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Sustainable Infrastructure Development Approach in the Construction and Maintenance of Road and Bridge Sector of Nepal

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Abstract:

Sustainable infrastructure development approach is the most important aspect for the development of infrastructure. This study emphasized to promote sustainability for the overall development and analyze this aspect in the perspective of rural road bridge sector of Nepal. This approach relates to the environmental, socioeconomic, ownership, livelihood and sustainability aspects of the project area. Infrastructure development is very easy, but the sustainability after development is the key issue which has to address by the infrastructure projects. Sustainable infrastructure development is one of the major components to compete sustainability. Many sub-components to ensure sustainability identified and tested in this study and presented data and analysis accordingly.

Key words: Rural Infrastructure, Sustainability, Sustainable Construction, Sustainable Development, Sustainability Approaches

1. Introduction

Sustainable development had its birth when the term 'sustainability' was first used in the United States in its National Energy Policy Act 1969. However, it was only in the late 1980s that the concept of sustainable development gained momentum, following the publication of the Bruntland Report of the World Commission on Environment and Development (WCED, 1987). This international effort shows that the world has begun to realize the importance of conservation of natural resources and environmental quality, given the specific evidence on the critical depletion of the environment that has started to threaten the well-being of mankind both present and future.

The Brunt Land Report states that development is sustainable when it meets the needs of the present without compromising the ability of future generations to meet their own needs.' Since then, this quote has become a principal reference for sustainable development initiatives, world-wide. The report also suggests seven strategies for its implementation that include (1) Reviving growth; (2) Changing the quality of growth; (3) Meeting the essential need for job, food, energy, water and sanitation; (4) Ensuring a sustainable level of population; (5) Conserving and enhancing the resource base; (6) reorienting technology and managing risk; and (7) Merging the Environment and economy in the decision-making process (Langston, 1997).

Subsequently, The United Nations Conference on Environment and Development (UNCED) echoed the noble objectives of sustainable development by announcing The Rio Declaration on Environment and Development, agreed to by world leaders in 1992. Accordingly, Agenda 21 was adopted as an action plan to pursue the principles of sustainable development into the next century. Agenda 21 for Sustainable Construction in Developing Countries appropriately highlighting the points that the economic aspects of sustainability require the development of an economic system that facilitates equitable access to resources and opportunities, and to the fair sharing of a finite ecologically productive space (Du Plessis, 2002). This involves the continuous process of maintaining a dynamic balance between the needs and demands of people for equity, prosperity and quality of life, while maintaining a healthy ecology.

With specific reference to the construction industry covering both buildings and civil engineering works, the Agenda 21 provides the following description of sustainable construction:

Sustainable construction means that the principles of sustainable development are applied to the comprehensive construction cycle from the extraction and beneficiation of raw materials, through planning, design and construction of buildings and infrastructures, until their final deconstruction and management of the resultant waste. It is a holistic process aiming to restore and maintain harmony between the natural and built environment, while creating settlements that affirm human dignity and economic equity.

Hopwood et al. (2005) argue that the concept of sustainable development is the result of the growing awareness of the global links betweensocioeconomicenvironmental problems, socio-economic issues to do with poverty and inequality, and concerns about a healthy future for humanity. According to (Sage, 1998), it refers to the fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems. The fundamental driver is that all parties agree that there is a need to change for the better.

For decades, while scholars and researchers across the globe have attempted to bring about universal principles for sustainability, their good-will efforts have proved in vain. They are often criticized, however, for not representing the full vision of sustainable development (Eagan & Joeres, 1997). As a result, they attract continuing and increasing debate and argument which give rise to many definitions, interpretations and concepts of sustainable development. The application of sustainable development also continues to attract criticism and engender debate (Springett, 2005); (McKenzie, 2004); (Sachs, 1999).

It is widely acknowledged that sustainability is a vague, uncertain and polymorphous concept (Philis & Andriantiatsaholiniaina, 2001). To different people, sustainability can mean different things (Chaharbaghi & Willis, 1999). In a survey, when asked to provide definition of sustainability, participating companies have described different individual and organizational perceptions and definitions of sustainability (Shelbourne, 2006).

