

THE USE OF ECO EFFICIENT CRITERIA IN THE DESIGN OF INFRASTRUCTURE PROJECTS

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ABSTRACT

Globally, the construction industry is one of the main contributors to the depletion of natural resources and a major cause of unwanted side effects such as air and water pollution, solid waste, deforestation, health hazards, global warming and other negative consequences. In the area of sustainability, there is an urgent need to apply technologies and methods that deliver better and more sustainable performance in a way that is cost-effective. Sustainability, adaptive and mitigative approaches to climate change, in the design of infrastructure, are therefore important steering elements [1]. A systematic and iterative analysis of the environmental impact of various design solutions is commonly suggested for infrastructure projects, but rarely happens. The lack of appropriate tools and skills for sustainable design was often quoted as a barrier to sustainable design [2]. To stay competitive and to meet upcoming stricter environmental regulations and customer requirements, designers have a key role in designing civil infrastructure so that it is environmentally sustainable. These and other factors have compelled the engineer to design with greater care and in more detail. The changing roles of engineers will be highlighted, to react to changes in climate. This paper aims to demonstrate the importance of eco efficient criteria on infrastructure projects. The use of the proposed criteria would ensure a sustainable design for township infrastructure services through the consideration of scarce resources, ecological sensitivity in the design and planning of infrastructure projects. This paper also gives an overview of the proposed Green Township Infrastructure Design toolkit and promotes the use of green practices on infrastructure services design that is environmentally sound, placing fewer burdens on the environment.

Keywords: eco-efficiency, green infrastructure, green technology, infrastructure design, sustainable development.

1 INTRODUCTION

Civil engineering projects can have significant site-specific and cumulative impacts on our ecological and social systems if not correctly planned, designed and implemented.

Relatively few designers have as yet explored the transformative potential of ecological design and have preferred to remain apolitical and unconcerned with the distributional impacts of design as they affect the health of humans and ecosystems [3].

Engineers have been focused mainly on financing issues and engineering aspects on infrastructure projects. Mainstreaming environmental aspects, utilising environmental friendly seeking design solutions and incorporating the eco-efficiency concept into various stages of infrastructure design development, have not been considered as much as they should have been.

By utilising improved environmentally friendly seeking design solutions, this study aims to introduce environmentally friendly design decisions prior to the infrastructure design approval process. This increases overall competitiveness by bringing a whole new class of productive solutions to problems while at the same time adding a fresh perspective to the traditional infrastructure design process. This paper describes the benefits of an Eco Approach to Infrastructure Design, which describes the potential of ecological design.

2 THE NEED TO IMPLEMENT GREEN TECHNOLOGY ON CIVIL ENGINEERING INFRASTRUCTURE PROJECTS

In the area of sustainability, there is an urgent need to apply technologies and methods that deliver better and more sustainable performance in a way that is cost-effective. Sustainability, adaptive and mitigative approaches to climate change, in the design of infrastructure, are therefore important steering elements [1].

Environmentally sustainable design on township infrastructure services entails the use of ecologically sensitive innovative design solutions, integrating a consideration of resources, the environment, maintenance and recyclable materials, from the early design stages of a project.

Infrastructure elements such as roads, water, sewage and stormwater can result in loss of critical ecosystems and biodiversity. There is a need to create an eco sensitive infrastructure design rating system that encourages and promotes the use of 'softer' design solutions.

Due to the ecologically sensitive nature of civil engineering infrastructure, there is a need for a green rating tool to evaluate the performance of infrastructure. The proposed research assesses the environmental impacts of infrastructure design decisions on development.

Diligent attention to greener infrastructure solutions from the very earliest phases of a project will help guarantee that quality design environmental solutions are 'built in' from the beginning.

3 INFRASTRUCTURE ECO EFFICIENCY CRITERIA

The role of criteria for sustainable green infrastructure are tools that can be used in the conceptualisation, implementation and monitoring of progress in township infrastructure projects. The criteria define the essential components of the proposed Green Infrastructure Toolkit against which sustainability may be assessed. Thus, collectively, the criteria provide an implicit, generally agreed-upon global definition for the concept of eco efficient infrastructure solutions. Each criterion relates to a key element of sustainability. Through the measurement and monitoring of these indicators, the overall effects of the proposed Green Infrastructure Toolkit can be assessed and evaluated, and action can be adjusted to meet the stated aims and objectives more effectively.

