Sustainable Roadway Planning: A Model for a Proposed Rating System in Iraq

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ABSTRACT

The goal of the research is to develop a sustainable rating system for roadway projects in Iraq for all of the life cycle stages of the projects which are (planning, design, construction and operation and maintenance). This paper investigates the criteria and its weightings of the suggested roadway rating system depending on sustainable planning activities. The methodology started in suggesting a group of sustainable criteria for planning stage and then suggesting weights from (1-5) points for each one of it. After that data were collected by using a closed questionnaire directed to the roadway experts group in order to verify the criteria weightings based on the relative importance of the roadway related impacts that each credit addresses. Statistical analysis for expert's answers have been evaluated by using factor analysis method to ensure the compatibility and validity of credits selected for the rating system and the actual weights conducted for each criteria by using the factor analysis method by using SPSS program V.19. Finally the researcher put the details for each criterion that contain from aim, requirements and strategies. The researcher reached to that the study of the all life cycle stages is important to make a clear comparison between the roles of the criteria in different stages.

Keywords: rating system; sustainable criteria; sustainable planning.

التخطيط المستدام لمشاريع الطرق: نموذج نظام تقييم مقترح في العراق

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الخلاصة

الهدف من هذا البحث هو تطوير نظام تقييم مستدام لمشاريع الطرق في العراق لجميع مراحل دورة حياة المشاريع التي تشمل (التخطيط والتصميم والبناء والتشغيل والصيانة). يتضمن البحث تحديد المعايير والأوزان لنظام تقييم الطرق المقترح اعتمادا على فعاليات مرحله التخطيط المستدام . بدأت المنهجية في اقتراح مجموعة من المعايير المستدامة لمرحلة التخطيط ثم اقتراح الأوزان من (1-5) نقاط لكل معيار منها، بعد أن تم جمع البيانات باستخدام استبيان مغلق موجه الى مجموعة خبراء مختصين من أجل التحقق من الأوزان و المعايير التي تقوم على اهمية المعيار وتأثيره على المشروع . تم عمل التحليل الإحصائي بعد الحصول على إجابات الخبراء باستخدام طريقة تحليل العوامل لضمان التوافق وصحة الاعتمادات المحددة لنظام التصنيف والأوزان الفعلية التي أجريت لكل المعايير باستخدام أسلوب تحليل العوامل بواسطه برنامج التحليل الاحصائي (SPSS,V.19) وأخيرا تم وضع التفاصيل لكل المعايير والتي تتكون من الهدف والمتطلبات والاستراتيجيات. توصل الباحث الى ان دراسة دورة حياة المشروع كامله في مثل هذه المواضيع مفيدة جدا من الناحية العملية لأن المقارنة بين ادوار المعايير في المراحل المختلفة ستكون اوضح.

الكلمات المفتاحية: نظام التقييم , المعايير المستدامة , التخطيط المستدام

1. INTRODUCTION

In earlier decade, sustainable development idea has grown up from numerous environmental movements. Recently sustainable issues have been widely discussed especially in construction industry.

Sustainable development is a key issue in order to meet the environmental objectives and fulfills the demand of the large infrastructure projects due to increasing numbers of population growth and urban density, **Constandopoulos,** and **Nation, 2010**.

The decisions regarding the location, type, timing, feasibility or other planning level ideas are excluded. While planning is fundamental to roadway and community sustainability, these decisions are often too complex or political to be adequately defined by a point-based performance metric, **Stephen**, and **Jeralee, 2009**.

The green highway rating system was introduced to determine the level of greenery and environmental friendly of the highway. Since roads run through the landscape, road have point source impact and linear effect. Greenroads is the first green highway rating system that has been established in United States. It is a voluntary third party rating system for road project which seeks to recognize and reward the roadway projects that exceed the public expectation for environmental, economic and social performance. Washington Internship for Students Engineering (WISE) has introduced the green highway rating system. The rating system is to make sure the highway design is sustainable, environmental friendly and giving less impact of environment damage which can be used for developing and classifying an environmentally and economically sustainable highway, **WISE**, **2011**.

Nowadays, green rating system becomes a popular tool to confirm the green credential of building. Most countries have developed their own green building rating system. The countries that already have the rating system are United States, Canada, Australia, United Kingdom, Hong Kong, Japan, Taiwan, Singapore, Philippine, European, Korea, India and Australia. Malaysia also owns the green building rating system which is GBI. With the successful implementation of green building rating system, the rating system has been widened into the highway. There are three rating system for the highway that has been found which is Greenroads, Green Leadership in Transportation and Sustainable (GreenLITES) and Illinois-Livable and Sustainable Transportation (I-LAST), **Raffia,** and **Rooshdi**, **2013**.

Sustainable planning could minimize the impacts of the roadway projects on the environment. Costing, safety, health, management, siting, water, energy are the most important factors that should be highlighted in the sustainable rating system through the project life cycle. The evaluation for the sustainable roadway is not yet available in Iraq and this paper seeks to address this problem.

2. CRITERIA

As development of criteria for green highway, there were several green rating tools which are Greenroads, GreenLITEs, I-LAST and INVEST that had been reviewed as a summary of green highway criteria.

