Jurnal Teknologi

Full paper

Elements of Green Highway Assessment: Social and Safety

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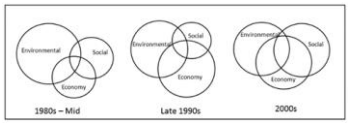
Article history

Received :1 May 2014
Received in revised form :
14 September 2014
Accepted :1 Oktober 2014

Graphical abstract



Abstract

A green highway is fundamental for the infrastructure to be environmentally responsible and sustainable in all aspects. The need for promoting sustainability and green highway construction requires an assessment system. The Green Highway Assessment provides a management and technical approach for highway life-cycle from construction to its maintenance processes. It should also cover the relationship between environment and social responsibility with highway development. Nevertheless, safety and social element of highway development are often not addressed in majority of green highway assessments. The aim of this study is to identify and choose which social and safety elements are to be included in green highway criteria and therefore utilised in Malaysian Green Highway Index and its assessment. Data was obtained through comprehensive literature reviews, expert interviews and distribution of questionnaires. Respondents included experts and stakeholders from highway development field. The Average Index Value analysis was also utilised for the result of the questionnaire. The study resulted in 7 main criteria and 12 sub-criteria that were accepted to be used for green highway index assessment. The full list of main criteria and sub-criteria will be explained further in the text.

Keywords: Social element; safety element; green highway assessment; sustainability; highway construction

1.0 INTRODUCTION

During the United Nations Conference on Environment and Development in Rio Janeiro 1992, a need for sustainable development was acknowledged. One major blueprint on how the world's nations can work individually and collectively towards sustainable development was documented under Agenda 21 which has been endorsed by more than 150 nations [1]. Construction industries play a major role in achieving sustainable development. Green highways are required for highway infrastructure to be environmentally responsible and sustainable in all aspects. Green Highways are expected to be eco-friendly and will significantly reduce the emission of carbon dioxide and other green effect gases. To make it successful the green highway concept requires a huge amount of attention from all road shareholders, including concessions, drivers and authorities. To achieve the green highway standard, focus should be on harmonizing highway needs with consideration of local ecological protection, how to avoid subsequent environmental destruction and excessive resource consumption and how to incorporate sustainable development concepts into highway projects. The need for promoting sustainability and green highway construction requires a green highway assessment system. The green highway rating provides an updated current version of highway management practices. The system classifies various parts of highway construction processes and then rates them based on their environmental sustainability.

Research on Green material in highway construction, especially pavement material, has become a favourite topic among researchers. Researchers conduct study to discover the perfect balance between economic and ecological advantages to obtain most sustainable material to be used in highway construction. All these research have been conducted to study the best material to be utilised and to understand the character for each material such as cement composite, and even steel for concrete [2][3][4][5][6][7]. For example, the use of geopolymer concrete to replace ordinary concrete for Rest and Service Area construction. Geopolymer concrete could reduce the CO_2 emission to the atmosphere caused by cement and aggregate industries by 80% [8]. In addition, geopolymer concrete exhibit better structural stability, better performance and better heat resistance compared to ordinary concrete [9]. This creates a perfect balance economic and ecological factors in finding the best elements for sustainable highway. Indeed, normal concrete has been regarded as a good structural material with respect to fire resistance [10]. However, it is a fact that concrete, especially cement-based material is intrinsically brittle type of failure owing to low tensile strength and poor fracture toughness. In order to satisfy the performance of cement-based matrices, incorporation of addictive materials to increase the tensile properties, fatigue endurance, toughness, impact resistance in addition to energy adsorption capacity. [11] In additional, the effect of addictive material such as Palm Oil Fuel Ash (POFA) or Ground Granulated Blast Furnace Slag

(GGBFS) or the use of construction waste as a replacement for aggregates have been studied. [12] [13] [14] [15]. Not only could this reduce the quantity of waste by reusing it, concrete added with this addictive are reported better in quality.