The client's vision, goals and objectives for eco efficiency on a project can be translated into a core set of project criteria. While project goals set the direction, the project eco efficiency categories provide the means to measure a project. They enable clients, engineers and stakeholders to gauge progress towards sustainable development by comparing the performance achieved on a project with the intended performance.

The eco efficient criteria that characterise sustainable criteria of Green township infrastructure are listed in Table 1.

The criteria, namely economy, functional efficiency, safety and environmental quality, were derived from goals that were set out for layout planning and related services for residential township developments [4].

The proposed eco efficient infrastructure criteria namely efficient layout planning ensures that infrastructure is placed in environmentally responsible ways. The resources criteria encourage an efficient utilisation of materials/resources. Environmental quality mitigates environmental impacts of infrastructure. Functional efficiency ensures that infrastructure is designed optimally. Future Maintenance maximises the opportunities for integrating capital and operation of infrastructure. Economy maximises the opportunities for integrated cost-effective adoption of green infrastructure options. Safety minimises the environmental impact

Table 1: The eco efficient infrastructure performance criteria.

Eco-efficient infrastructure sustainable criteria	Measure
1. Efficient layout planning	Placement of infrastructure in environmentally responsible, efficient ways, conserve land
2. Resources	Encourages the efficient utilisation of materials/resources, selection of environmentally friendly materials
3. Environment quality	Design features that mitigate environmental impacts of infrastructure by reducing effects of pollutants
4. Functional efficiency	Design of infrastructure that maximises functional efficiency of infrastructure
5. Future maintenance	Maximises the opportunities for integrating capital and operation of infrastructure, ensuring reliability of level of service
6. Economy	Maximises the opportunities for integrated cost-effective adoption of green infrastructure options
7. Safety	Minimises the environmental impact of infrastructure by incorporating safety into the design
8. Social	Ensuring social sustainability of infrastructure promoting convenience, social resources and public participation

of infrastructure by incorporating safety into the design. Social sustainability of infrastructure promotes the use of social resources, encourages public participation and the placement of infrastructure in the most convenient manner.

The infrastructure eco efficient criteria used in the proposed Green Township Infrastructure Design Toolkit were developed to:

- determine the means by which eco-environmental efficiency can be assessed, monitored, quantified and verified at any stage of the project, to ensure a value-added, quality driven, green approach to infrastructure design;
- provide a basis for the consultants and clients to work together on creating and evaluating sustainable infrastructure solutions thereby ensuring comprehensive infrastructure planning with maximum stakeholder involvement;
- achieve the required balance of sustainability, expenditure, value for money and quality, between the various elements of the project.

4 WEIGHTING OF ECO EFFICIENT CRITERIA

Weighting of the infrastructure eco efficient criteria allows the design team to target or prioritise certain infrastructure environmental sustainable performance categories over the various elements of the project. The weighting of the various categories are carried out at this early stage, before the design is developed, to avoid redesign later in the process.

Weighting the infrastructure eco efficient criteria enables the project to be tailored to the client's project requirements and specifications, at the earliest stages of the development process.

A lot of flexibility exists in the green township design rating system, so that designers can benefit by focusing on specific categories applicable to each design situation. The weighting and setting of targets for the sustainability categories helps the designer understand the many design choices, which need to be made in relation to layout planning, functional efficiency, environmental quality, economy, future maintenance, safety, convenience and resources, and their impact on the overall economics of the project.

Eco efficient criteria focus on scarce resources and priority areas; and to improve accountability linking project level work to the achievement of strategic objectives.

5 THE GREEN TOWNSHIP INFRASTRUCTURE RATING SYSTEM FOR INFRASTRUCTURE PROJECTS

This paper proposes a rating system that enforces environmentally sustainable design on township infrastructure services by integrating a consideration of resources, the environment, ecologically sensitive innovative design, maintenance and recyclable materials, from the early design stages of a project.

The Green Township Infrastructure Design Toolkit, as illustrated in Fig. 1, uses the concept of eco-efficiency and would allow the designer to evaluate design options, enabling him/her to choose the one likely to yield the best performance with the least environmental impact, based on proven technology.

This toolkit is intended to encourage developers to consider green methods and practices in the earliest stages of project planning, by assessing a number of recommended green practices and its environmental impacts on infrastructure services design, placing fewer burdens on the environment.

