HiJASE
Himalayan Journal of Applied Science and Engineering (A peer-reviewed Journal)

ISSN 2738-9898 (Print) ISSN 2738-9901 (Online)

An Assessment of Operation and Maintenance of Trail Bridges for Sustainable Mobility in Nepal

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Received on: 17th Nov., 2021

Accepted for publication: 15th Feb., 2022

Abstract

Trial bridges have a significant impact on mobility and socioeconomic status in rural regions of Nepal. The construction of the trail bridges is the important transportation mobility of Nepal to enhance rural mobility. It is essential to establish an effective operation and maintenance (O&M) plan for the long-term sustainability of the trail bridges. Proper O&M mechanism has a significant impact on safe, secure, durable, and sustainable service in the community. In our context, it is very challenging due to a lack of proper technology, a proper management system, and a scarcity of resources. The study was focused on evaluating the implementation status of operation and maintenance of trail bridges in Mugum Karmarong Rural Municipality of Mugu district of Nepal. Quantitative and qualitative data have been collected to evaluate the operation and maintenance status of twenty bridges. The related officials, businessmen, teachers, students, local community members, user group members, health workers, and other stakeholders of Trail Bridge were considered for the survey. The design guidelines, published literature, and other related guidelines of the Government of Nepal (GoN) were analyzed for the research. The convenient survey was conducted from sampled respondents along with three focus group discussions in three trail bridge projects. Further, key informants were interviewed comprising different stakeholders involved in the project planning and implementation process from central to the local level. The quantitative and quantitative data has been adopted and analyzed using a simple statistical method has performed for quantitative data analysis, and the content analysis method is used to interpret qualitative findings. The study concluded that the overall implementation status of O&M of trail bridges in Mugum Karmarong Municipality is disappointing and needs immediate operation and maintenance. The study indicates that proper O&M of trail bridges have a significant reduction in time to reach the school and health service is directly related to increased enrollment in schools and increased health facilities in communities, respectively. The income status and livelihood of people in communities have improved due to an increase in mobility and market accessibility from the operation of trail bridges . The output of this study will be the milestone for the proper operation, and management system development for sustainable, reliable, and cost-effective infrastructure development in the country.

Keywords: Trail Bridge, Operation and maintenance, Durability, Sustainability, Safety Rainfall.

1. Introduction:

There are more than 6000 rivers and rivulets crossing through the different territories of Nepal having approximately 4500 km in length. The high hills and mountains encompass 83 % of the land of Nepal [1]. The means of production and social wellbeing that depend on natural and water resources are scattered throughout the country and not constant in the same places of the settlements. Because of these crossings, hills, and mountains, the cost-effective trail bridge technology is regarded as suited for facilitating rural people's transportation. The trail bridge construction aids in the alleviation of rural poverty by greatly improving people's access to health, education, trade, agriculture, and markets. For fulfilling people's daily needs like food, clothes, and social services including basic education and health needs, people have to move from place to place within and outside the country. Trail bridges have been built in Nepal since 1964 with the specified method, and the plan starts from 1964[2]. Since its inception in 1972 by the Swiss Association for International Cooperation (SDC/Helvetas), the trail bridge program has a long list of accomplishments. Trail bridges require a correct operation, ongoing maintenance, and rehabilitation (M-and-R) in order to offer seamless service and meet project outcomes and productivity.

The construction of trail bridges is expensive, time-consuming during construction, and technically complicated for design and construction. The planning for proper operation and maintenance of less priority in most of the projects of Nepal resulting lack of proper maintenance and operation plan and activities. The ultimate goal of maintenance is to ensure both safety and serviceability of deteriorating bridges and to develop appropriate bridge maintenance strategies and tools to meet serviceability criteria and optimization the life cycle cost of the new bridge. Operation and maintenance system takes account of wider social responsibilities, such as safety and sustainability to achieve the three internationally accepted dimensions of sustainability: environment, economy, and society[3]. Industrial occupational safety and health innovation effects are key parameters for the sustainability of the project that is an essential aspect of our research[4]. In the past, O&M activities were not given attention in the projects. The occurrence of failure of large projects due to poor O&M; has become a matter of priority. Nowadays, it is becoming an essential activity for long-term use, sustainability, and safety of projects. To be aware of the existing problems and to help with rational maintenance decisions, bridge management systems have been developed and are being implemented all over the world[5] . Any type of bridge is expensive in terms of resource use and the necessity of complicated technology. To reduce construction and maintenance costs and resource utilization proper bridge management system is necessary. As the third millennium dawns, the United States is in the midst of a "bridge crisis": Maintenance needs for older bridges have far outpaced available resources. This situation indicates the need not only for improved repair and rehabilitation techniques but also for a comprehensive approach to bridge management[6]. To increase bridge usable lifespan and achieve its set performance appropriate infrastructure maintenance, and management approaches are fundamental necessities. The health of structure is reduced by age, but the lifespan is extendable by appropriate maintenance. Hence, maintenance gives a significant effect on the structure's performance level and lifespan [7] .