A green highway can be defined by five broad topics, each of which include various aspects [16]. Green Highway should incorporate storm water management, life cycle energy and emissions reduction, be recyclable, reusable and renewable, facilitate conservation and ecosystem management and overall societal benefits. M. Bryce believed that sustainability can be defined as a tool focused on the natural environment and that effects on man-made environments have been overlooked. However, in a holistic approach to sustainable construction, overall societal benefits should be taken into account. Highways have an important impact on local economies. An aesthetically appealing highway design can draw businesses into a community and supply local jobs and tax income, whereas a poorly designed highway can decrease traffic to a business and eventually cause the business to seek a better location.

Highways are the principal infrastructure and main element for a nation's economic development. The construction of highways normally involve enormous earthwork such as cutting hilly areas, backfilling low lying areas, crossing wetland, reliance on non-renewable energy and generation of harmful emission. Malaysia set an agenda to produce extensive infrastructure, including a vast network of highways. In 2000, the total length of roads in Malaysia was approximately 65,445 km. The total length of roads has increased by 33% from 2000 to 2005. From 2005 to 2007, the length of roads increased by 35% [17]. According to Malaysia Highway Authority, there are altogether 29 highways in Malaysia with a total length of 173, 244 km. Highways should be constructed as one socially responsibility element [18]. However, the overall process of such construction will also produce huge amounts of tangible and intangible waste that bury the benefit of constructing a highway. Highways that have been sustainably built can control the quantity of waste produced which will then ultimately fulfil the requirement of social sustainability principle. Globally, researchers and road stakeholders search for green highway characteristics. The latter can be translated into numerous green highway models and standards that ultimately define the 'greenness' of a highway. Virtually, every single assessment model of a green highway is different. This is because each model is generally designed and built based on local capacity in particular regions which covers local needs. This problem might contribute to different elements of weightage used in every single model. There is no standardization between models of assessment as they come out with their own interpretation. Nevertheless, the importance of social and safety factors were not critically addressed in most green highway assessment.

■2.0 SOCIAL AND SAFETY ELEMENTS

There are numerous discussions in literature that relate sustainability with public welfare. Studies have shown that social and safety aspects should be included as a sustainability indicator. [19] [20] [21] However, Smith argued that there is general agreement that the different dimensions of sustainable development have not been equally prioritised by policy makers within the sustainability discourse [22]. In the early 1990s, a comprehensive study of this concept was still missing due to the fact that environmental and economic issues dominate the sustainability agenda. Social issues have been gradually merged as a result of practical understanding of plausibility and current political agendas [23]. In addition, a study by [24] points out that social sustainability is currently dealt with in connection with the social implication of environmental politics rather than as an equally constitutive component of sustainable development. The gradual level of involvement for environmental, social and economic elements have been summarised in Figure 1.

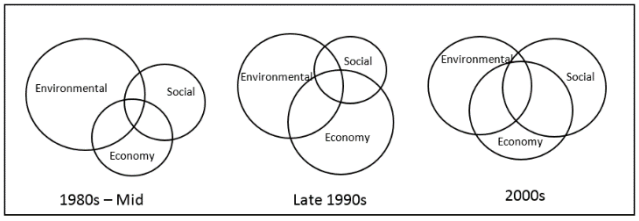


Figure 1 The different dimensions of sustainable development and their relative importance [25]

Value of life and sustainability incorporate similar perspectives in principle. At their most basic level, sustainability and safety are really about the same thing: conserving resources. In the case of sustainability, those resources are typically thought of as environmental. In the case of safety, the resources are human. Despite this common ground, discussion of sustainability is only beginning to pay attention to safety. After a chain of high-profile accidents that have led to both human and environmental costs, some large corporations have been accused of putting profits ahead of worker safety. It is common knowledge that when workers are wounded or killed, there should be a 'mountain' of financial implication [26]. The resulting accidents have cost those companies dearly. The financial impact can significantly influence the economic vitality of a firm and a community and, thus, sustainability over the long term.