The above rating systems have similarities and differences. Specifically, all of sustainability rating systems are applicable to the planning and design phases of projects. Only GreenLITES, Greenroads and INVEST are applicable to the construction phase; and only GreenLITES and INVEST are applicable to the operations and maintenance phases of a project. I-LAST is

currently developing a sub-system applicable to the construction phase. The all rating systems are only applicable to highway projects, **Caroline, et al., 2013**.

There are some common criteria that can be found in every green rating system such as sustainable site, water efficiency, energy efficiency, materials and resources and innovation. The sustainable criteria includes of geometrics and alignment, earthworks, pavement, drainage, slope protection, landscape ecology, transportation facilities, maintenance, sound insulation, electrical, mechanical and lighting. These criteria were different in every project according to the country circumstances, **Raffia,** and **Rooshdi, 2013**.
The rating system consist the explanation of different certification levels and the total points that are needed to obtain them. Starting with the least green to exceptional green, most of the certifications are distinguished by four different levels, **Clark, et al., 2009**.

For Greenroads the certification levels are as follows:
Certified: All Project Requirements + 32 - 42 Voluntary Credit points
Silver: All Project Requirements + 43- 53 Voluntary Credit points
Gold: All Project Requirements + 54- 63 Voluntary Credit points
Evergreen: All Project Requirements + 64+ Voluntary Credit points

For GreenLITES the certification levels are (GreenLITES Certified, GreenLITES Silver, GreenLITES Gold and GreenLITES Evergreen awards) and so on.

Therefore, this paper attempts to identify the criteria for sustainable planning stage according to the most popular rating system manuals and (the World Bank reports) by depending on their working concepts in road projects and also criteria identification depend on roadway experts' opinions.

3. METHODOLOGY

3.1 The Closed Questionnaire

The absence of a system depends on the application of the sustainability concepts in the evaluation of the lifecycle of roadway projects in Iraq was the reason for thinking through this research to find the appropriate method for the selection of the main criteria and sub-criteria in a suggested rating system specifically planning stage. The development of these criteria is largely based on conducting a comprehensive literatures review and reports for sustainable roadway. Criteria related to sustainable project in planning stage activities in many green roadway rating systems have been chosen depending on literature review and the country circumstances that are related to the environmental, social and economical impacts. The criteria selected in the questionnaire have been discussed among the experts to select the most appropriate criteria by making the questionnaire checklist flexible and the expert can add, remove or modify on any criteria according to his/her opinion. They would share their experience, opinion and suggestion on the best criteria in sustainable planning stage activities. **Table 1** shows the profile of the respondents. The survey indicates that, 17.5% of respondents have more 21 years' experience followed by 82.5% of them has at least 7 years' experience. This shows that the respondents have an extensive experience, which helps to provide this study with reliable data.

World Bank reports in addition to other references have been used as a guide for the similar criteria in indicating the criteria for this research. **Table 2** shows the suggested criteria and sub criteria for sustainable planning stage activities and the weights suggested by the researcher.

3.2 Discussion of the Questionnaire Results

After returning the questionnaire results, the researcher tried to organize the weights that most of the experts agreed on it, for each criterion during the planning stage to present an initial idea for the weights for each criterion before the statistical analysis which is made by using SPSS program V.19. **Table 3** shows the percentage of the maximum respondent answers for each criterion and the weight that most of the experts agreed on it in planning stage.

3.3 Statistical Analysis of Criteria Weightings

Once the criteria had been finalized through questionnaires and expert opinions, the data had been analyzed using factor analysis method to produce mean index and factor loading for each criterion to have the actual weight at the end of the analysis process. The final model of the suggested rating system consisted of 11 criteria for planning stage. Reliability test were done in the beginning of the section analysis due to check the reliability of data to be analyzed for planning stage where the Cronbach's Alpha computed in Eq. (1):

$$Alpha = [n/(n - 1)] \times [(Vart - \Sigma Vari)/Vart] \quad (1)$$

where Alpha = estimated reliability of the full-length test, n = number of items, Vart = variance of the whole test (standard deviation squared), and ΣVari = sum the variance for all n items.
This data set show Cronbach's Alpha is 0.834 for planning stage.
There is high internal consistency for the data set which the Cronbach's Alpha is more than 0.7, **Hair, et al., 2010**.
Then the data were analyzed by using Kaiser-Meyer-Olkin measure of sampling (KMO) to test the sampling adequacy where KMO index computed in Eq. (2):

$$KMO = (\sum\sum r^2\_ij)/(\sum\sum r^2\_ij + a^2\_ij),\ i \neq j \quad (2)$$

where the correlation matrix is $R = [r_{ij}]$ and the partial covariance matrix is $A = [a_{ij}]$.
The KMO ranges from (0-1) with higher values indicating greater suitability, and greater than 0.750 is much better, **Raffia,** and **Rooshdi**, **2013**. The KMO value is 0.853 for the data of planning stage.
As suggested that accepting values greater than 0.5 is acceptable, **Kaiser, 1974**. And the values of KMO between 0.7 until 0.8 is good, **Hutcheson,** and **Sofroniou, 1999**
Planning stage has three factors had eigenvalues over Kaiser's criterion of 1. **Table 4** shows the factor loadings for planning stage.
In weighting the criteria, the factor loading had been multiplied with mean index as shows in Eq.(3):

$$Actual\ weight = factor\ loading * mean\ index \quad (3)$$

Factor loading shows the important of these criteria in the planning stage and the mean index shows the level agreement of respondents towards those criteria. By combining the important and level of agreement of each criterion, **Table 5** shows the mean and the weightage of each criterion.

