary wealth but also many other services provided by the natural environment. Therefore, effective sustainability approaches need to address the relationships between ecosystems and economic systems (Jansson *et al*., 1994).

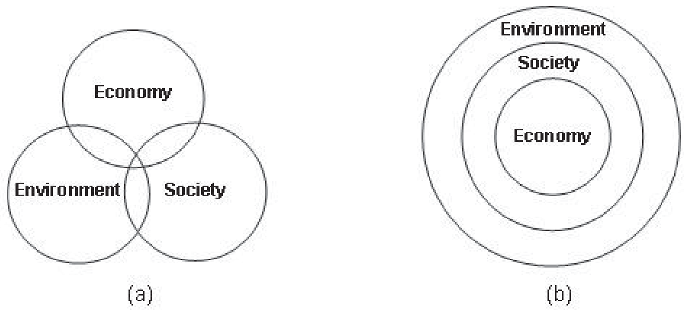


Figure 1: Ring model and Nested model (Giddings *et al*., 2002)

This fact should be considered in environmental assessments and ERSs should include the factors to address these interactions. Therefore, the literature on the interactions between the ecological system and the economic system was reviewed and will be presented in the next section.

6.2. INTERACTIONS BETWEEN NATURAL ENVIRONMENT AND ECONOMIC SYSTEM

The major interactions between the economic system and the natural environment are discussed to establish the requirements for ES for the proposed model. Such interactions identified by several authors in the field of Environmental Economics are summarized in the Table 1.Since the concern of this study is to propose changes to the current patterns of economic activities to achieve ES, the interactions are listed from the perspective of impacts of the economic system to the natural environment whether positive or negative.

These major interactions which provide the basis of the theoretical framework for the assessment of ES of infrastructure projects will review below.

6.2.1. USE ENVIRONMENT AS A SOURCE OF LAND

Although land could be considered as a unique resource that it is perfectly inelastic in supply and available to society as a fixed total quantity (Hanley *et al*., 2001), with the rapidly growing development activities, there is a greater concern about changing land quality (FAO, 1997). The way land is used highly affects the future availability of productive land in terms of both quantity and quality. Therefore, minimising land use in terms of area and considering the composition of the land (whether it is a greenery area, wetland, marshy land and so on) are important for environmental sustainability and therefore, considered in the theoretical framework in this study.

6.2.2. USE ENVIRONMENT AS A SOURCE OF MATERIALS AND ENERGY SOURCES

The environment provides inputs to the economic system; raw materials and energy resources (Hanley *et al*., 2001) for both production and direct consumption (Common and Stagl, 2005; Asafu-Adjaye, 2005). The earth is considered as a closed system in terms of materials and receives a limited amount of outside energy (solar energy) within a certain period. Therefore, natural resources are considered as scarce resources and with growing developmental activities they become scarcer. At the same time, materials extraction causes damages to the environment. For example, quarries developed in national parks will damage the biodiversity and amenity flow (Hanley *et al*., 2001) rather than one in a brown-field area. Logging in a rainforest largely impacts biodiversity compared to a logging in a planted forest. It might involve the extraction of the same amount of materials by quantity but cause different harms. Similarly, the type of materials should be considered whether harmful or not. Hazardous materials cause larger damages to the environment than compared to a same amount of non-hazardous materials.

These aspects are applicable to non-renewable energy sources as well. Therefore minimizing the usage of materials and non-renewable energy resources by quantity, damages during extraction and during selection are considered as major requirements for ES in the theoretical framework in this study.

Table 1: Summary of Literature Review of Economic - Ecosystem Interactions

Interactions	Sources
1. Use the environment as a source of land	Pearce and Turner (1990); de Groot (1992); Turner *et al*. (1994);
2. Use the environment as a source of materials and energy resources	Pearce and Turner (1990); de Groot (1992); Daly (1994); Turner *et al*. (1994); van den Bergh (1996); Lovins *et al*. (1999); Hanley *et al*. (2001); Thampapillai (2002); Common and Stagl (2005); Asafu-Adjaye (2005)
3. Use the environment as a sink for disposing of waste	Pearce and Turner (1990); de Groot (1992); Daly (1994); Turner *et al*. (1994); van den Bergh (1996); Lovins *et al*. (1999); Hanley *et al*. (2001); Thampapillai (2002); Common and Stagl (2005); Asafu-Adjaye (2005)
4. Use the environment as a flow of amenities and life support services	de Groot (1992); Turner *et al*. (1994); Hanley *et al*. (2001); Thampapillai (2002); Common and Stagl (2005); Asafu-Adjaye (2005)
5. Invest in natural capital	de Groot (1992); Daly (1994); Lovins *et al*. (1999); Thampapillai (2002)
6. Conserve biodiversity	Hanley *et al*. (2001)

