



Eco-efficient criteria

There is an urgent need to apply cost-effective technologies and methods that deliver better and more sustainable performances.

By Shian Saroop and Prof Dhiren Allopi

THE CONSTRUCTION industry is one of the main contributors to the depletion of natural resources and a major cause of air and water pollution, solid waste, deforestation, health hazards, global warming, and other negative consequences.

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 is often quoted as a barrier to sustainable design (Richardson et al [2]). In order 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.

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 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 (Van Wyk [3]). Infrastructure development focused mainly on financing issues and engineering aspects in the region. Mainstreaming environmental aspects and incorporating the eco-efficiency concept into various stages of infrastructure 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.

Sustainability in civil engineering infrastructure projects

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.

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 (FIDIC [1]).

The rating of green buildings evaluates the environmental impacts of buildings but with little emphases on the environmental performance of civil engineering infrastructure. The proposed research proposes a decision toolkit that 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.

Sustainability

The criteria for sustainable green infrastructure are tools or indicators which 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 sustainability on infrastructure projects.

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 stated aims and objectives more effectively.

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

The Environmental Sustainability criteria that characterise the sustainable criteria of green township infrastructure are listed in Table 1.

The Infrastructure Sustainability 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 to create and evaluate 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.

Weighting of environmental sustainability indicators

The weighting of the Infrastructure Environmental Sustainability Categories

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.

The proposed Infrastructure Environmental Sustainability Categories Weighting Report Form 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.

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

The Green Township Infrastructure Rating System

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 Figure 1, uses the concept of eco-efficiency and would allow the designer to evaluate design options, enabling them 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 their environmental impacts on infrastructure services design.

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 (Saroop, 2013).

During the briefing and preliminary design stage (1 and 2), the client and 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

Table 1 The eco-efficient infrastructure performance criteria

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

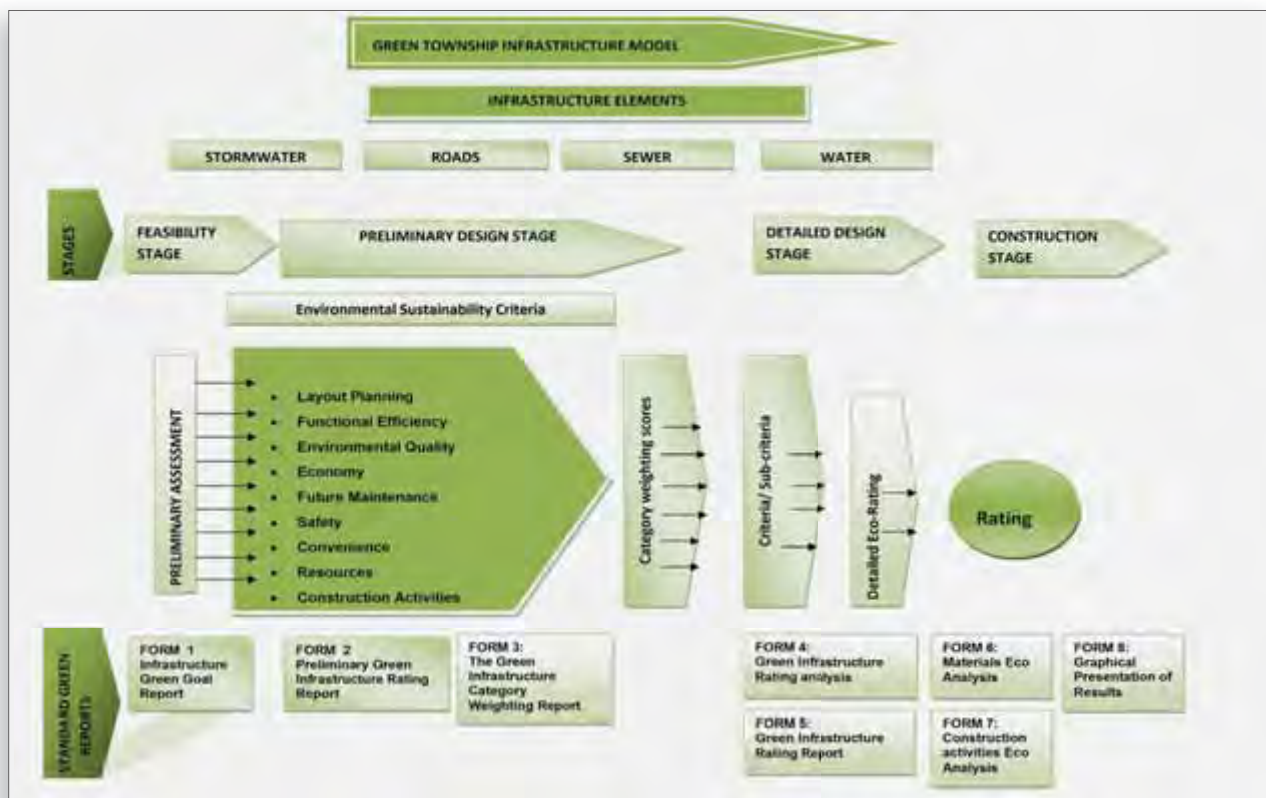


Figure 1 The Green Township Infrastructure Design Toolkit (Saroop, 2013)

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.

Advantages of using the eco approach to infrastructure design

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

- Resource benefits:
 - recycled used products
 - conserved natural resources
 - recharged ground water flow for streams, conserving water supplies.
- Environmental benefits:
 - enhanced and protected ecosystems and biodiversity
 - increased vegetation and improved 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

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

- more efficient use of existing infrastructure
- reduced operating costs
- enhanced asset value and profits
- optimised life-cycle performance.
- Health and community benefits:
 - improved air and thermal and acoustic environments
 - community safety
 - convenience for users
 - enhanced occupant comfort and health
 - minimised strain on local infrastructure
 - contribution to overall quality of life.

Green techniques provide adaptation benefits for a wide array of circumstances by

conserving and reusing water, promoting groundwater recharge, and reducing surface water discharges that could reduce to flooding. In addition to this, vegetation improves urban aesthetics and community liveability by providing recreational and wildlife areas. Green infrastructure may save capital costs associated with paving, creating curbs and gutters, building large stormwater conveyance systems and other hard infrastructure and energy costs and costs of repairing the damage caused by stormwater, such as streambank restoration.

Conclusions

The sustainability criteria focus is on scarce resources and prioritising areas; and to improve accountability, linking project level work to the achievement of strategic objectives.

Improvement in the 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 (United Nations Economic and Social Commission for Asia and the Pacific [4]).

A new paradigm for infrastructure design is required in order to ensure environmental sustainability on infrastructure projects.

The weighting and rating of environmental sustainability criteria provide adaptation benefits and also provide the means to measure projects. Engineers need to look at greener technologies rather than just

using traditional engineering solutions. By using this 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. By softening the environmental footprint, avoiding waste and finding efficiencies, clients and local governments can increase their long-term sustainability. **35**

This paper has been edited for publication. For more information or references, please contact the editor nicholas@3smedia.co.za

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