This reflected back to the element that has been included in the green manual category. Frustratingly as stated earlier, the majority of the manual does not include social and safety factors, and in some cases is not being addressed critically. This research has discovered that the assessment tools have incorporated safety and social sustainability as main criterion rather than addressing them as one key topic. However, this technique falls short of emphasizing the impact of safety and social sustainability especially for public well-being. It is in the public interest to incorporate social sustainability and safety as one main criterion instead of intertwining it into other key elements. Some of the social sustainability and safety issues have significantly defined sustainability in green highway construction. As an example, periodic road safety audits during operation (Source: Greenroad; AE1) and user service facility as mentioned in Greenroad; AE2, LLM Manual, GreenLITES: E1, and I-LAST: T1, are among elements which come from social and safety concerns [27] [28] [29] [30] [31] [32] [33] [34] [35]. However, the mentioned elements were not addressed as critical criteria in the respective manual. A list of social and safety elements have been included and are summarised in Table 1.

The list in Table 1 consists of material from manuals from Federal Highway Administration (FHWA), Greenroads, BE2ST, Sustainable Infrastructure Project Rating System (SIPRS), Sustainable Transportation Environmental Engineering and Design (STEED), GreenLITES, I-LAST and STARTS.

Researchers have stressed the importance of social and safety factors in green highway construction. Sustainable development has become an important issue in the construction industry. Despite this common ground, discussions of sustainability are only beginning to pay attention to safety and social element. Social and safety sustainability reportedly appears to be lagging behind other industries [36]. This was also echoed by Gambatese who claimed that sustainable concepts should start with the health

and welfare of humans. Reports from USA [37], Finland [38], Taiwan [39] [40] [41] and Japan [42] take into consideration the aspect of human health and comfort, while also emphasizing the reduction of environmental impact.

Study conducted in China looked at it from three sides; environment, society and economy. [39].

Table 1 List of social and safety elements and its sources

Element In Consideration	Reference/Source/Manual
Job creation	I-LAST : P1 SITES: Credit 2.3 Pre-Design Assessment and Planning
Population growth	Green Building Index: SM3
Retail area (shop lot /hotel/petrol pump) in Rest and Service Area, RSA / Lay-by	LLM Manual
Promotion of local identity	LLM Manual
Tourism activity / local identity	Greenroad: AE9
Dedicated landscaping area	Greenroad: EW5 I-LAST: D2
Aesthetic value in highway road furniture	GreenLITES: S2
Comfort temperature of highway facilities	Green Building Index : EQ6 LEED: Credit 7.1 & 7.2 (Indoor Environmental Quality)
Budget for R&D activities to improve the sustainability level for highway	GreenLITES: I1
Green technology for innovation	Green Building Index: IN1
Compliance on Occupational Safety and Health aspects (OSHA & FMA)	LLM Manual
Periodical Road Safety Audit during operation	Greenroad: AE1
Public complaints	Greenroad: PR5, PR7 Green Building Index : EQ4 GreenLITES: E5 I-LAST: E3
Adequacy of basic services Highway maintenance team Patrol team Disaster management team Emergency traffic control team	LLM Manual

Ten assessment items were used including natural conservation, energy conservation, water or soil conservation, waste reduction, re-vegetation, materials, safety and comfort, fair development, cultural preservation, and cost effectiveness to perform summary assessments of different types of projects. While the aspects considered by the latter two researchers are completely in line with the spirit of sustainable development, they are not specifically connected with road construction.

There are highway applications that increase the safety feature of highway while simultaneously reducing the social features. Transverse rumble strip (TRS) are widely used by local authority to reduce vehicle speed and to alert drivers about the road conditions ahead. However, results have shown that using TRS can be noisy which later caused dissatisfaction of road user [43]. Therefore, social and safety elements that are included in the manual should be able to balance the effect of installation and also the role of safety and social features.

■3.0 QUESTIONNAIRE SURVEY AND FOCUS GROUP

One set of standardized questions are pre-determined in order to obtain information about social and safety factors from the perspective of various experts involved in green development construction. By using the data obtained from literature reviews and guidelines set up previously, a set of questions considering the element of social and safety factors, green highway framework and sustainability were selected for this approach.