6.2.3. USE ENVIRONMENT AS A SINK FOR DISPOSING OF WASTE

The natural environment provides materials and energy sources for both production and consumption. In production processes, useful products are made and residuals are also generated. When these residuals are not inserted again into the economic system by reusing or recycling, they become waste (Common and Stagl, 2005). Similarly, useful products become waste after consumption. Waste cannot be destroyed in an absolute sense and also not possible to recycle all waste as explained in Environmental Economics theories according to the first and second laws of thermodynamics respectively. Hence, eventually be discharged into the environment (Turner *et al*., 1994; Thampapillai, 2002). When the disposal of the waste is continuous, intense, and exceed the "assimilative capacity" (the capacity that the natural environment is able to handle waste) (Thampapillai, 2002), then it is no longer able to fulfil its functions as a waste sink. This affects other functional performances of the natural environment consequently and imposes limits to economic and development activities (Turner *et al*., 1994; Common and Stagl, 2005). Both the quantity and the quality of waste disposal and also the location should be considered to ensure environmental sustainability. For example, the discharging of non-treated water into a river system is more harmful than that of the same quantity of treated effluent. Hence, these factors are considered in the proposed theoretical framework.

6.2.4. INVEST IN NATURAL CAPITAL

It is not possible to attain a target of zero harm to the environment during economic and development activities. Therefore, a way to compensate for the harm to the environment should be included in economic activities. Thampapillai (2002) suggested the reinvesting part of the income generated in the economic system in the natural environment. This takes the form of compensation for what the economic activities consume. This investment in natural capital can take several forms including: to maintain the flow of services of endowments that currently provide services (functional), to restore the flow of services from endowments which have ceased to provide services (non-functional), or to create new natural capital. The first form is similar to offsetting wear and tear of capital goods. Cleaning up a polluted river periodically and reforestation are examples of these forms, respectively. Daly (1994) emphasizes the importance of the latter, in order to cope with the increasing demand for environmental goods and services. Therefore, investing in natural capital to maintain its status and to enhance its stock are important requirements for ES and are considered in the proposed theoretical framework.

6.2.5. IMPACT BIODIVERSITY

According to Hanley *et al.* (2001), biodiversity loss involves more than the loss of particular species. Direct impacts such as loss of genetic materials for food crops or as a source of medicine, loss of a range of ecosystem services and, impacts on non-use benefits such as aesthetics can also be experienced. Biologically diverse ecosystems provide a greater flow of ecosystem services than non-diverse systems (Parker and Cranford, 2010). Also, diversity provides an important property of natural systems which is known as 'resilience', the ability to withstand shocks such as drought and fire (Hanley *et al*., 2001). Although natural resources are conserved in terms of quantity of total natural capital stock, the diversity of that natural capital stock is of importance in order to continue the functionality of the life-supporting ecosystems (Wilson, 1988 cited in Jansson *et al*., 1994). Hence, conserving biodiversity and reducing negative impacts on biodiversity are regarded as major requirements for ES in the proposed theoretical framework.

6.2.6. USE ENVIRONMENT AS A FLOW OF AMENITIES AND LIFE SUPPORT SERVICES

People derive utility in terms of happiness and satisfaction (Common and Stagl, 2005; Hanley *et al*., 2001) through amenity services provided by the natural environment including sightseeing, sunbathing, wilderness recreation and so on (Hanley *et al*., 2001; Common and Stagl, 2005). Negative impacts on natural resources disturb the functioning of ecological systems and these amenities. The natural environment also provides biophysical necessities of life such as food, energy, mineral nutrients, air and water (Jansson *et al*., 1994) through life-support services including climate regulation, operation of the water cycle, regulation of atmospheric composition, nutrient cycling, and so on (Hanley *et al*., 2001). Maintaining the life support services of the environment is important for the survival of humankind.