4. SUGGESTED ACTIONS FOR ROADWAY RATING SYSTEM "PLANNING STAGE"

The planning stage contained 11 criterion that the researcher conducted depending on the researches and the world bank reports that are compatible with Iraq circumstances as much as sustainable planning need for roads projects and each one of it consisted from aim of it, requirements that need to meet this criteria and strategies that could conduct it to have this criteria and also the actual weight that the researcher reached to it after the statistical analysis for each criterion. **Fig.1** to **Fig. 10** shows the details for the criteria of planning stage.

5. ROADWAY RATING SYSTEM "PLANNING STAGE" VERIFICATION

The verification process based on the questionnaire attached with the suggested rating system for sustainable roads project "planning stage" that the researcher suggested it previously with the criteria details, weights of it, and the amount of the criteria suitability.

The survey process contains fifteen evaluator (five experts from Iraq and ten experts from outside of Iraq) who has related to the fields of roads projects, the verification process contains seven questions to evaluate the suggested SRSI for planning stage; the answering of these questions contain three answers (Yes, No and Yes with suggestion) to reflect the experts (evaluators) opinions about the applicability of the system and system components, the required modification through the suggestions pointed out by the respondents, or the system components not applicable or unrealistic for planning stage.

Table 6 shows the verification process for planning stage.

6. CONCLUSIONS

1. The study of the all life cycle in this type of subjects is necessary because the comparison between the criteria in more than one stage must be the clearest.

2. Green highway classifications will help transportation planning officials to have a clearer understanding of techniques and incentives for maximizing sustainable efforts.

3. From the verification process the following conclusions founded:

    - The costing criteria should study planning, construction and operation and maintenance stages.
    - The risks criteria should be considered later in planning stages.
    - The quality management system is important criterion and it should be highlighted in all the life cycle stages

7. RECOMMANDATIONS

1. It's recommended to dependence the suggested rating system (SRSI) by one of the establishment who has relevant with the roads projects such as the Iraqi directorate for roads and bridges.

2. The sustainability aspects should be adopted during the construction of the roadway projects, because of its importance on environment, economic and social life in Iraq.

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Table 1. Respondent's designation and years of experience.

Position	**Experience**			
	Less than 7 years	7-14 years	15-21 years	More than 21 years
Manager	0	0	5	2
Consultant	0	0	4	3
Resident Engineer	0	14	10	2
	0.0%	35%	47.5%	17.5%

Table 2. Criteria and sub criteria for planning stage.

Planning Stage			
Criteria	Sub Criteria	Suggested Weights	Description
1. Costing plan	Costing plan	1 point	To analysis the cost during the life cycle of the project at the early stage of the plan
	Life cycle cost analysis	1 point	
2. Safety and Health	Risks management plan	1 point	To show the amount of reduction in risks during the project life
	Safety improvements	1 point	
	Workers safety audit	1 point	
3. Management and Planning	Environmental and social impact analysis	1- 3 points	To describe the management facilities that should provide in the planning concepts
	Quality control plan	1 point	
4. Siting-position selection		1 point	To describe the accuracy in alignment selection during the planning stage
4. Energy		1 point	To describe the amount of reduce in material energy emissions and try to encourages the efficient use of energy resources

Table 2. Continued .

Planning Stage			
Criteria	Sub Criteria	Suggested Weights	Description
6. Water		1 point	Improve stormwater quality from the impacts of the project and control the flow to minimize their erosive effects on receiving water bodies and related water resources
7. Waste management plan	Construction and demolition Waste management plan	1 point	Create an accounting and management plan for roadway construction and demolition waste materials

Table 3. Maximum respondent answers for planning stage.

Max. Percentage Respondents Answers		Planning Criteria
57.50%	1 point	Life cycle cost analysis
57.50%	1 point	Costing plan
52.50%	1 point	Risks management plan
55%	1 point	Safety improvements
50%	1 point	Workers safety audit
100%	3 points	Environmental and social impact analysis
57.50%	1 point	Quality control plan
100%	1 point	Sitting position selection
100%	1 point	Energy
100%	1 point	Water
60%	2 points	Construction and demolition waste management plan

Table 4. The factor loading for the sub criteria of planning stage.

Criteria	Categories		
	1	2	3
Safety improvements	.960	.069	—
Costing plan	.927	.140	—
Life cycle cost analysis	.890	-.116-	—
Quality control plan	.889	.005	—
Risks management plan	.886	.050	—
Workers safety audit	.752	-.159-	—
Construction and demolition waste management plan	-.021-	.990	—
Siting position selection	—	—	—
Energy	—	—	1
Water	—	—	1
Environmental and social impact analysis	—	—	1
			1

Table 5. The mean and the actual criteria weights for planning stage.

Criteria	Mean	Actual weighting = Factor loading * Mean
Safety improvements	1.4500	1
Costing plan	1.4250	1
Life cycle cost analysis	1.4250	1
Quality control plan	1.4250	1
Risks management plan	1.5250	1
Workers safety audit	1.5500	1
Construction and Demolition Waste Management Plan	1.6000	1
Siting position selection	1.0000	1
Energy	1.0000	1
Water	1.0000	1
Environmental and social impact analysis	3.0000	3

Table 6. Summary of evaluating planning stage verification results.