O&M enhances the economy through three channels: it is an essential input in the production of infrastructure services, increases the life of public capital, and expands the durability of private capital [8].

Bridge management system is becoming an emerging issue to maintain overall reliability and optimum use of available sources. The aim of management is to maintain the overall reliability of the bridge stock at a satisfactory level and to do so with the optimum use of available resources [9]. A bridge management system or BMS is a means for managing bridges throughout the design, construction, operation, and maintenance of the bridges [10]. Bridge management systems help agencies to meet their objectives, such as building inventories and inspection databases, planning for maintenance, repair, and rehabilitation interventions in a systematic way, optimizing the allocation of

financial resources, and increasing the safety of bridge users [11].

Though it's important worldwide is misinterpreted and undervalued. The impacts maintenance, repairs, and operation can have a corporate performance is regularly misinterpreted and undervalued by manufacturing organizations [12].

For the effective and compulsory implementation of infrastructure operation, and maintenance top management commitment and decision are the keys. Top management commitments and decisions are the keys to the proper O&M of any project. If the decision-maker does not have a clear operation plan, it will lead to the lack of continuity of maintenance measures, which will lead to the lack of understanding of the bridge's maintainability and sustainable development ability [13].

Cooperation, dedication, and participation at all stakeholders are very important to achieve the best results in projects O&M. A successful O&M program requires cooperation, dedication, and participation at all levels and cannot succeed without everyone involved understanding the basic principles and supporting the cause [14].

In our perspective , the government of Nepal issued a guideline for bridge inspection and maintenance in 2003, which addressed the inspection and maintenance of road bridges for long-term sustainability, safety, and durability. Trail Bridge Strategy 2006 has made some provisions regarding the building and maintenance of long span trail bridge (LSTB) through collaboration with a co-operation committee comprised of user representatives [15]. It also has been keeping and updating bridge records municipality-wise according to maintenance categories and providing present status of the bridge for further action with the help of Sector Wide Approach (SWAp), Swiss Agency for Development and Coordination (SDC), and Trail Bridge Support Unit (TBSU). In this regard, the research study focused on the assessment of operation and maintenance of trail bridges for the sustainable infrastructure development of Mugum Karmarong Rural Municipality, Pulu, Mugu, Nepal.

2. Study Plan:

2.1. Study Area:

The study was done at Mugum Karmarong Rural Municipality, Pulu, Mugu, Nepal. The map of study area is shown in Fig. 1. The construction of trail bridges is always unavoidable in Mugum Karmarong Rural Municipality due to its complex geology, geography, innumerable crossings, and large mountainous area. The area of Mugum Karmarong Rural Municipality is 2106.91 km^2 which is more than half of total area of Mugu districts [16]. The center point of the study area is about 46 km far from the district headquarter Gamgadhi Mugu [17].

Figure 1: Map of Mugum Karmarong Rural Municipality, Pulu, Mugu, Nepal

2.2. Research Approach:

The study involved mix method approach to collect the data and information for the study. The study includes the focus group discussions with the official employee, trail bridge user's group, social workers, shopkeepers, teachers, health workers, and leaders, and in-depth interviews with selected key informants comprising clients, contractors, technicians, and elected representatives are the stakeholders in trail bridge construction, and trail bridge project

planning and implementation. Similarly, the interview of concerned stakeholders in persons near the trail bridge site has also been conducted. The site observations were also made in three trail bridge projects areas to get visible information that supported to triangulate and validate the data, and support in the analysis of information and interpreting results and discussion.