Since land use, resource use, waste disposal and loss of biodiversity which are discussed in the previous sections, are the causes of the disruption of the amenities and life-support services, controlling those causes during development activities will help in continuing the amenities and life support services as well and thus they are not duplicated in the proposed framework

6.3. OTHER FACTORS TO ENSURE ENVIRONMENTAL SUSTAINABILITY EFFORTS

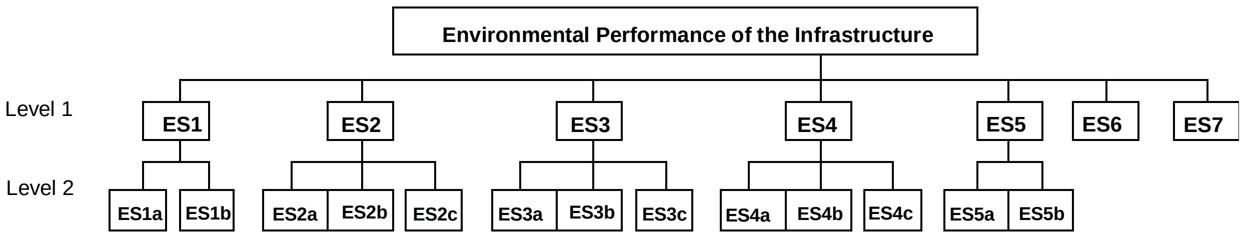
The factors identified in the previous sections are ecological factors that contribute directly to minimising impacts on the natural environment and to enhancing its status. Several researchers have claimed that the scope of ERSs should be broadened to embrace the wider agenda of sustainability as a necessary requirement (Haapio and Viitaniemi, 2008). However, the review of the literature on SD in section 6.1 revealed that the natural environment should be sustained for everything else to be sustained, but it is hindered in developing countries due to the priorities given to economic and social issues. Therefore, rather than inserting economic and social performances, this study reviewed such critical socio-economic barriers to ES efforts. As a result, two major factors, namely poverty and corruption, are considered in the theoretical framework, and are now discussed.

6.3.1. *ERADICATE POVERTY*

"The Future We Want", the report of the Rio+20 United Nations Conference on Sustainable Development, emphasizes the eradication of poverty as an indispensable requirement for SD today (UNCSD, 2012). However, this is not a new issue. Eradicating extreme poverty and hunger is Goal One of the Millennium Development Goals declared by the United Nations. Goodland and Daly (1993) claimed that reduction of poverty is a must for ES. In a study of the poverty-environment relationship for rural households in Zimbabwe, Cavendish (2000) found empirical regularities to show that poorer households heavily depend on environmental resources for income generation. A study in Nigeria by Akinola *et al.* (2012) showed that the eradication of poverty is a solution for attaining ES and otherwise the poor degrade the environment and its resources. Although not frequently addressed in ERSs, poverty eradication can be addressed to some extent at the project level as well. World Bank (2012) provides some examples such as investing in local agriculture, creating jobs, expanding nutrition programs and enhancing education in the locality. Although eradicating poverty would not solve all the global environmental problems, in developing countries, this is one of the requirements to achieve ES in developing countries. Otherwise, it will become a barrier to such efforts. It is important to promote such efforts in development projects and it is possible to address them through ERSs. Therefore, it is included in the theoretical framework in this study.

6.3.2. *AVOID CORRUPTION*

Corruption enables individuals to avoid environmental regulations (Transparency International, 2008) and hence, hinder conservation efforts and endanger the environment (Robert and Walpole, 2005). The Rio+20 report stresses that fighting corruption at both the national and international levels is a priority because corruption is a serious barrier to SD. Corruption can take place in different stages and in different forms. Although high-level political corruption is difficult to address at project level, the project stakeholders can ensure that they are not involved in any such activities within the project, either taking bribes or giving bribes. Although not noted so far, ERSs can address such issues by imposing demerit points on the projects on which any corrupt activities were involved. Hence, "avoid corruption" is considered in the theoretical framework of this study.



ES 1 – Minimize the impacts of land use
- minimise the area utilise (ES1a)
- minimise damages to composition (ES1b)

ES 2 – Minimize the impacts of materials usage
- minimise amount of material usage (ES2a)
- minimise damages during extraction (ES2b)
- minimise damages due to harmful types (ES2c)

ES 3 – Minimize the impacts of usage of non-renewable energy sources
- minimise amount of usage (ES3a)
- minimise damages during extraction (ES3b)
- minimise damages due to harmful types (ES3c)

ES 4 – Minimize the impacts of waste disposal
- minimise amount of waste disposal (ES4a)
- minimise damages due to negative quality of waste (ES4b)
- minimise damages due to location of disposal (ES4c)

ES 5 – Invest in natural capital
- to maintain it (ES5a)
- to enhance it (ES5b)

ES 6 – Conserve biodiversity

ES 7 – Eradicate poverty

ES 8 – Avoid corruption

Figure 2: Proposed Framework for ERSs

6.4. THEORETICAL FRAMEWORK

By considering the impacts on the natural environment due to economic and development activities and the other factors to be considered to ensure the ES efforts, seven major factors and several sub-factors which are important to achieve ES of infrastructure projects were determined. These are illustrated in a hierarchical structure in Figure 2. These are the factors to be considered when assessing the environmental performance of development projects, thus providing the theoretical base for infrastructure ERSs.