Verification Questions	Yes	No	Yes with suggestion	Suggestions
Are the four project requirements discussed for planning stage complementary for the roads projects in that stage?	86%	14%	__	
About the costing criteria, can it found otherwise planning stage for more benefits?	21%	13%	66%	According to sustainability aspects this criterion should found in construction and O&M
For safety and health criteria in planning stage, Are the sub criteria of it from the sustainability seen adequate or not?	67%	33%	__	
For the siting position selection criteria in planning stage, are the requirements of it comprehensive for the sustainability needs in that side or not?	75%	10%	15%	Agreed, but it should has sub division for more details and benefits
Are the requirements and strategies of the energy criterion in planning stage achieving the sustainability requirements or not?	80%	20%	__	
For water criterion in planning stage, is the best management practice strategies of this criterion adequate or not?	54%	16%	30%	Agreed and it prefer to link with the sustainable strategies
Is the planning stage criteria's conducted the important sides of sustainability that can found in this stage?	73%	13%	14%	Agreed, but the researcher could discuss the risks in planning stage.

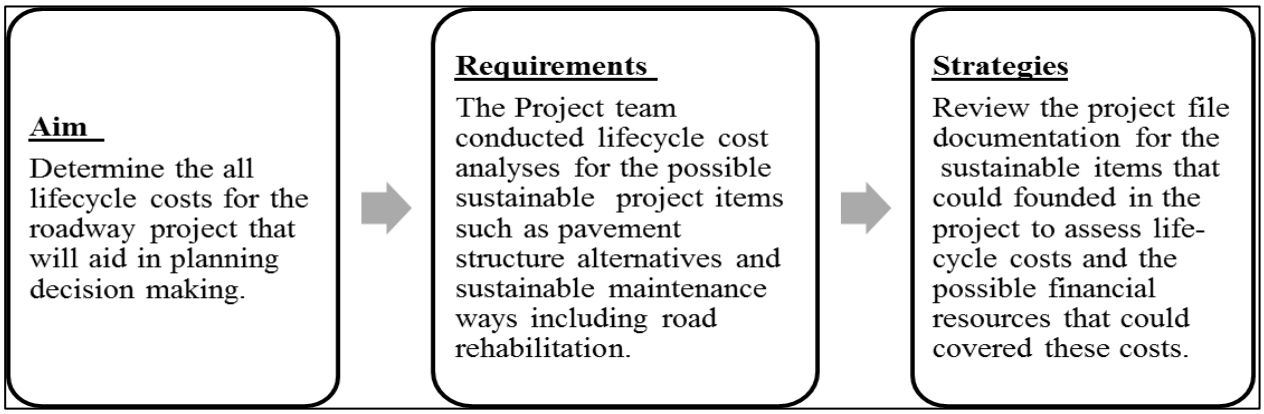

Figure 1. The details for life cycle cost analysis criterion in planning stage.

