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RESEARCH ARTICLE

CRITERIA IDENTIFICATION FOR SUSTAINABLE HIGHWAYS IN PAKISTAN

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ABSTRACT

Pakistan is a developing country, and like most developing countries it utilizes a considerable portion of its annual budget on development projects particularly in highways and roads infrastructure. Development and construction of highways and roads may however have a negative impact on the surrounding environment. To control this negative impact, green and sustainable highway initiatives have been undertaken in Some European countries and in North America. Rating systems have been developed in these countries to determine the sustainable performance of highways. Pakistan does not have a rating system and thus, to develop a rating system, it is necessary to identify the criteria across which the rating system will measure the sustainable performance of highways. This paper, therefore, aims to identify sustainable criteria elements in highway projects lifecycle. The identification process was completed by means of reviewing literature and by comparing other rating systems. As a result different sustainable criteria and subcriteria elements were identified in different phases of lifecycle of Highways I,e Planning, Design, Construction and Operation and Maintenance.

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INTRODUCTION

Construction of infrastructure particularly roads and highways result in deterioration of surrounding environment and ecosystems by contributing in the emission of greenhouse gases such as CO_2 (Willmott Dixon *et al*., 2010). Pakistan like many countries in the world is severely affected by climatic change (Rasul *et al*., 2012). Recently there has been an increased emphasis on the development of roads and highways in Pakistan. Many road projects are currently being planned and constructed under China-Pakistan Economic Corridor (CPEC) (Butt and Butt, 2015).There is a desperate need to incorporate sustainable and green practices in the lifecycle of highway projects to reduce the negative impact on the surrounding environment. For this purpose. the concept of sustainable or green highways was developed and different assessment tools and rating systems were developed to assess the sustainable performance of highways. The ist rating system developed, was known as greenroads, which was developed in Washington university as a part of a research project (Muench *et al*., 2011). Other rating systems are INVEST, GreenLites, ILAST and Green Guide for Roads etc. The rating systems are unique in many ways but also share a lot of commonalities (Reed *et al*., 2009). In Pakistan, there is no rating system by means of which sustainability of highways can be evaluated. Therefore, there is a need to develop a rating system specialized in the context of Pakistan as research has shown that rating systems and assessment tools are applicable only in the region or country for which they were developed (Darus *et al*., 2009). The importance of sustainable criteria elements differ from region to region and place to place and the importance of some issues (Energy, water etc.) associated with a tool design is different across regions (Cole, 1999) (Alyami and Rezgui, 2012). The rating systems are basically a holistic frame work of sustainable criteria elements that consists of green technologies and practices that are to be used in highway projects lifecycle (Park and Ahn, 2015). The green practices and technologies include the recycling and reuse of pavement materials, reduction in energy and greenhouse gas emissions, storm water treatment, Dust control, and enhancement of social and economic benefits etc (Chavan and Phadtare, 2015). The development of a sustainable rating system requires identification of criteria elements through which sustainability of highways can be assessed (Rooshdi *et al*., 2014). The aim of this paper is to identify sustainable criteria elements particularly in the context of Pakistan for the development process of a sustainable highway rating system.

Literature Review

Sustainability or sustainable development can be defined as "development that meets the needs of the present without

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compromising the ability of the future generations to meet their own needs (Brundtland, 1987). The three pillars of sustainability are economy, society and environment (AL Shayeb, 2013). They are dependent on one another and in the long run one cannot survive without another (Morelli, 2011) The three pillars have been utilized in many certification systems related to sustainability including in roads infrastructure. Thus, a road or highway is said to be sustainable of it satisfies all the three pillars. However a complete definition of a Sustainable highway or raid can be as "Sustainable highways are ones that allow for basic access and development needs in a manner that is consistent with human and ecosystem goals, allow for transport mode and choice regardless of age and ability, are affordable, and operate efficiency – efficiently, limits emissions of – and new and non-renewable resource use and these principles are equally applicable in urban, suburban or rural areas and can be applied to all functional classifications" (Slide *et al*., 2014). Therefore, the concept of sustainability is highly valuable in roads projects as it ensures not only economic prosperity but social acceptability, environmental feasibility and institutional capability and capacity building as well, resulting in the enhancement of quality of life while also protecting natural resources and ecosystems of the plant. Thus, to ensure the implementation of sustainability in road projects, the development of a sustainable road rating system is of utmost importance to improve in the current practices of roadways construction. A rating system can result in baselining and benchmarking sustainable performance and will establish a means for decision makers to prioritize different sectors for investment. "(Slide *et al*., 2014). As mentioned earlier different rating systems have been developed to assess the sustainability of highways and roads projects, one such rating system is Greenroads. Developed in 2009 by CH2M HILL and University of Washington, Greenroads evaluates sustainability in the construction of highways by giving credits to projects having successfully integrated sustainable practices. In Greenroads rating system, the sustainable criteria elements are divided into two categories; required and voluntary (Muench et al., 2009). Majority of the credits in Greenroads are allocated towards social concerns i.e. about 25% of the achievable credits are allocated towards Access and Equity (Muench *et al*., 2011). INVEST (Infrastructure Voluntary Sustainability Tool), is another rating system developed by United States Federal Highway Administration (US-FHWA) and was launched in 2012 (FHWA, 2012).