On the other hand, the question of whether social, economic and environmental concerns have to be treated equally and simultaneously, or whether protecting natural life support systems is of utmost importance (and, thus, the environmental dimension of sustainability dominates the others) is still controversially discussed (Luetzkendorf, 2007). Others, yet again, suggest sustainability could mean anything that is being encapsulated in the equation of '*n Bottom Line*'. Summarily, the beauty and wisdom in this clashing of concepts is that all parties agree that there is a need to change for the better. However, questions as to 'how to change' and 'what needs to change' remain open for interpretation. Above all, the emphasis should be on implementing a process which seeks to achieve consensus among interested parties on which principles are more, and which are less, important to be applied in an infrastructure project. Nevertheless, given the trend of evolution, the principle of sustainability is likely to change to enlist other notions that are currently not known or taken into consideration. According to (Sneddon, Howarth, & Norgaard, 2006), for example, ecological economics and other trans-disciplinary modes of knowledge production are vital to such endeavors. Despite on-going debate, the universally accepted set of principles of sustainable development is named the *Triple Bottom Line* that includes three broad components: social, environmental and economic aspects of sustainability. This international set of sustainability metrics is often used to gauge the success of a particular development project (Roger, Jalal, & Boyd, 2006). It is treated as a basic start-point for sustainability initiatives where scholars and researchers of various disciplines engage in, and formulate, the sustainability principles concept for their respective area of development interests.

For the context of the built environment discipline, sustainable construction is seen as a way for the building industry to respond to achieve sustainable development (Bourdeau, 1999). Principally, sustainable construction can be defined as a construction process which incorporates the basic themes of sustainable development (Parkin, 2000); (Chaharbaghi & Willis, 1999); (Sage A. P., 1998). In other words, a construction project is sustainable when it responds to the conventional environmental challenges of resources depletion, addresses social and cultural needs and practices, as well as generates economic empowerment or alleviates poverty.

In an attempt to integrate sustainability into construction industry, Hill and Bowen (1997) have developed the principles of sustainable construction that are divided into four 'pillars' of sustainability – social, economic, biophysical and technical – with a set of overarching, process-oriented principles. Although the proposed concept of sustainability principles provides a good understanding of sustainable construction, for the most part, it is too general to elicit application at project level. This is a challenge still to be met. Hill and Bowen do advise, however, that the choice of which principles to apply to a particular construction project, and the decision on the extent to which each chosen principle should be applied, reflect value judgments; i.e. whether to apply weak, strong or very strong sustainability. They further contend that it is best if these judgments are made by the interested and affected parties involved in a project. The emphasis, therefore, should be on implementing a process which seeks to achieve consensus among interested parties on which principles are more, and which are less, important.

Given the pressing need of our mother earth, the growing maturity of mankind towards a shared future, and an increased awareness by governments of different nations, sustainability development initiatives will continue for the long-haul. It is a journey rather than a destination for mankind, and an organic process that naturally invites all parties to its noble fold. However, until each individual, local, national and international community responds earnestly to these initiatives, the potential results, as promised by sustainable development, will remain unrealized.

Parkin (2000), define sustainable construction as a construction process which is carried out by incorporating the basic objectives of sustainable development. The Government Construction Clients' Panel (GCCP, 2000) Sustainable Construction Action Group (2000) describes sustainable construction as the set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure and their immediate surroundings which: (i) enhance the quality of life and offer customer satisfaction, (ii) offer flexibility and the potential to cater for user changes in the future, (iii) provide and support desirable natural and social environments and (iv) maximize the efficient use of resources.

2. Objective of Study

The objective of this study is the identification of current trends and emphasis on sustainable infrastructure development and review of the existing sustainability elements especially in road and bridge sector by:

- Understanding the global initiatives on sustainable infrastructure development.
- Reviewing the current assessment methods on infrastructure sustainability, and
- Identifying sustainability elements for infrastructure projects.