The various Green Report Forms enable the client to select a combination of alternatives and evaluate a number of possible design options – with their environmental implications – at each stage of the design process [5].

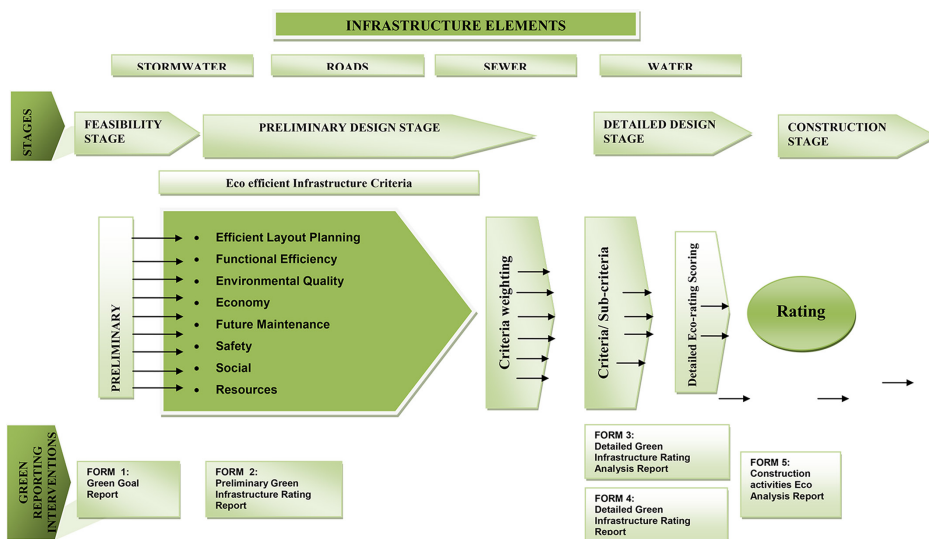


Figure 1: The Green Township Infrastructure Design Toolkit [5].

During the briefing and preliminary design stage (1 and 2), the client and the engineer have a joint responsibility of deciding just how green the project should be, or alternatively of deciding what environmental quality of services can be provided. During the detailed stages (3), the engineer has the responsibility of designing, while maximising the green value of the project. Stage 4 gives the designers an opportunity to add environmental value at the construction stage, by analysing eco-friendly construction material.

The underlying structure of the Green Township Infrastructure Design Toolkit is based on a hierarchical breakdown of the project into five stages described in Table 2.

The various green reports developed for use at different stages of the project provide clients and consultants with more control over the environmental impact of design decisions taken and enable a comparison of the options of various engineering solutions.

6 ADVANTAGES OF USING THE ECO APPROACH TO INFRASTRUCTURE DESIGN

Green township infrastructure solutions will contribute to greenways and green corridors and provide linkages between habitats and wetlands. The Greener infrastructure design approach has a number of environmental, economic benefits and community benefits. The benefits of this approach are as follows:

Resource benefits:

- Recycling of used products.
- Conservation of natural resources.
- Recharged ground water flow for streams, conserving water supplies.

Environmental benefits:

- Enhance and protect ecosystems and biodiversity.
- Increased vegetation, improve air quality by filtering many airborne pollutants.
- Minimised impervious surfaces reducing soil erosion.
- Reduced concentrations of pollutants.

Economic benefits:

- Reduced infrastructure costs by water collection, storage, treatment and distribution.
- More efficient use of existing infrastructure.
- Reduced operating costs.
- Enhanced asset value and profits.
- Optimised life-cycle economic performance.

Table 2: Stages in the Green Township Infrastructure Design Toolkit.

Stage		Activities
Stage 1	Feasibility stage	Establishing environmental objectives
Stage 2	Scheme design stage	Preliminary eco rating
Stage 3	Preliminary design stage	Weighting of environmental sustainability categories and targets
Stage 4	Detailed design stage	Detailed eco rating analysis
Stage 5	Construction stage	Materials and construction activities eco analysis

Health and community benefits:

- Improved air, thermal and acoustic environments.
- Community safety.
- Convenience of users.
- Enhanced occupant comfort and health.
- Minimised strain on local infrastructure.
- Contributed to overall quality of life.

7 A CASE STUDY TO COMPARES THE USEFULNESS OF THE PROPOSED GREEN INFRASTRUCTURE TOOLKIT

The two residential developments case studies were compared to each to test the usefulness of the rating in searching for green solutions.