The rating system consist of three main categories namely System Planning, Project Development and operation and maintenance. Most of the credits in the rating system are directed towards the planning phase of the project with System Planning containing 43% of the total credits. Project Development consists of 22% and Operation and Maintenance consist of 36%of the total credit points (FHWA, 2012). Similarly GreenLITES (Green Leadership in Transportation and Environmental Sustainability) was developed by New York State Department of Transportation and consists of 5 major categories with total number of 175 credits (Sherona Patrice Simpson, 2013). Green Guide for Roads was developed by Stantec in 2008 and consists of seven major Categories namely; Mobility for all, Transportation Planning, Environmental Impact, Energy and Atmosphere, Energy and Resources, Community Impact and Innovation in Design Process (Clark *et al*., 2009). Another rating system is I-LAST (Illinois Livable and Sustainable Transportation) that can be utilized in the conceptual, Design and also in construction phase of the project. ILAST consists of a total of 153 sustainable criteria elements with total credit points of 233 and eight major categories namely; Planning, Design, Environmental, Water Quality, Transportation, Lighting, Materials and Innovation (Illinois Department of Transportation, 2012). BE2ST in Highways is a rating system that consists of standardized methods of measurements such as Life Cycle Assessment and Life Cycle Cost Analysis to evaluate environmental and economic impacts respectively. It uses Analytical Hierarchy Process (AHP), which is embedded in an excel spread sheet to weigh sustainability indexes. It consists of two major criteria elements I.e. Mandatory Screening and Judgment. Evaluation of Mandatory requirements and required pre-requisite assessments are done in the screening phase. Projects must ensure the screening phase to be evaluated. Once they have met all the requirements of the screening phase, they are assessed further in the judgment phase. The Judgment layer consist of many sub criteria elements such as Greenhouse Gas Emissions, Energy use, Waste reduction (Including ex-situ materials), Waste reduction (recycling in situ materials), Water consumption, Hazardous waste, Life cycle cost, Traffic noise and social carbon cost saving etc. (Lee *et al.,* 2013).

Methodology

The objective of this research was to identify the sustainable criteria and sub criteria elements required for the development of sustainable highway rating system for Pakistan. As a result, a literature survey was conducted and different Sustainable and Green highway rating systems were reviewed and all the relevant sustainable elements were listed out, compared and then selected (Zakaria *et al*., 2012). The sustainable criteria and sub criteria elements were identified from the following sources.

1. Greenroads
2. Green Guide for Roads
3. I-LAST
4. InVest

RESULTS AND DISCUSSION

The criteria elements were identified four stages of highway projects lifecycle i.e planning, design, construction and operation and maintenance (Alsaffar and Lafta, 2016). Each stage consists of many different major criteria elements and each major criterion consists of many sub criteria elements. Similar sub criteria elements were grouped together in one major criterion. Table 1,2,3 and 4 shows the identified criteria and sub criteria elements in Planning, Design, Construction and Operation and Maintenance Stages of Highway projects lifecycle respectively.

Figure 1 shows the distribution of the identified criteria elements in the four stages according to their sources. Figure 2 shows the distribution of the identified sustainable criteria elements across the triple bottom line principle. The Identified sustainable criteria elements are almost evenly distributed across the triple bottom line as shown in the below figures which shows that the developed frame work is complete and can be used as a checklist to ensure sustainability in Highway projects life cycle of Pakistan.