The alternative hypothesis used in this study was: "*Sustainable infrastructure development is the best approach in the construction and maintenance of road and bridge sector in Nepal*". The lack of a common understanding of sustainable infrastructure development among the multiple stakeholders can be the main hurdles of sustainability approaches. Identifying and understanding the various perceptions, and motivations with respect to sustainability, will help promote more integrated thinking and a consistent approach to the implementation of sustainability in rural infrastructure development.

3. Methodology

Only by use of appropriate methodologies and method of research, applied with rigor, can the body of knowledge for construction be established and advanced with confidence (Fellow & Liu, 1997). Therefore, each element in the research – the theoretical and conceptual framework guiding the study, sample characteristics, data collection approaches and procedures, and the analysis and interpretation of data – is equally important in the overall plan for the conduct of the study. A well organized research methodology that follows logically from the specific aims and demonstrates the integration of each these aims throughout the research plan is crucial component of successful application.

The methodology used for this study was questionnaire survey. The main objective of the questionnaire survey was to address the critical sustainability approaches by identifying the best practices in the real projects in Nepal, which covers the projects of snowy mountain (Himali) region, Mountain region and plain (Tarai) region. Almost data was primarily quantitative as the research, at this phase, sought to understand the measures taken and processes involved at project level to address sustainable infrastructure development.

The fact that the desired investigation required a close understanding of what was happening at project level, and had to rely on the interpretation of data (by collecting information from, and experiencing, the project environment) made this investigation not only suited to a quantitative approach, which requires structured and standardized quantities. Furthermore, the identification of good practice at the project required the more mature lines of enquiry provided by the qualitative approach. A questionnaire survey is one of the most cost effective ways to involve a large number of people in the process in order to achieve better results, as recommended by McQueen and Knussen (2002). Pilot survey and Cronbach's Alpha test of questionnaire were also done during this study.

4. Data Analysis and Presentations

The purpose of this survey is to investigate the current trends and approaches on sustainable rural infrastructure development and find the perspectives of clients and users towards sustainability.

The questionnaire survey was conducted in 3 regions of Nepal (Himal, Mountain and Tarai) with 5 rural bridge projects. Eastern, Central and Western part of Nepal was also covered by the survey. Table 1 gives the overlook of the survey area of Nepal. The study covered all region and locations of the nation, so that the survey is reliable and credible.

S.N.	Districts	Region	Name of the Project	Area	Remarks
1	Bankey	Tarai	Duduwa Nala Bridge	Western	
2	Rasuwa	Himali	Bhote Koshi Bridge	Central	
3	Solukhumbu		Solu Khola Bridge		
4	Illam	Mountain	Karphok Khola Bridge	Eastern	
5	Panchthar		Nibu (Siwa) Khola Bridge		

Table 1: Questionnaire survey locations and respective bridge projects

Sources: Field study, 2013

Basic factual data was collected relating to the respondents personally with the clients and users of bridges. This data is presented in this section. The size of the response across available response categories is indicated in both percentage (%) and raw numeric terms. Table 2 indicates most respondents (85 %) are from users' side, 15 % are from clients.

Region	Respondent Type				Total (299)		
	Clients (44)		Users (255)		M	F	%
	M	F	M	F			
Himali	5	1	48	27	53	28	27
Mountain	19	-	65	16	84	16	33
Tarai	16	3	59	40	75	43	40
Total	40	4	172	83	212	87	100
%	15		85		71	29	
Respondent Type	Region			Total			
	Himal	Mountain	Tarai				
Client	6	19	19	44			
Users	75	81	99	255			
Total	81	100	118	299			
%	27	33	40	100			

Table 2: Number of Respondents according to their type and regional basis

Sources: Field study, 2013

The percentage of male and female respondents is 71 % and 29 % respectively. As the regional basis the respondent percentage of Himal, Mountain and Tarai are 27 %, 33 % and 40 % respectively. The total number of respondents was 299. Among them 81 from Himal, 100 from Mountain and 118 from Tarai and 44 clients and 255 users were taking part in this study. As the type and regional basis of the respondents is quite respectable, opinions and views obtained through the survey can be regarded as important and reliable. Majority of respondents had reasonable experience in respective bridge construction which further shows that respondents are sufficiently experienced enough to provide data which are credible. The survey was conducted in five districts which represent all the 3 geographical regions of Nepal (Table 3).