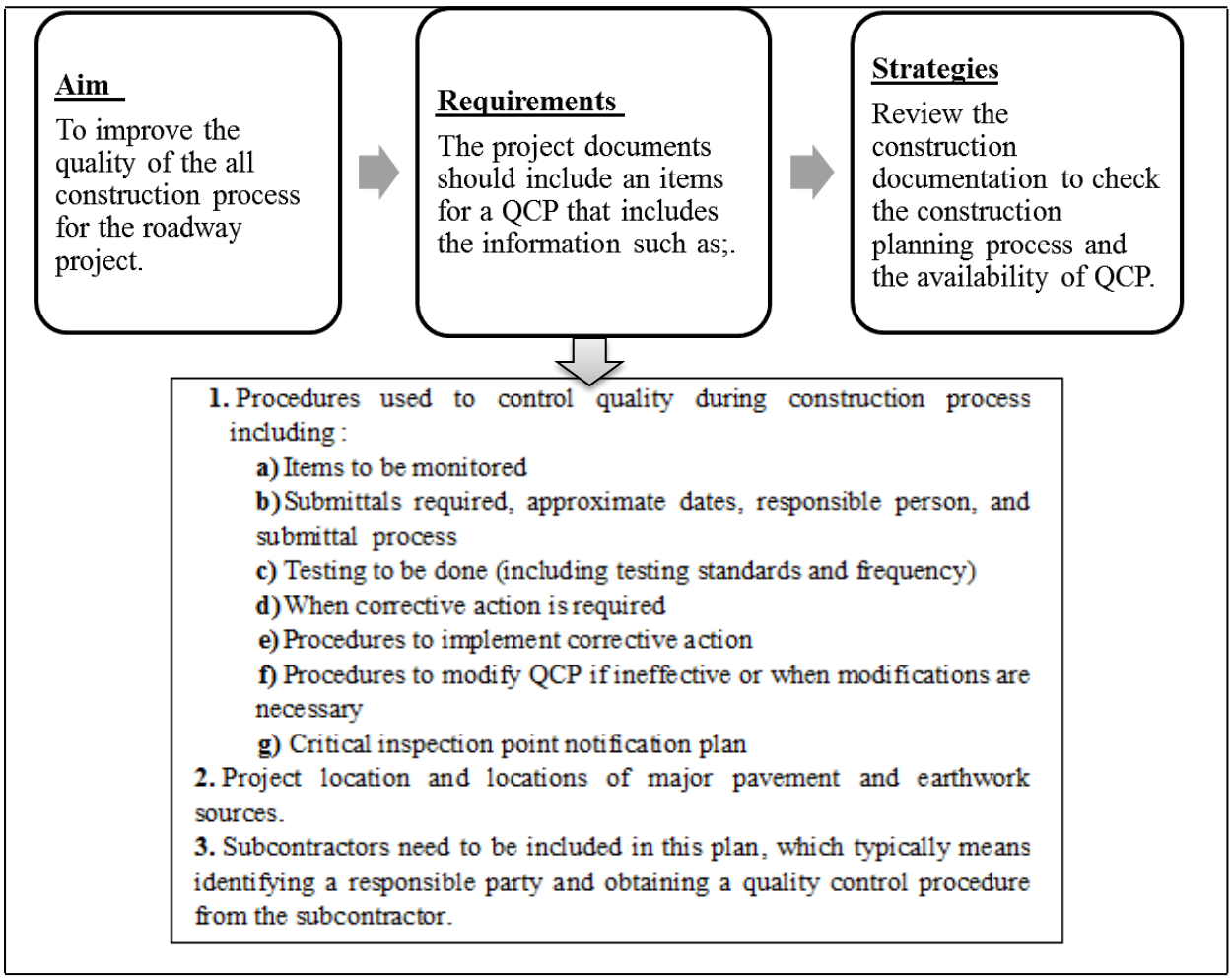

Figure 2. The details for quality control plan criterion in planning stage.

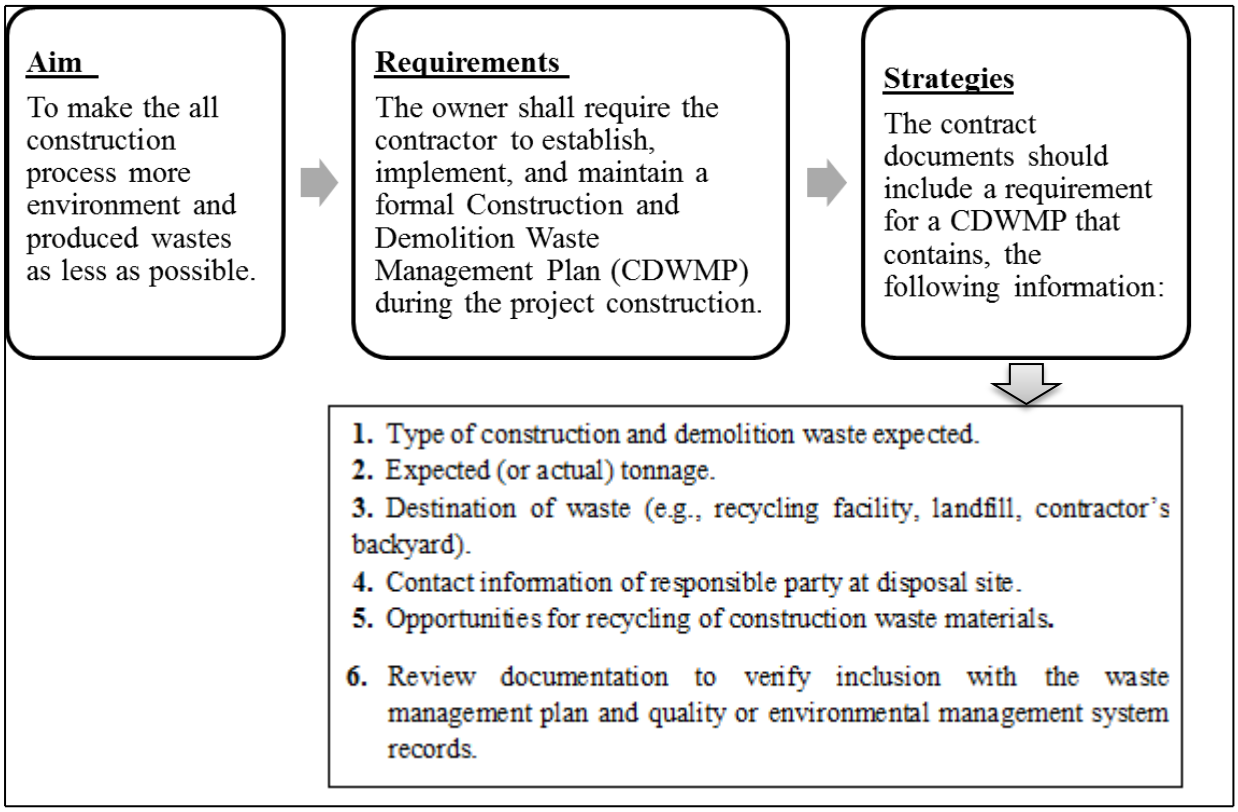

Figure 3. The details for construction and demolition waste management plan criterion in planning stage.

