Proceedings of IOE Graduate Conference, 2017
Volume: 5 ISSN: 2350-8914 (Online), 2350-8906 (Print)

Integrated Roadside Vegetation Management along the Highways of Nepal

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Abstract
Integrated Roadside Vegetation Management (IRVM) is a decision making process that integrates planning, design, construction, maintenance, monitoring, evaluation needs, knowledge, and government policies with proper technologies to economically manage roadsides for safety plus environmental as well as visual quality. A survey of transportation agencies in the Nepal has not considered it fully and showed that many agencies are still in the process of implementing a science-based integrated approach to making decisions on roadside vegetation management. There is no development of best management practices (BMPs) for roadside management in Nepal. The research aims to attract the interests of policy makers for the betterment of road transport in Nepal. Thus, the research focuses on developing framework of best management practices from the analysis of allocation of maintenance budget data, the bio- engineering works has been in increasing trends and so is routine maintenance which partially includes IRVM works. Hence, the increasing maintenance needs show the degradation of road as one of the factors for affecting the budget allocation. Thus, we can say that the durability is affected by the improper IRVM of the highways. Using the gaps between International references for IRVM practices and existing state of practices in Nepal, the framework of IRVM is proposed with the help of questionnaires with professionals and literature. The framework is divided into planning phase, design phase, construction phase and maintenance phase. The required polices and guidelines in each phase are identified with the relevant major legal bodies that can contribute. The report further quantifies one beneficial aspect: noise pollution reduction in the case study site Dhulikhel-Sindhuli-Bardibas highway by the implication of IRVM practices. The general design of vegetation plantation method for noise reduction is obtained for the case study site. The result shows IRVM is highly beneficial for maintaining the sustainable, safe and healthy environment.

Keywords
IRVM (Integrated Road Side Vegetation Management); Best management Practices (BMPs); durability; maintenance management; noise pollution.

1. Introduction

Most IRVM definitions identified a decision-making process that integrates needs of local communities and highway users; knowledge of plant ecology and natural processes; design, construction, and maintenance considerations; monitoring and evaluation procedures; government statutes and regulations; and technologies. Alongside these elements are cultural, biological, mechanical, and chemical control methods to economically manage roadsides for safety plus environmental as well as visual quality[1]. According to appropriate management techniques for vegetation along a specific roadway depend on many factors, including the type of vegetation desired, the desired appearance of the roadside soil conditions, roadway traffic, roadway use and visibility, adjacent land use, roadway location and topography[2].For developed systems of travel, nature has challenged the integrity and function of those systems with vegetation growth.

Such challenges for a modern highway system range from risks to the safety of facility users to premature deterioration of the road system infrastructure to negative impacts on the environment where the highway facility is located. Limitations on resources available for designing, building, and maintaining highways need to be considered by roadside managers during decision-making processes especially in Nepal.Thus, new methods and technologies need to be embraced throughout the country to enhance the effectiveness, safety, and efficiency of roadside vegetation management activities. Doing so will allow programs to benefit from innovation and to expand vegetation management methods, materials, and techniques.Roadside vegetation management depends on an integrated approach. This includes a wide variety of best management practices to address the many issues involved. This integrated approach includes an assessment of the existing conditions and determination of the type of roadside environment desired. Looking into global context, however, few written documents are available to roadside managers nationally. Some states have provided BMPs and other resource documents, through institutions of higher education, to county and state government agencies that manage roadsides. BMPs cover a wide spectrum: some address programmatic methodology of IRVM plans and administrative organizations, whereas others are developed to be site specific or species specific to address the control of a single species of plant and a specific plant community.