District	Himal (81)		Mountain (100)		Tarai (118)		Total (299)	
	M	F	M	F	M	F	M	F
Banke	-	-	-	-	75	43	75	43
Rasuwa	30	18	-	-	-	-	30	18
Solukhumbu	23	10	-	-	-	-	23	10
Panchthar	-	-	43	8	-	-	43	8
Ilam	-	-	41	8	-	-	41	8
Total	53	28	84	16	75	43	212	87
%	27		33		40		71	29

Table 3: Distribution of Respondents by their district, gender and project area
Sources: Field study, 2013

In Tarai Region the District was Bankey, in Mountain Region the Districts were Panchthar and Illam, and in Himali Region the Districts were Rasuwa and Solukhumbhu. The Districts covers Eastern, Central and Western part of Nepal also. The female participation (29%) is encouraged. Tarai, Mountain and Himali participation 40%, 33% and 27% is according to population distribution. The distribution of sample is homogeneous and representative so that the outputs are reliable.

The responding clients and users indicated that they were aware of the impact of construction activity on the sustainable development. Many components were measured to find out the sustainable development towards rural infrastructure: Matching of design standard with project function (Table 4), Stakeholders' interest regarding sustainability in infrastructure development (Table 5) and Use of local construction materials in the construction of bridge (Table 6) were highly significant.

Table 4 shows the results, which suggest that 68% of the respondent agreed or strongly agreed that the project function is matching with design standard, that means the designed norms and standard is followed in the construction of infrastructure. Only 23% of the respondents were disagreeing on it. This means the projects were aware in sustainable development.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	4	2	12	26	44	192	4.36
Users	31	35	25	75	89	255	921	3.61
Total	31	39	27	87	115	299	1121	3.74
%	10	13	9	29	39	100		

Table 4: Matching of design standard with project function
Sources: Field study, 2013

Table 5 indicates 73% of the respondents were aware of sustainability in infrastructure development and only 20% were not convinced on it. Here the data shows the stakeholders were aware of sustainability aspects of the bridge projects and they were responsible in each and every activity of the projects.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	2	0	18	24	44	196	4.45
Users	22	38	21	86	88	255	945	3.7
Total	22	40	21	104	112	299	1141	3.81
%	7	13	7	35	38	100		

Table 5: Stakeholders' interest regarding sustainability in infrastructure development.
Sources: Field study, 2013

60% of the respondents were agreed that the projects were using local construction materials which were available in the site and 33% were not agreed on it (Table 6). It was not possible to have all types of construction materials in the rural area. Data shows the bridge projects were using whatever is available in the area.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	5	1	12	26	44	191	4.34
Users	39	56	19	64	77	255	849	3.32
Total	39	61	20	76	103	299	1055	3.52
%	13	20	7	25	35	100		

Table 6: Use of local construction materials in the construction of bridge.

Sources: Field study, 2013

Other key aspects of sustainable rural infrastructure development were accessibility for pedestrian and vehicles, appropriateness of bridge construction site, matching with national sustainable development strategies, information sharing with local communities about project, Compliance with contract document & project specifications, Linkage of communities, industry and other amenities with the project, Involvement of local communities in the project activities, Stakeholders' activities regarding sustainability in infrastructure development, Effects on fish and other aquatic life during construction and Effects on Livelihood of the people of the bridge construction area. All the aspects were analyzed thoroughly and the data are presented accordingly as follows:

95% of the respondents were convinced that the bridges were accessible for pedestrian and vehicle (Table 7). Only 4% denied on it. That means the transportation facilities were increased due to the construction of bridges. Bridges were playing the role of accessibility in the life of the people.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	0	0	3	41	44	217	4.93
Users	6	6	2	40	201	255	1189	4.66
Total	6	6	2	43	242	299	1460	4.88
%	2	2	1	14	81	100		

Table 7: Accessibility for pedestrian and vehicles

Sources: Field study, 2013

In some cases, due to unfavorable locations, the bridges cannot be useable for majority of the populations. Here 94% of the respondents were satisfied about the location of bridges and 4% were not satisfied on it (Table 8). This indicates most of the locations were decided targeting the majority of the population

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	0	2	3	39	44	213	4.84
Users	3	6	8	68	170	255	1161	4.55
Total	3	6	10	71	209	299	1374	4.59
%	1	2	3	24	70	100		

Table 8: Appropriateness of bridge construction site.

Sources: Field study, 2013

National sustainable development strategies are the views of the nation towards sustainable development. Each and every construction projects are bounded to follow the strategies. Table 9 indicates 80% of the populations think that the strategies were followed and 13% were not agreed on it.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	4	5	10	25	44	188	4.27
Users	8	27	17	55	148	255	1073	4.2
Total	8	31	22	65	173	299	1261	4.21
%	3	10	7	22	58	100		

Table 9: Bridge construction match national sustainable development strategies

Sources: Field study, 2013

Transparency will minimize the corruptions and increases the responsibility of the stakeholders. Sharing of information with local communities about the project plays a vital role for sustainable development. 59% of the respondents are not satisfied about the sharing of information and 31% only satisfied on it (Table 10). This is one of the weak parts of the projects.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	11	10	7	6	10	44	126	2.86
Users	100	55	23	36	41	255	628	2.46
Total	111	65	30	42	51	299	754	2.52
%	37	22	10	14	17	100		

Table 10: Information sharing with local communities about project.
Sources: Field study, 2013

Contract document and project specifications are the major documents to drive any project. Compliance with these two documents can guide the project effectively in the way of sustainable development. Table 11 denotes the strong majority in the compliance with contract document & project specifications. 72% of the respondents were in favor and 18% were against it. In the compliance with these two documents the bridge projects were positive.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	8	5	11	20	44	175	3.97
Users	22	26	26	86	95	255	971	3.8
Total	22	34	31	97	115	299	1146	3.82
%	7	11	10	33	39	100		

Table 11: Compliance with contract document & project specifications
Sources: Field study, 2013

67% of the respondents are agreed that the Linkage of communities, industry and other amenities with the project was strong and 22% respondents were disagreeing on it (Table 12). The linkage between these stakeholders helps to develop ownership towards the project. The data shows that the projects were strong in Linking with these stakeholders.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	5	5	10	24	44	185	4.2
Users	26	34	28	71	96	255	942	3.69
Total	26	39	33	81	120	299	1117	3.73
%	9	13	11	27	40	100		

Table 12: Linkage of communities, industry and other amenities with the project
Sources: Field study, 2013

Involvement of local communities in the project activities is the strong part to develop ownership feeling towards projects. The life of the infrastructure will be long enough with the support of local community. Person love and care the things which are established by them. The data shows 73% of the respondents were in fever of their involvement in the project and 21% were not in fever about the involvement (Table 13). As a whole the involvements were satisfactory.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	1	3	4	14	22	44	185	4.2
Users	20	38	15	82	100	255	969	3.8
Total	21	41	19	96	122	299	1154	3.85
%	7	14	6	32	41	100		

Table 14: Involvement of local communities in the project activities
Sources: Field study, 2013

Table 15 denotes the activities of stakeholders regarding sustainability in infrastructure development. Awareness creation plays a vital role to involve stakeholders in sustainability. If they are convinced they can perform the activities towards sustainability. 74% of the population agreed that the stakeholders' activities were appreciable and 17% population were disagreeing on it. Projects activities towards sustainability were satisfactory.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	4	3	14	23	44	188	4.27
Users	9	39	24	86	97	255	988	3.87
Total	9	43	27	100	120	299	1176	3.93
%	3	14	9	34	40	100		