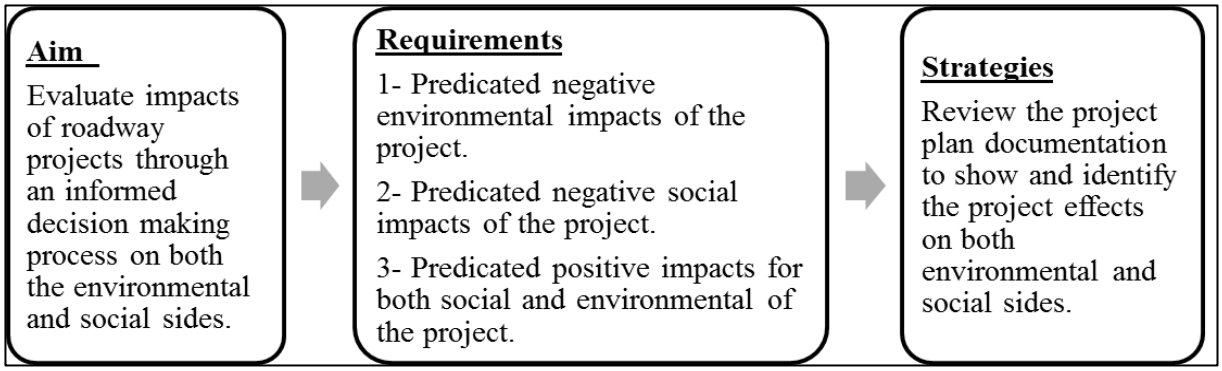

Figure 4. The details for environmental and social impact analysis criterion in planning stage.

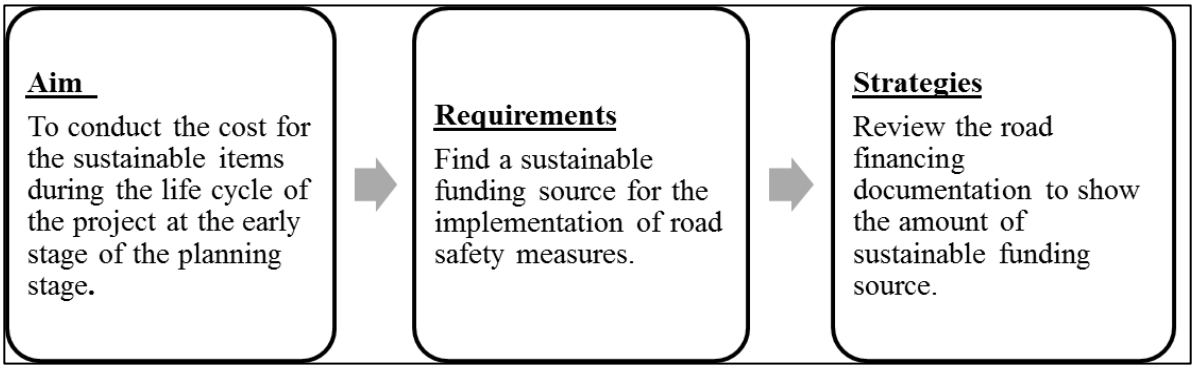

Figure 5. The details for costing plan criterion in planning stage.