2. Literature Review

Bio-engineering measures, which are cost-effective and locally adapted, could significantly reduce severe erosion and landslides along roads but are rarely incorporated as part of road construction activities in Nepal. Currently rural roads are constructed in a quick, " cut and dump " and unsustainable manner and require costly maintenance work after every monsoon season. What is needed is a change in mindsets toward more sustainable road constructions " cut, fill, ensure drainage, then plant ", or " eco-safe roads ", which take a bit longer to construct and have slightly higher initial costs but will be more cost effective over several years and safer for communities [3].A Weed Management Plan (WMP) is provided here to remove/control macro weeds as well as numerous minor (micro) weeds within the restricted development area (RDA) on Lot 1 (see Fig. 1) as part of a consent condition from the Hills Shire Council for the subdivision of the subject property into two Lots. In addition, a simple Vegetation Management Plan (VMP) for those areas weeded and other degraded areas within Lot 1 under the WMP is also proposed [4].According to Nepal Road Standard 2070[5],it is clearly mentioned that roadside plantation of trees and shrubs should be encouraged as far as possible on all urban and non-urban roads with appropriate species without clear codes for urban areas.The Banepa-Dhulikhel-Sindhuli-Bardibas Project road alignment areas experience the sub-tropical climate with an annual precipitation of about 2525 mm .The road alignment area experience high amount of rainfall as compared to other parts of eastern Nepal. The vegetation along the given road corridor fall under the forest type- Sub-tropical moist deciduous forests. Vegetation along the given road corridor fall under the forest type- Sub-tropical moist deciduous forests (source: EIA report of the project area).The Dhulikhel - Sindhuli – Bardibas Road lies in the Central Region of Nepal and traverses two Zones, Bagmati and Janakpur and four districts, Sindhuli, Kavre, Mahottari and Dhanusa. The Banepa-Dhulikhel-Sindhuli-Bardibas Project Road is one of the shortest roads to link the Kathmandu valley with the eastern terai of Nepal in the present context. The construction of Banepa Sindhuli Bardibas Road started in November 1996 with a grant assistance of Government of Japan. The main objective of this road is to connect Capital city of Kathmandu with the Eastern Terai and hence linking to neighboring cities in India. This road link is not only expected to provide an alternate link to Kathmandu with the Terai, it is also expected to bring considerable socio- economic changes along its corridor. This road joins Dhulikhel along the Arniko highway to Bardibas along the East West Highway with a length of about 158 km. For the construction purpose this road has been divided into four sections. Section I : Bardibas- Sindhulibazar (37 km), Section II : Sindhulibazar- Khurkot (39 km),Section III : Khurkot – Nepalthok (32 km) and Section IV : Nepalthok- Dhulikhel (50 km).

3. The Need and the Objective of the Study

3.1 The Need of the Study

The recent researches on IRVM across the world only describes the types of vegetation and some only focuses on best management practices for particular case study only. The awareness of environmental issues are recently been emphasizing in many developing countries. The research on IRVM is a crucial study as different areas should need different strategies to make a better Road side vegetation management. It differs by case to case. IRVM directly affects the Road durability and Serviceability. No researches are done taking it seriously. This research would help to grab the attention of Authorized people to take IRVM as a very important issue in planning, design, construction and maintenance period.For a country like Nepal, where we are still focusing on the basic infrastructures for making life simpler and easier, investing huge amount of budget for maintenance of roads due to lack of proper designing considering roadside vegetation management seems to be wasted. Huge amount of money is used in before time maintenance, which may be invested in some other productive areas such as health, education, business, research works etc. Till now, problems for Road safety and durability, premature deterioration of the road system infrastructure have not taken into account. The problems encountered due to poor IRVM practices are safety considering visibility while driving,erosion and landslides,pollution (air),noise barrier, water/Seepage problem and fragments of ecosystem and habitats, landscapes.There are insufficient research in IRVM for Nepal. For instance: Role of road side Vegetations in taking water away from Road section. As we know that Water is the enemy of road. And also, improper management of vegetations can grow the roots to road sections and decrease its durability. A survey of transportation agencies in the Nepal has not considered it fully and showed that many agencies are still in the process of implementing a science-based integrated approach to making decisions on roadside vegetation management. There is no development of best management practices (BMPs) for roadside management. Even our Nepal Road Standards (NRS 2070) hasn't considered it.