2.3 Sample Size Calculation:

Conveniently different persons of the different sectors were selected for the interview through the sample estimated from the finite population (N=200) for the interview of 17 completed trail bridges and 3 under construction trail bridges of Mugum Karmarong Rural Municipality. The sample size was calculated by using the following scientific formula

$$n_0 = \frac{N \times z^2 \times P(1-P)}{(d^2 \times (N-1) + z^2 \times P(1-P)} = 131$$

where n_0= required sample size

z = standard normal deviation set at 95 % confidence level = 1.96

n = Total number of known population=200

p = Expected proportion (50 %) = 0.5

d = Precision/margin of error = 0.05

3. Results and Discussion:

The results and discussion drawn are based on the analysis of both primary and secondary data collected through quantitative and qualitative techniques. This section includes findings of the overall implementation scenario of trail bridges operation and maintenance by trail bridge program in the country and more specifically Mugum Karmarong Rural Municipality, Fulu, Mugu, Nepal.

3.1. Status of Trail Bridge O&M at Mugu District:

There are altogether 69 bridges (LBS, Helvetas, 2021) in Mugu district among them 12 are steel truss bridges, 4 are suspension trail bridges (N-type) and 53 are suspended bridges (D-type) [18]. The regular operation and maintenance were found very poor on the bridges. The result of the study indicates that the present status of operation and maintenance of 9 bridges require major maintenance, 1 bridge require obsolete repair condition and 59 bridges are in a usable condition which can be presented below:

Table 1: Operation and Maintenance Status in Mugu District

Number of bridge	Condition
9	Major maintenance
1	Absolute maintenance
59	Usable condition

Source: TBSSP, TBSU, PMIS 2021

3.2. Status of Trail Bridge at Mugum Karmarong Rural Municipality:

There are altogether 20 Trail Bridges at Mugum Karmarong rural municipality among them 3 are steel truss bridges, 1 is suspension trail bridge (N-type) and 16 are Suspended bridges (D type). 3 bridges have to be done major maintenance, three bridges are in under construction stage others are in usable condition. The result of the study concluded that lack of technical human resources and lack of structured maintenance plan is the major factor for slow repair and maintenance of the bridges.

Table 2: Operation and Maintenance Status in Karmarong Rural Municipality

Number of bridge	Condition
3	Major maintenance
3	Absolute maintenance
14	Usable condition

Source: TBSSP, TBSU, PMIS 2020

3.3. Status of Project O&M Schedule after Construction:

The (TBS, 2006), trail bridge action plan (DoLIDAR, PPA 2007, and PPR 2008 have developed the provision for project O&M schedule after construction. There has not been adopted the project O&M schedule after construction in the research site.

Table 3: Operation and Maintenance Schedule After Construction

Project Status	Response (%)
O&M schedule after construction	No = 57.69
	Yes = 42.31
	Total = 100

Source: (Field survey, 2021, n=131)

3.4. The Project As-built Drawing after the Completion of the Project Construction:

The (TBS, 2006), trail bridge action plan (DoLIDAR, PPA 2007, and PPR 2008 have mentioned the provision of as-built drawing after the completion of the project construction. There has not been an as-built drawing available even after the completion of the construction.

Table 4: As-built drawing after completion of the construction

Particular	Response (%)
As-built drawing after completion of construction	No = 82.83
	Yes = 17.17
	Total = 100

Source: (Field survey, 2021, n=131)

3.5. Provision of Bridge Warden and its' Significance:

There has not been the provision of the bridge warden for the bridge O&M and the result reveals that there has been the significance of the bridge warden for effective bridge O&M.

Table 5: Provision and significance of bridge warden

Particular	Response (%)	
Provision and significance of bridge warden	Provision	No=59.01
	Significance	Yes=59.20
	Provision	Yes=40.90
	Significance	No=40.80
		Total = 100

Source: (Field survey, 2021, n=131)

3.6. Status of Education/Health Services Access Due to O&M:

Transportation facility has a great influencing factor for the access to the education stations. The study has greatly supported this statement that the number of children joining the school has been increasing due to the proper operation and maintenance of trial bridges in the Mugu district.

Table 6: Status of education/health services access due to O&M

Particular	Response (%)
Access to the education/health services	No = 99
	Yes = 1
	Total = 100

Source: (Field survey, 2021, n=131)

3.7. Development of Project O&M Plan and Protocol after Completion of Construction:

The project O&M plan and protocol after completion of construction has not been developed after the completion of the project. The result indicates that the responsible body has not taken serious concern for the operation and maintenance of the trail bridges.