Table 15: Stakeholders' activities regarding sustainability in infrastructure development
Sources: Field study, 2013

78% of the respondents are agreed that the effects on fish and other aquatic life during construction were minimum and 19% were against this (Table 16). The aquatic lives are responsible to protect environment and make the earth better place to live in. The data shows the positive reinforcement towards the protection of aquatic lives in the project area.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	1	2	0	13	28	44	197	4.47
Users	19	33	9	48	146	255	1034	4.05
Total	20	35	9	61	174	299	1231	4.11
%	7	12	3	20	58	100		

Table 16: Effects on fish and other aquatic life during construction
Sources: Field study, 2013

Table 17 denotes the effects on livelihood of the people of the bridge construction area. 71% of the respondents were agreed that the bridge projects were able to increase livelihood of the people. 11% of them are not in fever of this. It is believe that any projects will create employment to the local people. The people with skill can generate employment in the project area, but the people without skill and not interested to have skill cannot grab the opportunity.

Group	Scale values					Total Responses	Weighted Value	Mean Weight
	1	2	3	4	5			
Clients	0	4	2	8	30	44	196	4.45
Users	10	20	20	55	150	255	1080	4.23
Total	10	24	22	63	180	299	1276	4.26
%	3	8	8	21	60	100		

Table 17: Effects on Livelihood of the people of the bridge construction area
Sources: Field study, 2013

Test of significance for current trends and approaches on sustainable rural infrastructure development was done with two populations who agree with the proposed approaches. Based on the populations' percentage who agrees with the approaches value, p value and conclusions with significance and insignificance were calculated using SPSS. Individual and overall test of significance were made accordingly. Regarding the individual test, table 4.24, 4.28, 4.32 are highly significance whether the p value is less than 0.05 and regarding other remaining 10 individual tests, in the remaining tables, the p value is greater than 0.05, so that it seems these are insignificance.

Overall significance test regarding current trends and approaches on sustainable rural infrastructure development (Table 4.33) was done accordingly. Mean, standard deviation, t value and p value were calculated using SPSS and the p value found less than 0.05. Here it is proved that the alternative hypothesis "Sustainable infrastructure development is the approach in the construction and maintenance of road and bridge sector in Nepal" is highly significance. The rules, regulations and the commitments of the government towards sustainable development is highly significance in the perspectives of clients and users. They are really committed to introduce sustainable development approach in rural infrastructure development in Nepal.

Group	Means	Std. Deviation	t Value	p Value	Sig if p < 0.05
Client	55.6591	6.921	Equal variances assumed 4.422 Equal variances assumed 4.891	0.000	Significant
User	50.000	7.983		0.000	

Table 18: Overall significance test regarding current trends and approaches on sustainable rural infrastructure development (H1 is accepted when p value is less than 0.05)

5. Conclusion

In an effort to establish sustainability criteria and indicators suitable for Nepalese road bridge infrastructure projects, a thorough review of existing sustainability rating tools and schemes was conducted at the beginning of the research. Several established sustainability assessment tools that are being adopted in the built environment or infrastructure in Nepal and overseas were examined.

Representing the views of various stakeholders in the interviews, the framework mainly embodies the criteria for sustainable bridge infrastructure development; however, it also outlines general perceptions of sustainability and links the motivations and drivers behind the sustainability move. Thus, it provides a holistic industry perception of sustainability in the context of road and bridge infrastructure development. This holistic view allows formulation of strategies to encourage infrastructure stakeholders to up-take the sustainability agenda can be better planned and articulated. This is an imperative next step leading to sustainability engagement for the mutual benefit of all stakeholders.

The establishment of the framework, through answering the research question, achieved the objective which was *Identification of current trends and emphasis on sustainable infrastructure development and review of the existing sustainability elements especially in road and bridge sector.*

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