Correspondents involved were experts and shareholders in highway construction which include:

i. Concession companies of highway construction
ii. Public Work Department
iii. Malaysian Highway Authority

The results from the questionnaire were later presented in a focus group discussion for validation purposes. The focus group discussion was divided into two sessions. The first session was held on 2nd April 2012 and the second session was held on 19th November 2012. They was held at Mahkota Hotel, Melaka and Tiara Beach Resort, Port Dickson, Negeri Sembilan respectively. During the first session, each criteria that had been chosen were presented in order to determine its suitability to be adopted into the green highway manual. The second session was conducted after the questionnaire survey to validate the outcome for the elements that were considered significant to be implemented into the manual.

The survey input was fed into the SPSS software using frequency analysis. Results were then further analysed using the Average Index Value as tabulated in Table 2.

■4.0 RESULT AND DISCUSSION

Ranking of elements that had exceeded the average index of 3.5 are tabulated in Figure 2. The result is based on 143 respondent questionnaires that had been distributed from 9th to 18th July

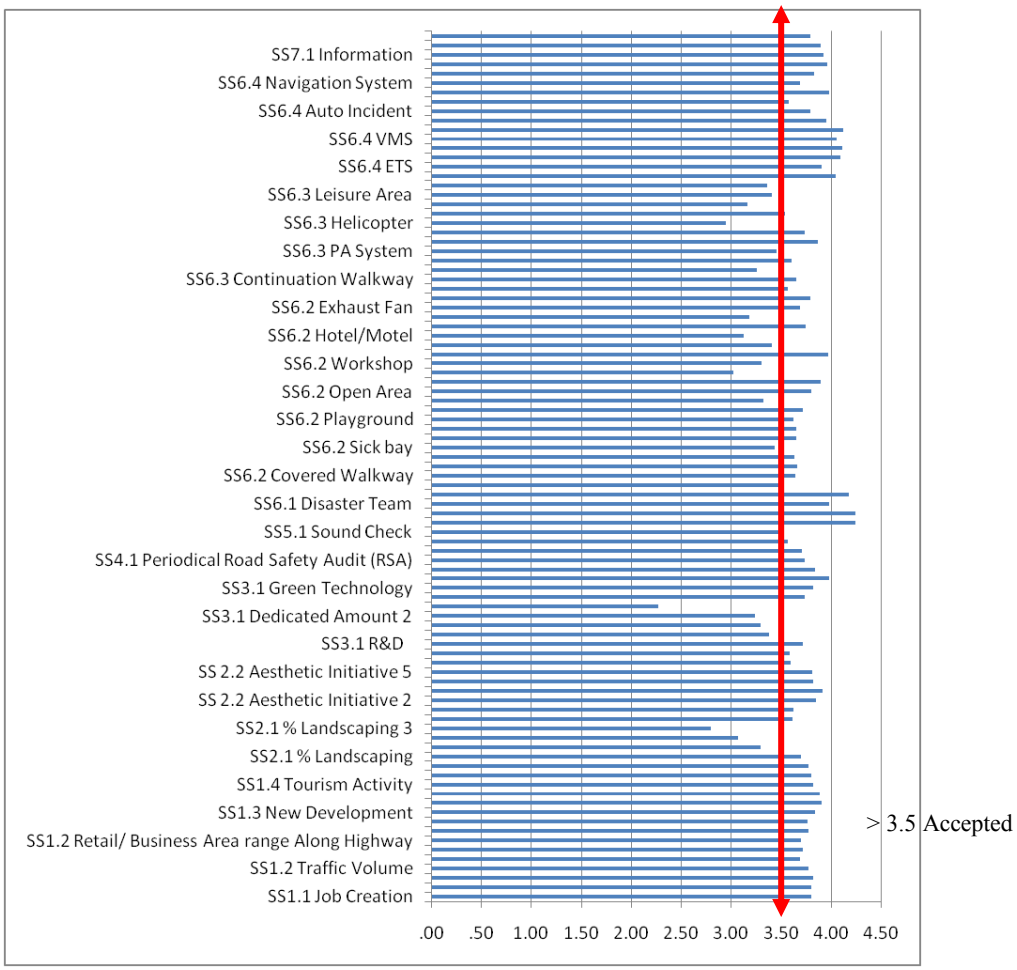
2012. Only elements which have an index value greater than 3.5 are considered significant and included in the green highway assessment. Study has shown that the most important element in social and safety criteria is the use of Intelligent Traffic System, ITS (Traffic Control and Surveillance System, TCSS; Close Circuit Television System, CCTV; Variable Message Sign, VMS ; Emergency Telephone System, ETS and etc.), followed by basic facilities especially in RSA and Lay-By. All these elements incorporate safety and social sustainability and were identified as adequate and appropriate to be included in green highway criteria. These criteria therefore can be utilised in the Malaysian Green Highway Index.