Table 7: Development of project O&M plan and protocol after completion of construction

Particular	Response (%)
O&M plan and protocol after completion of construction	No = 81.40
	Yes = 18.60
	Total = 100

Source: (Field survey, 2021, n=131)

3.8. Safety Feeling Due to the Use of Trail Bridges:

The trial bridge users have not felt safe to use the trail bridge in the existing condition. Due to poor repair and maintenance plans and activities, people are not comfortable using trail bridges. The Female has not felt comfortable than the man to use Trail Bridge.

Table 8: Safety feeling to the use trial bridge

Particular	Response (%)	
Safety feeling to the use trial bridge	Female	No=68.80
	Male	No=59.60
	Female	Yes=31.20
	Male	Yes=40.40
		Total = 100

Source: (Field survey, 2021, n=131)

3.9. Responsible entities for the delay and weak O&M in trail bridge in MKRM:

Table 9: Responsible entities for delay in O&M

Particular	Response (%)	
Responsible entities for delay in O&M	Executive office	29.70
	Executive office and Contractors	22.80
	Contractors	15.80
	office, community user group and contractors	11.40
	Others	21.30
		Total = 100

Source: (Field survey, 2021, n=131)

The executive office alone, executive office and contractors, contractors alone, and office,

community user group, and contractors combined together are responsible for delay in O&M of the Trail Bridges in MKRM.

3.10. Sources for proper O&M:

The budget and top management commitment, budget alone, and budget, technical assistance and top management commitment are essential sources for the effective O&M in trail bridges.

Table 10: Sources for proper O&M

Particular	Response (%)	
Sources for proper O&M	Budget and top management commitment	32.50
	Budget, technical assistance, and top management commitment	21.80
	Budget	19.30
	Others	27.40
		Total = 100

Source: (Field survey, 2021, n=131)

3.11. Provision required for the mandatory implementation of O&M:

Table 11: Provision for mandatory implementation of O&M

Particular	Response (%)	
Sources for proper O& Provision for mandatory implementation of O&M	Enforcement by law	33.30
	Enforcement by law, awareness, training, and demonstration	32.50
	Enforcement by law, awareness, training, demonstration, field visit, reporting, and recording	27.20
	Others	7.00
		Total = 100

Source: (Field survey, 2021, n=131)

The provision of enforcement by law, the enforcement by law, awareness, training and demonstration, the enforcement by law, awareness, training, demonstration, field visit, reporting, and recording are necessary for mandatory implementation of O&M in trail bridges.

The focus group discussion and field observation of Tse Jang Phung suspended bridges, Pulubagar suspended bridge and Dhungedhara suspension bridge showed that there was not any O&M schedule, plan, budget, committee, protocol for the trail bridge operation and maintenance in Mugum Karmarong Rural Municipality. After the federal system of Nepal, there has been the poor institutional capability of new local bodies and hence the O&M trail bridge has been interrupted.

4. Conclusions:

The comparison of before and after the construction of trail bridges and proper O&M of trail bridges indicates that a significant reduction in time to reach the school and health service is directly related to increased enrollment in schools and to increase health facilities in communities respectively. The income status and livelihood of people in communities have improved due to an increase in mobility and market accessibility from the operation of trail bridges. Key informants expressed that maintenance of trail bridges has been interrupted because of lack of institutional development of newly formed local governments. The causes of poor operation and maintenance of trail bridges are associated to both technical and non-technical reasons. The major technical reasons assessed related to poor operation and maintenance was: untimely technical monitoring, assistance, insufficient technical manpower, weakness in designing and estimating. Non-technical reasons are related to poor planning, poor management, weak commitment, scarcity of budget, lack of strong and updated law, rules, and regulation, lack of awareness and training about safety, durability, and sustainability of trail bridge services. The government has provisioned some rules, regulations, directions, and manuals regarding trail bridge proper operation and maintenance, though they are in the passive condition. The use, updating, and implementing process is very weak. The recording system of trail bridge status of O&M has been done though treatments of identified trail bridges are not done in time. There has not been any plan and schedule for the implementation of these treatments.

Data Availability Statement:

The data that support the findings of this study are available from the main author, upon reasonable request.

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