Table 1. Identified Sustainable criteria and sub criteria elements of planning stage of highway projects lifecycle

S.No	Criteria	Sub criteria	Code
1	Quality of Life	Economic Impact Analysis (FHWA, 2012)	PQ1
		Social impact assessment (Alsaffar & Lafta, 2016)	PQ2
		Context Sensitive Solutions (Illinois Department of Transportation, 2012)	PQ3
2	Financing and Costing	Advance Costing Estimation and Revenue Forecasting (FHWA, 2012)	PF1
		Cost Benefit Analysis (FHWA, 2012)	PF2
		Finance and Investment Plan(Shen, Hao, Wing-Yan Tam, & Yao, 2007)	PF3
		Life cycle cost analysis (FHWA, 2012)	PF4
3	Safety	Safety Planning and Adaption strategies (FHWA, 2012)	PS1
		Hazard Identification (FHWA, 2012)	PS2
		Vulnerability Assessment (FHWA, 2012)	PS3
		Risks Assessment/Management Plan (FHWA, 2012)	PS4
3	Management and Planning	Land Use Planning (Illinois Department of Transportation, 2012)	PM1
		Comprehensive Transportation Plan (Clark *et al*., 2009)	PM2
		Freights and Goods Movement Planning (FHWA, 2012)	PM3
		Linking Asset Management and Planning (FHWA, 2012)	PM4
5	Energy and Environment	Evaluating Energy Needs and renewable energy policies (Saeed Balubaid *et al*., 2015; Shen *et al*., 2007)	PE1
		Emissions Reduction Plan (FHWA, 2012)	PE2
		Noise Assessment and Mitigation Plan (Alsaffar & Lafta, 2016; Shen *et al*., 2007)	PE3
		Environmental Impact Assessment (Alsaffar & Lafta, 2016; Jay, Jones, Slinn, & Wood, 2007)	PE4
		Site Vegetation Plan (FHWA, 2012)	PE5
		Flow Control plan (Muench *et al*., 2011)	PE6
		Low Impact Development (Muench *et al*., 2011)	PE7
		Storm Water Cost Analysis (Muench *et al*., 2011)	PE8
		Plan for Water quality treatment and Water Bodies Protection (Alsaffar & Lafta, 2016)	PE9

Table 2. Identified Sustainable criteria and sub criteria elements of design stage of highway projects lifecycle

S.No	Criteria	Sub criteria	Code
1	Alignment Selection	Avoid Impact to ecological and Environmental Sensitive areas (Illinois Department of Transportation, 2012)	DA1
		Avoid impacts to socioeconomic resources (Illinois Department of Transportation, 2012; S. Muench *et al*., 2011)	DA2
		Minimizing earth work or performing earth work balance (Illinois Department of Transportation, 2012; Muench *et al*., 2011)	DA3
2	Safety	Design Speed (Clark *et al*., 2009)	DS1
		Separation of Mode (Clark *et al*., 2009)	DS2
		Conflict Points (Clark *et al*., 2009)	DS3
		Road Safety Audit (Clark *et al*., 2009)	DS4
3	Transportation Planning	Optimum Level of Service (Clark *et al*., 2009)	DT1
		Context sensitive design (Illinois Department of Transportation, 2012)	DT2
		Special Use HOV or Reversible Lanes (Clark *et al*., 2009)	DT3
		Transit Facilities (Clark *et al*., 2009)	DT4
		Bicycle lanes, parking and Facility Design (Clark *et al*., 2009)	DT5
		Pedestrian Paths and Facility Design (Clark *et al*., 2009)	DT6
		Parking Management (Clark *et al*., 2009)	DT7
		Innovative intersection/Interchange Design (Clark *et al*., 2009)	DT8
4	Pavement Technologies	Long life Pavement Design (Muench *et al*., 2011)	DP1
		Use of Recyclable Materials in Mix Design (Muench *et al*., 2011)	DP2
		Permeable Pavement (Muench *et al*., 2011)	DP3
		Use of WMA (Warm Mix Asphalt) Technologies in Design (Muench *et al*., 2011)	DP4
		Design to reduce urban heat island effect (Cool Pavements) (Muench *et al*., 2011)	DP5
		Quiet Pavement Design (Muench *et al*., 2011)	DP6
5	Energy and Environment	Road Energy Systems (Saeed Balubaid *et al*., 2015)	DE1
		Reduce Impervious Area (Protection of Water bodies) (Illinois Department of Transportation, 2012)	DE2
		Design Practices to protect Water Quality (Storm Water BMPs) (Illinois Department of Transportation, 2012)	DE3