3.2 The Objective of the Study

The aim of this research is to introduce the integrated approach of roadside vegetation management along the highways of Nepal. For the country like Nepal, integrated approach is needed for the sustainability of road functioning. General objective:-

- Improving the Vegetation Management along highways of Nepal by grabbing the attention of policy makers. (As a basis for betterment of Road Standards that means re-visit /upgrade the quality of road standards).

Specific objective:-

- To introduce IRVM concept in highways of Nepal.
- To quantify noise pollution reduction of IRVM implication in Nepal.

4. Methodology

The synthesis will be developed based on a survey of provincial agencies, a review of the literature on IRVM, and follow-up interviews with selected respondents. Subsets of survey questions covered the following specific topics: agency policies and procedures and state laws and regulations, costs and benefits, environmental impacts, public opinion, methods of vegetation management, implementation, re-vegetation, effectiveness, best management practices (BMPs), and additional items.Literature review of various codes, policies, road patterns and Roadside Vegetation types is done in the first hand. The major hotspots identification based on Pollution (Air and Noise), Landslide and Erosion Prone Areas, Ecosystem, landslides and habitats sensitive areas and Water logged / seepage prone areas are identified. Analysis of IRVM based on these criteria is to be done in this step. No highway data for IRVM works considering above mentioned major problems can be obtained. Thus, the case study of Dhulikhel-Sindhuli-Bardibas Project- is taken due to the availability of data and importance of this road for IRVM framework preparation. The EIA report of Khurkot-Nepalthok section, Bio-engineering manual from DOR and allocated maintenance budget data are taken as a reference as secondary data for the case study

to prepare BMPs frame work considering International practices and literatures. The standard questionnaire is prepared for understanding the prevailing practices on vegetation management in professionals group. It is a primary data used including structured and semi-structured questions with interviews. The gaps of perspectives from different sectors can be identified using questionnaires and interviews. By comparing the maintenance budget of various years, the importance of IRVM in Nepal is shown. The need of IRVM for increasing durability is obtained in this process. Best Management Practices for Nepal in Planning, design, construction and maintenance phase of highway is proposed for Nepal. The Preparation of BMP's framework and the gaps prevailing in Nepal are identified. For the validation of the use of IRVM practices in Nepal ,noise pollution aspect of IRVM is quantified in case study site using international references. The list of few vegetation that are included in Nepal showing the quantified value of noise reduction is obtained by using international literatures and expert identification showing similar behaviors as in International literatures.

5. Data Analysis and Results

Data analysis is done in three stages. Firstly, the maintenance budget data obtained from DoR for different types of maintenance for different years. This shows the trend of budget allocation. Secondly, the data obtained from the questionnaires prepared, the questionnaire includes both opened and closed questions. This shows the familiarity of IRVM in Nepal's context with the perspective analysis of professionals in Road sectors and thirdly, the data from available EIA report, bio-engineering reference manual and project information using site visit and secondary data etc. of our case study Dhulikhel-Sindhuli-Bardibas Road Project are analyzed with available literatures of IRVM practices from different countries. The detail of each step is given below in sub sections.

5.1 Road Maintenance Data:

The separate allocation for Bio-Engineering is 0.35% of total maintenance budget for the year 2070/71 and for the year2072/73 the budget allocation is 0.52% of total maintenance budget. The budget allocation for road safety is 1.67%,1.56% and 1.63% for the year 2070/71,2072/73 and 2073/2074 respectively. This analysis results are depicted from the Figure 1, Figure 2, Figure 3, Figure 4 & Figure 5The analysis of road maintenance budget allocated showed that almost same amount is allocated for routine and recurrent maintenance as shown in Table 1. The maintenance budget for routine and recurrent maintenance is in increasing trends except for 2070/71 B.S. The allocated budget for periodic is in ascending order from 7.65% to 30.66% till 2074 B.S. date since last four years. The budget for emergency maintenance has no particular trend. The Specific maintenance budget is in descending order. The budget allocation for Bio-engineering is in increasing trend. Though, there is no separate allocation for it for the year 2069/70 and 2073/74 but the year 2070/71 and 072/73 consists 0.35% and 0.52% of total allocated maintenance budget. The bio- engineering works has been in increasing trends and so is routine maintenance which partially includes IRVM works.Hence, the increasing maintenance needs show the degradation of road as one of the factors for affecting the budget allocation. Thus, we can say that the durability is affected by the improper IRVM of the highways.