Each element from the green highway assessment has been critically investigated. There were 81 elements that have been taken into consideration which have a social sustainability and safety approach. It was then classified into 16 sub criteria. The sub criteria were later categorised in 7 main criteria which are:

i. User Services and Facilities
ii. Economy
iii. Pollution Reduction
iv. Public Acceptance
v. Environment
vi. Management Issue
vii. Innovation

Each criterion has been given an ID number in order to make it more systematic. Based on the survey, the most significant criteria have been identified. This was later expanded into 12 sub criteria and finally 27 element descriptions have been approved to be utilised in the Malaysian green highway index. All elements that reflected social and safety sustainability were extracted and tabulated. In order to standardise the elements, each were classified into sub criteria and criteria respectively. All elements that measure financial and cost related issues were categorised as 'economy'. Economy has been divided into two sub criteria which are business enhancement and tourism. On the other hand, all elements that reflected the nature and human comfort especially for road users were categorised in environment criteria. Environment has altogether two sub criteria that include landscaping and environmental friendly. The same techniques have been applied to other elements which were later sorted into criteria such as innovation, management issues, pollution reduction, user services and facilities, and public acceptance. All the criteria should be able to show the holistic approach to achieve social sustainability and safety for highway designs.

Table 2 Average index value on social and safety sustainability elements



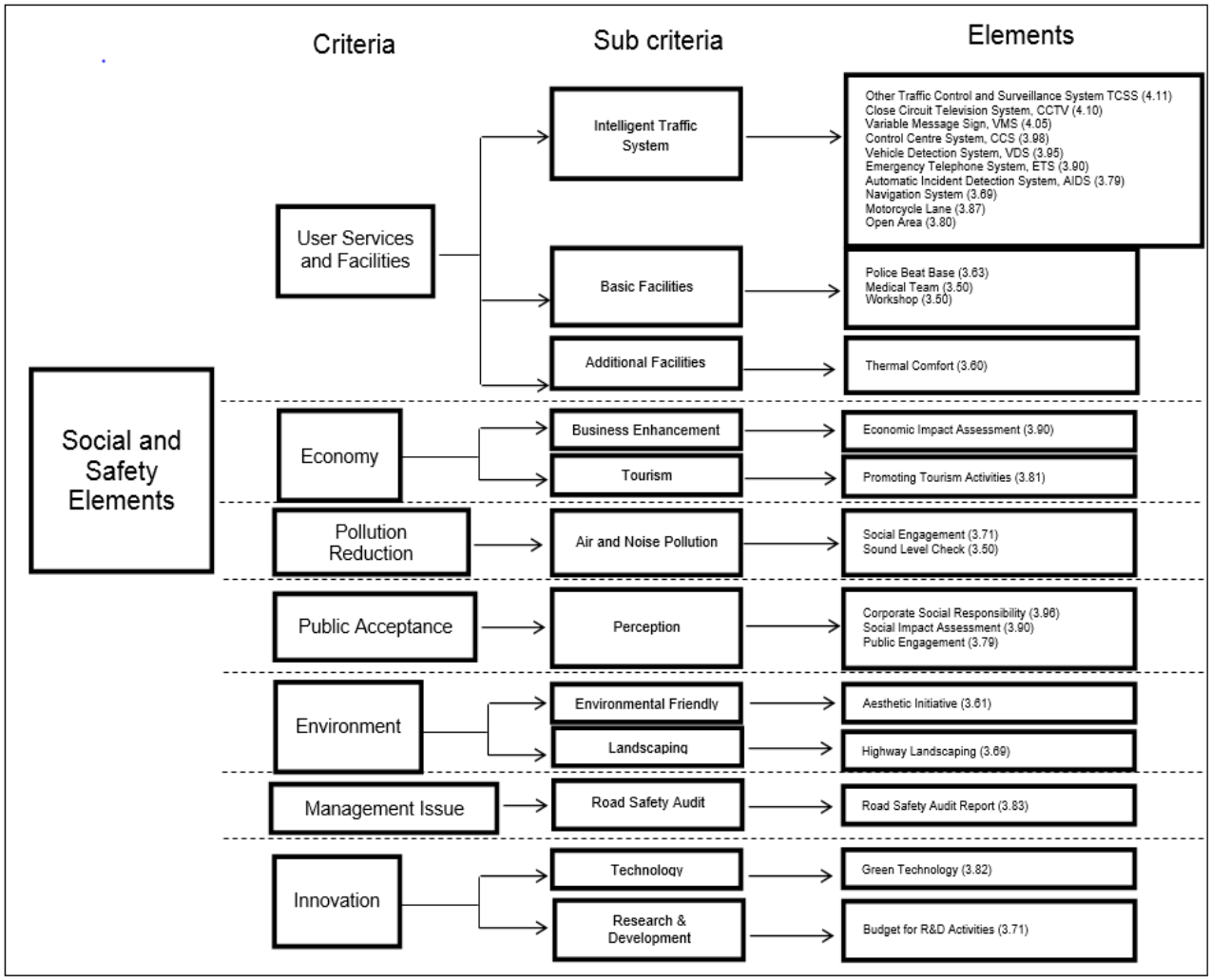


Figure 2 Social and safety sustainability criteria and elements in green highway manual

The element later has been sorted according to ascending order of most relevant element in green highway index as deemed by the road stakeholders. Four of the criteria reflected social sustainability (economy, public acceptance, environment and innovation) while three reflected safety issues (services and facilities, pollution reduction and management issue). This finding was then presented for verification to the experts and shareholders in highway construction in the second expert discussion on 19th November 2012. Only elements which have an Index value greater than 3.5 are considered significant. A list of elements which are appropriate and deemed suitable for the green highway index are tabulated in Figure 2 above.