Table 3. Identified Sustainable criteria and sub criteria elements of construction stage of highway projects lifecycle

S.No	Criteria	Sub criteria	CODE
	Safety	Construction Safety (Shen *et al*., 2007)	CS1
1		Public Safety (Shen *et al*., 2007)	CS2
		Road Safety Audit (Construction Stage) (Muench *et al*., 2011)	CS3
	Management	Traffic Maintenance Plan (Clark *et al*., 2009)	CMP1
2	and Planning	Quality Control Plan (FHWA, 2012; Muench *et al*., 2011)	CMP2
		Quality Management System (Muench *et al*., 2011)	CMP3
		Contractor Warranty (Muench *et al*., 2011)	CMP4
		Construction management plan (Alsaffar and Lafta, 2016)	CMP5
		Local Materials (Muench *et al*., 2011)	CM1
3	Materials	Certified Suppliers (Illinois Department of Transportation, 2012)	CM2
		Waste Management Plan and Implementation (Muench *et al*., 2011)	CW1
4	Waste Management	Site Recycling Plan (FHWA, 2012)	CW2
		Environmental Training Plan (Muench *et al*., 2011)	CE1
		Environmental Management System (Muench *et al*., 2011)	CE2
		Land Disturbance (Illinois Department of Transportation, 2012)	CE3
5	Environmental Management	Equipment Spill Impact Prevention (Illinois Department of Transportation, 2012)	CE4
		Invasive Species Prevention (Illinois Department of Transportation, 2012)	CE5
		Minimize Soil Compaction (Illinois Department of Transportation, 2012)	CE6
		Wetland and Greenspace Protection (Illinois Department of Transportation, 2012)	CE7
		Habitat Restoration (Muench *et al*., 2011)	CE8
		Vegetative Re-establishment (Illinois Department of Transportation, 2012)	CE9
	Water	Reduction in use of Potable Water (Ghisi, Montibeller, & Schmidt, 2006; Illinois Department of Transportation, 2012)	CWT1
6	Management	Erosion and Sediment Control (Illinois Department of Transportation, 2012)	CWT2
		runoff reduction and storm water control.(Illinois Department of Transportation, 2012)	CWT3
		Storm water treatment and protection of water quality during construction(Illinois Department of Transportation, 2012)	CWT4
		Fossil Fuel reduction (Muench *et al*., 2011)	CEA1
	Energy and	Equipment emission reduction (Muench *et al*., 2011)	CEA2
7	Atmosphere	Paving emission reduction (Muench *et al*., 2011)	CEA3
		Noise and Vibration control and mitigation (FHWA, 2012)	CEA4
		Dust Control (Alsaffar and Lafta, 2016)	CEA5

Table 4. Identified Sustainable criteria and sub criteria elements of operation and maintenance stage of highway projects lifecycle

S.No	Criteria	Sub criteria	Code
1	Quality of life	Employment and Business Opportunities (Shen *et al*., 2007)	OQ1
		Educational Outreach (FHWA, 2012)	OQ2
		Provision of Services and Facilities (Shen *et al*., 2007)	OQ3
2	Safety	Traffic Law Enforcement (Verma, Velumurugan, Chakrabarty, & Srinivas, 2011)	OS1
		Safety Management (FHWA, 2012)	OS2
		Emergency Management and Incident management (FHWA, 2012)	OS3
		Awareness Building (FHWA, 2012)	OS4
		warning signs (Jørgensen and Wentzel-Larsen, 1999)	OS5
3	Management and Planning	Bridge Management System (FHWA, 2012)	OM1
		Internal Sustainability Plan (FHWA, 2012)	OM2
		Pavement Management system (FHWA, 2012)	OM3
		Road Maintenance Plan (FHWA, 2012)	OM4
		Maintenance Quality assurance and management system (FHWA, 2012)	OM5
		Traffic Control Maintenance Plan (FHWA, 2012)	OM6
		Waste Management (Washington State Department of Transportation, 1993)	OM7
		Work Zone Traffic Control (FHWA, 2012)	OM8
4	Transportation Management and Operations	Traffic Management System (FHWA, 2012)	OT1
		Transit Management System (FHWA, 2012)	OT2
		Traveler Information System (FHWA, 2012)	OT3
		Road Weather Management Program (FHWA, 2012)	OT4
		Commercial Vehicle Operation System and Networks (FHWA, 2012)	OT5
5	Energy and Environment	Pavement Reuse (FHWA, 2012; Muench *et al*., 2011)	OE1
		Recycling Materials (FHWA, 2012; Muench *et al*., 2011)	OE2
		Lighting Energy Efficiency (Clark *et al*., 2009)	OE3
		Environmental Commitment Tracking System (Muench *et al*., 2011)	OE4