Case Study 1 used conventional infrastructure and was chosen to assess how the model rates conventional infrastructure.

The second case study was a low-income development that aimed to have a restricted damage to the environment, by using a combination of green solutions and conventional infrastructure.

The results indicated that Case Study 2 achieved a green rating of 66 and performed satisfactory to moderate scores across all dimensions of sustainability, being able to maintain a balance between the needs of society and the preservation of the environment.

Case Study 1 on the other hand demonstrated a significantly different performance, achieving a green rating of 18 and receiving low scores for almost all components, due to the lack of environmental interventions. This therefore offers a useful contrast to the situation in that Case Study 1 indicates the results when only conventional designs are used compared to simple inexpensive green interventions that can be used, as shown in Table 3 and illustrated in Fig. 2.

Table 3: Comparative assessment between Case Study 1 and Case Study 2.

Performance categories	Case Study 1					Case Study 2				
	Overall project	Roads	Storm water	Sewer	Water	Overall project	Roads	Storm water	Sewer	Water
1 Layout efficiency	16	13	10	33	10	77	88	60	89	60
2 Functional efficiency	10	15	7	6	7	67	75	63	53	67
3 Environmental quality	14	21	8	10	11	50	57	62	40	33
4 Economy	35	55	11	27	30	83	82	89	82	80
5 Future maintenance	14	10	13	13	25	62	50	73	63	75
6 Safety	17	13	10	17	33	81	80	60	83	100
7 Social	46	50	17	75	40	60	75	17	75	60
8 Resources	21	22	22	36	0	52	44	56	64	50
9 Construction	6	14	0	0	0	34	43	33	50	0
Scoring	18	24	10	18	16	66	69	66	62	66

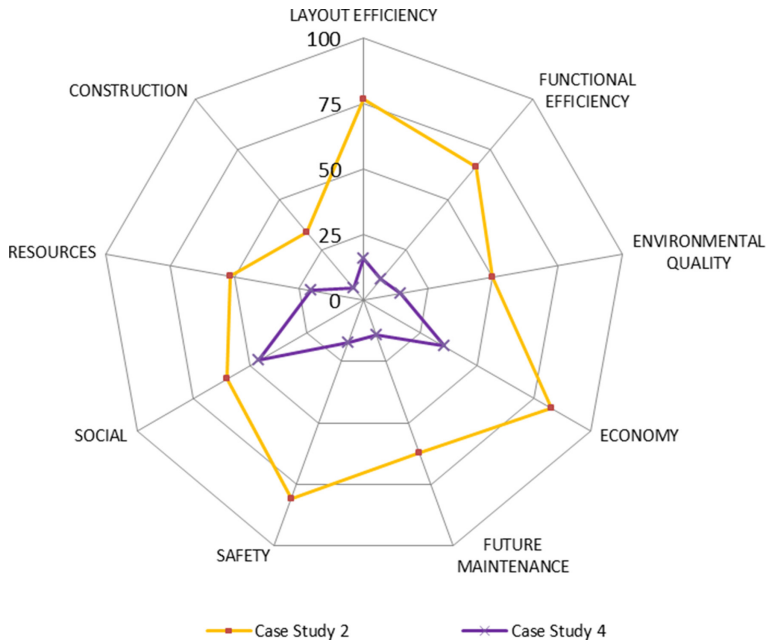


Figure 2: Comparative assessment between Case Study 1 and Case Study 2.

8 CONCLUSIONS

Increased awareness of eco-efficiency concepts is urgently needed among policy-makers, planners and decision-makers. However, the criteria applicable to, and measures for developing eco-efficient and sustainable infrastructure, are yet to be fully identified [6].

Engineers need to look at greener engineering solutions rather than just using traditional engineering solutions. A new paradigm for infrastructure design is required to ensure environmental sustainability on infrastructure projects. An important part of this paradigm is the eco-efficiency criteria. They need to be organised in the form of a method for the weighting and rating of infrastructure solutions in terms of adaptation benefits. The proposed Green Township Infrastructure Design Toolkit is an effective way to do that.

By using the green approach, sustainable design of township infrastructure services can be achieved by enforcing the consideration of resources, environmental impacts of ecologically sensitive design decisions, innovation, maintenance and materials, at the design stage of a project.

Taking a greener approach to infrastructure development not only mitigates the potential environmental impacts of development but makes economic sense as well.

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