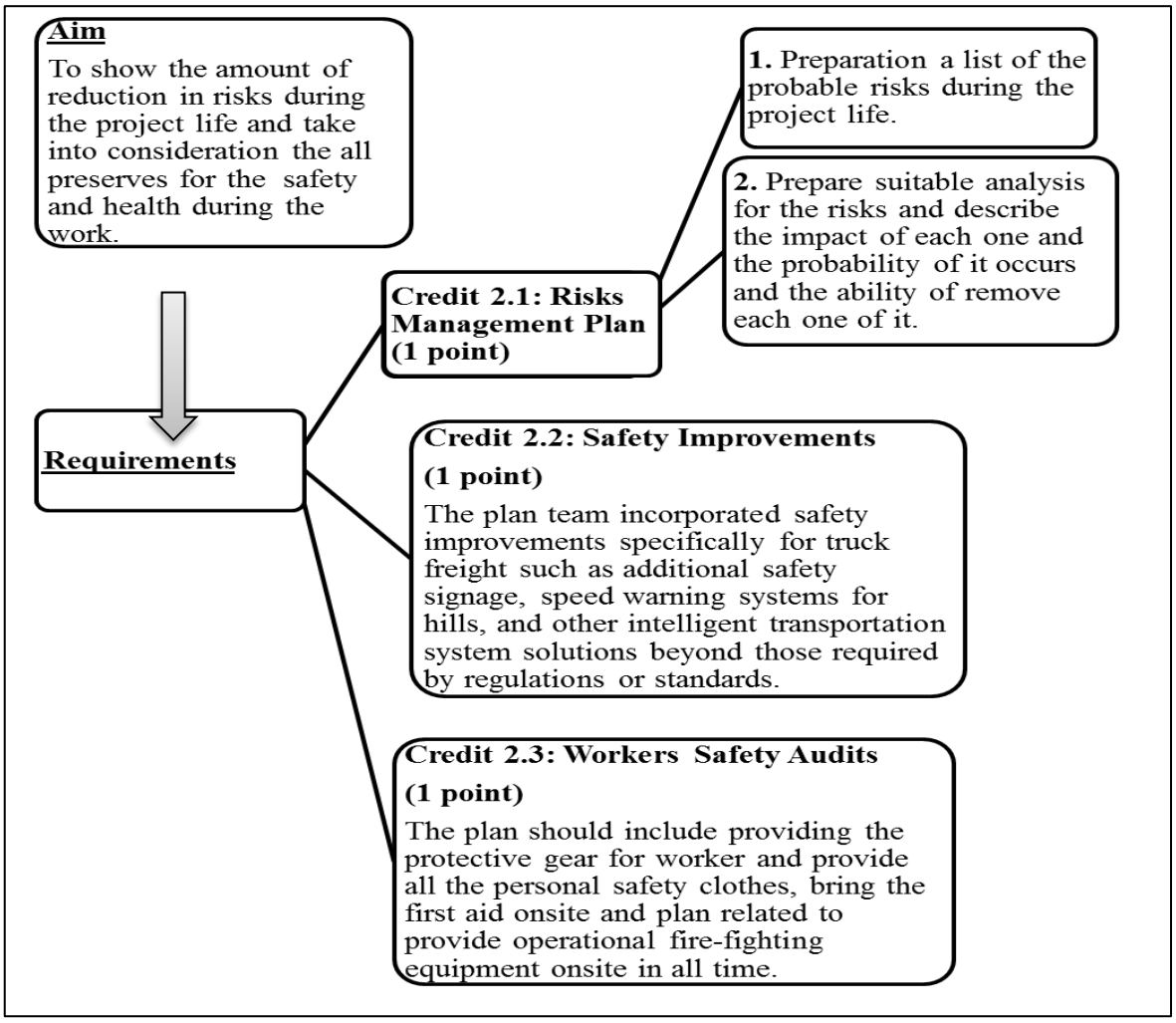

Figure 6. The details for safety and health criteria in planning stage.

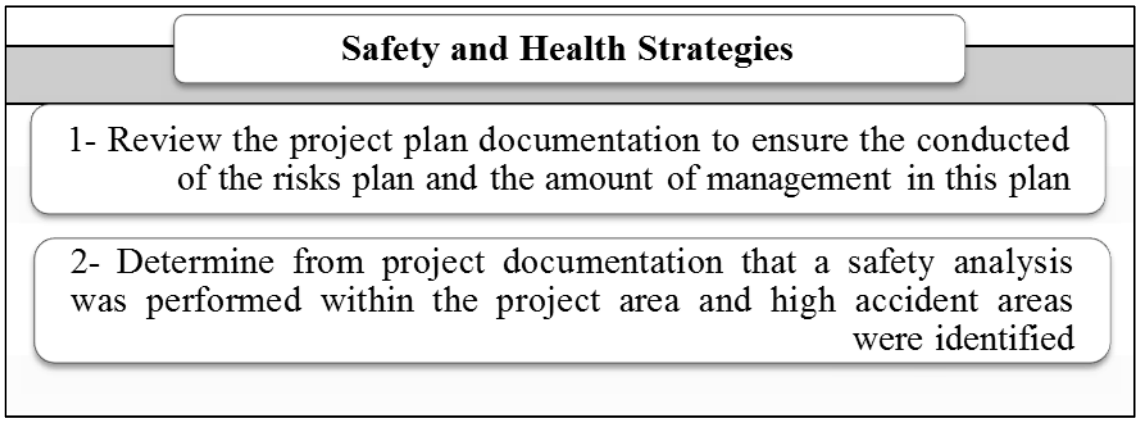

Figure 7. Strategies details for safety and health criteria in planning stage.