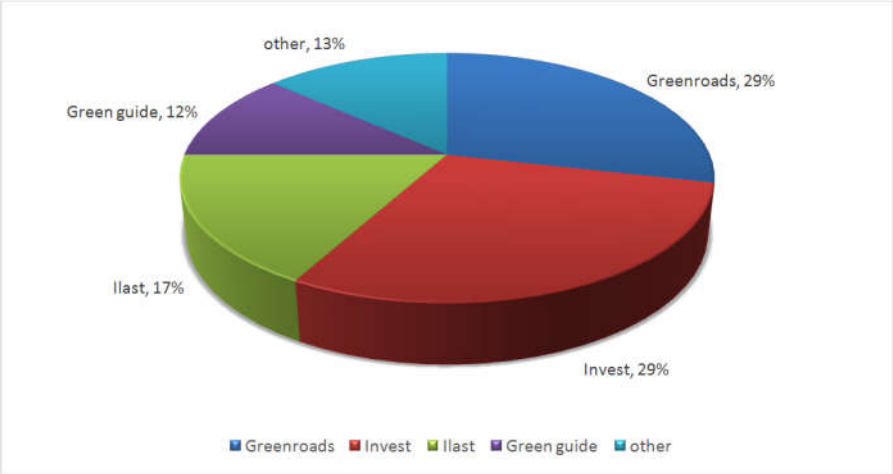

Figure 1. Percentage distribution of identified criteria elements according to their source

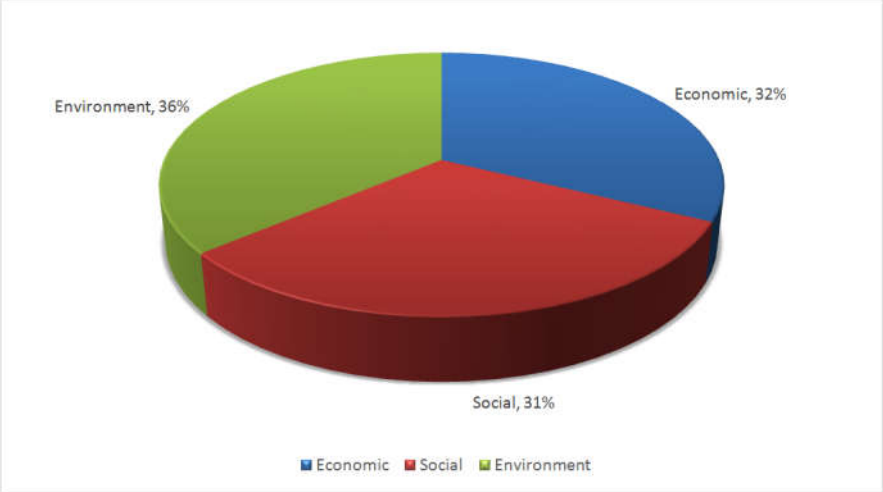

Figure 2. Percentage distribution of finalized criteria elements across the triple bottom line principle

Conclusion and Recommendations

This research proposes a list of criteria and sub criteria elements for Sustainable Highways in their Planning, Design, Construction and Operation and Maintenance Stages by means of exploring the sustainable requirements of different current existing rating systems such as Green roads, INVEST, Green Guide for Roads, and I-LAST etc. As discussed earlier, the lists consisting of the finalized criteria elements, almost equally cover all the three pillars of sustainability i.e. social, environmental and Economic. The identified criteria elements can also be used to satisfy many sustainable development goals 2030 directly or indirectly (UN-Habitat; UNEP; SLoCaT, 2015) (United Nations, 2016). It is recommended to determine relative aggregate weight age of each sustainable criteria and sub criteria element by means of Multi Criteria Decision Analysis techniques in order to develop a rating system specialized in the context of Pakistan.

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