7. DATA COLLECTION AND ANALYSIS

Data were analysed using the AHP method. The AHP literature states that the sample size is not critical if the representativeness of the sample is secured (Wind and Saaty, 1980 cited Kim and Kim, 2009) and it is not necessary for the study to involve a large sample (Wong and Li, 2008). To ensure the representativeness and reliability of data, questionnaires were distributed among a group of environmental experts consisting of 20 professionals working in the infrastructure sector with environment-related experience who have obtained post-graduate academic qualifications in environmental studies.

Although market based, voluntary environmental rating schemes seek stakeholder participation and expert opinion from a diverse group such as Architects, Civil Engineers, Quantity Surveyors and also Clients to include the architectural, technical, financial and other aspects to increase the application and to analyze the adoptability, it may compromises the fundamental environmental conservation perspective. Since this study addresses the issue of absence of a theoretical base for ERSs, it was expected that the respondents should have specific knowledge; the knowledge on environmental issues related to infrastructure sector in environmental conservation perspective and allocate weight to each factor based on their opinion on the severity/importance of such impacts in the country.

The key factors of the study were explained to the sample group prior to their participation in the study, in order to avoid misunderstanding and to ensure the reliability of data. The questions were structured in a way that facilitates pair-wise comparisons of environmental problems and positive environmental impacts and compared each pair of factors in both levels of the hierarchy shown in Figure 2. AHP is as a structured method for decision making and for solving problems by dealing with complex, unstructured and multiple-attribute decisions which considers decision variables or decision attributes, at least some of which, are qualitative, and cannot be directly measured (Partovi, 1992; Saaty and Vargas, 2001).

Table 2: Results of AHP Analysis

Main factors (Level 1)	Relative importance	Normalized (Xn)	Sub factors (Level 2)	Normalized (x_n)	Sub factor weighting (Xn)* (x_n)
ES1	0.889	0.091	ES1a	0.48	0.44
			ES1b	0.52	0.48
ES2	0.820	0.084	ES2a	0.89	0.25
			ES2b	1.03	0.29
			ES2c	1.10	0.31
ES3	1.766	0.181	ES3a	1.23	0.73
			ES3b	0.90	0.54
			ES3c	0.91	0.54
ES4	2.054	0.211	ES4a	0.90	0.63
			ES4b	0.93	0.65
			ES4c	1.19	0.83
ES5	0.886	0.091	ES5a	0.76	0.69
			ES5b	0.24	0.22
ES6	1.138	0.117			
ES7	0.825	0.085			
ES8	1.364	0.140			
Total		1.000			

8. Results and Discussion

Table 2 shows the normalized relative importance of each factor as obtained from the analysis using the AHP method. Waste disposal is the major problem identified, followed by the usage of non-renewable energy sources, and then corruption. The first two factors represent the most critical environmental problems in developing countries today.

The results suggest that it is important to avoid corruption to enhance the environmental performance of infrastructure; this is the case in many developing countries, as is also found in the literature. The location of the waste dump is critical among the sub-factors under the impacts of waste disposal and quantity of usage of non-renewable energy sources among ES3 sub-level issues.

9. Conclusion and Further Application

This study examined the factors to be included in ERSs for assessing the environmental performance of infrastructure projects in Sri Lanka. The literature review on SD showed that ES is important for everything else to be sustained. ERSs evaluating environmental performance and should embrace the minimisation of the negative impacts of development activities the natural environment, and on the enhancement of the positive impacts. Therefore, an impact-oriented approach was followed in the study and factors were identified through a review of interactions between the natural environment and the economic system. A survey was carried out to measure the relative importance of factors through a pair-wise comparison and AHP method was used to analyse the data. The results showed the relative importance of factors that should be considered in ERSs for Sri Lankan infrastructure projects, with the three most significant factors being minimising impacts of waste disposal, usage of non-renewable energy sources, and avoiding corruption. This framework can be applied to a specific infrastructure project type to develop type-specific ERSs. The current environmental problems and potential positive impacts of the project type can be identified and categorized under each ES factor in the proposed framework as the next hierarchical level. Experts in the sector can be asked to rank the importance of each type-specific factor under the ES factors and multiply by ES factor weighting to obtain final weighting. The study is the first to address the absence of a theoretical framework for ERSs in the built environment and it provides a path for establishing type-specific and regional ERSs based on an impact-oriented approach.

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