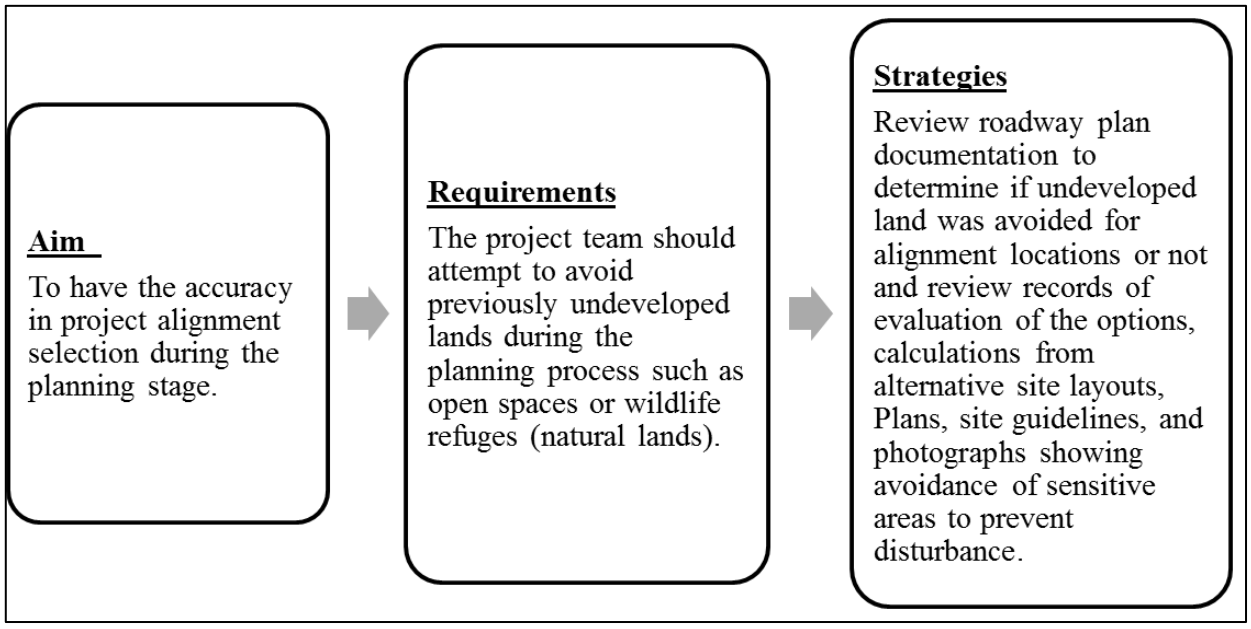

Figure 8. The details for siting position selection criterion in planning stage.

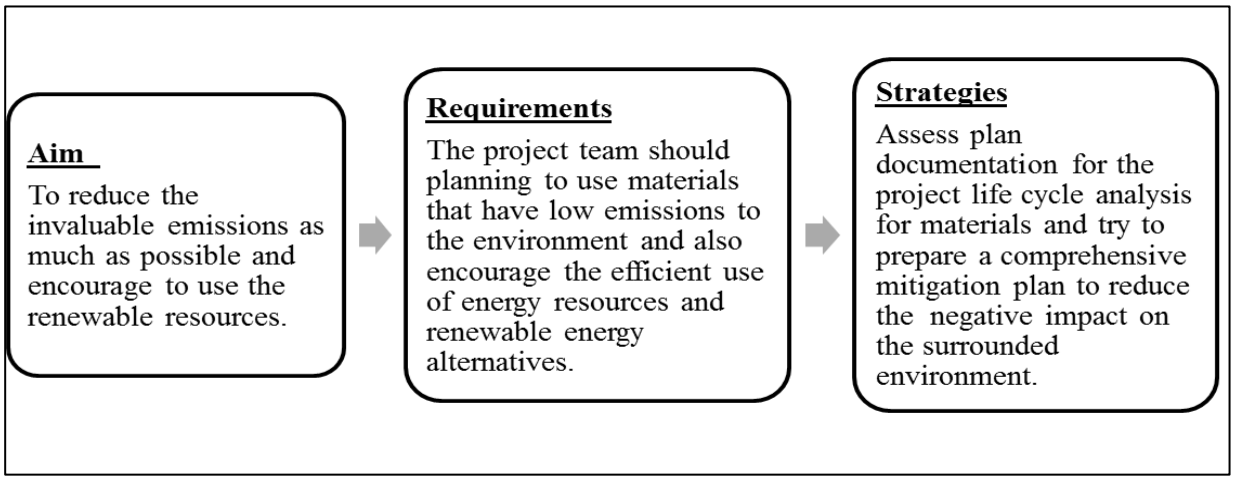

Figure 9. The details for energy criterion in planning stage.

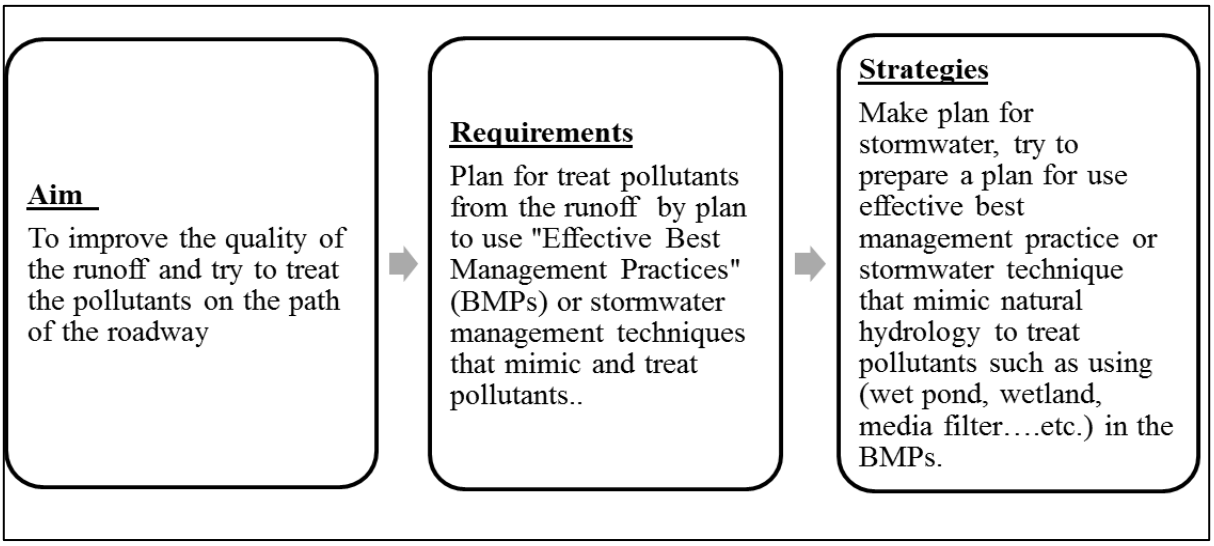

Figure 10. The details for water criterion in planning stage.