The results have shown that User Services and Facilities criteria top the most suitable elements to be included in green highway assessment. Road users felt safer to travel along highways when they knew help was easily assessable, CCTV and AIDS were available to provide monitoring of road users while during travel. Road users can also benefit from the installation of ETS and navigation system. Additionally, road users tend to stop at RSA and Lay-By for rest or food. A good highway should be able to provide stalls and facilities for road users. Meanwhile, a sustainable highway should be able to promote local tourism and boost local economy as well.

5.0 CONCLUSION

Most of the established road manuals agree that social sustainability and safety are important factors in green highway development. However, in general, elements were only incorporated with other interests and were not being addressed properly as key points. SITES, Envision and BE2ST in-Highways used social sustainability as the major category in their assessment model. Safety has been considered as the major criteria by SITES only. On the other hand, the majority of research (Huang *et al.*, 2002. Chang *et al.*, 2000.Huovila, 1999) had proved that social and safety factors are significant and should be one of the major criteria in green highway assessment. Since all these elements came from various sources, some may not be suitable for local culture and were eliminated from the list. Based on the survey, it was agreed that 27 elements from the previous objective were to be incorporated for the social and safety sustainability element of green highway index. The study has shown that the most important element in social and safety criteria is the use of ITS (TCSS, CCTV, ETS and etc.), followed by basic facilities especially in RSA and Lay-By. All these elements incorporated

safety and social sustainability and were identified as adequate and appropriate to be included in green highway criteria. These criteria therefore can be utilised in the Malaysian Green Highway Index.

Acknowledgement

The authors are grateful to UTM for the financial support by MOSTI; 4S085 (Science Fund) and also MOE; 06H44 (GUP Grant).

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