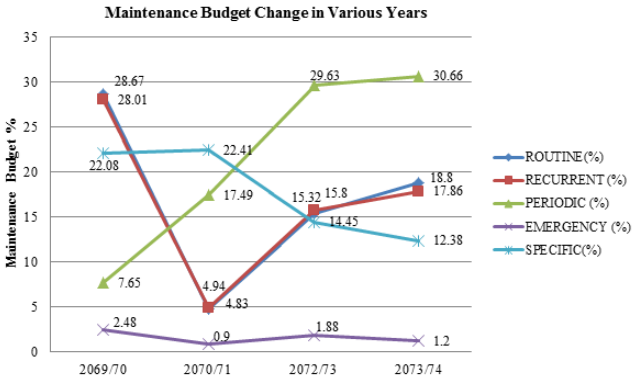

Figure 1: Comparing types of maintenance expenses in various years

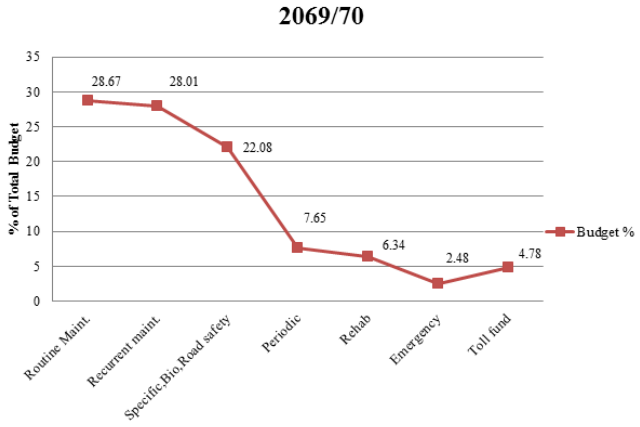

Figure 2: Maintenance budget (%) for different types of maintenance (2069/070)

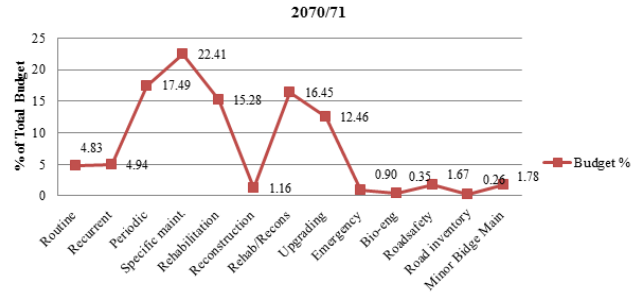

Figure 3: Maintenance budget (%) for different types of maintenance (070/71)

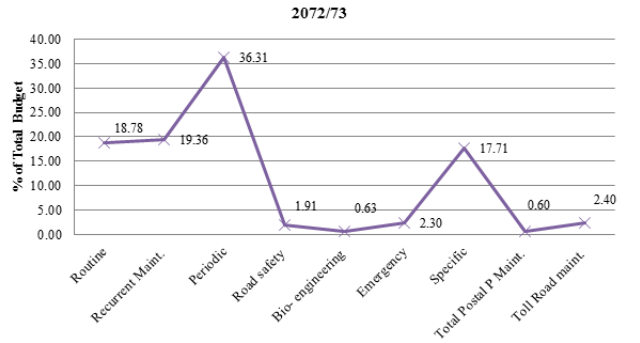

Figure 4: Maintenance budget (%) for different types of maintenance (072/73)

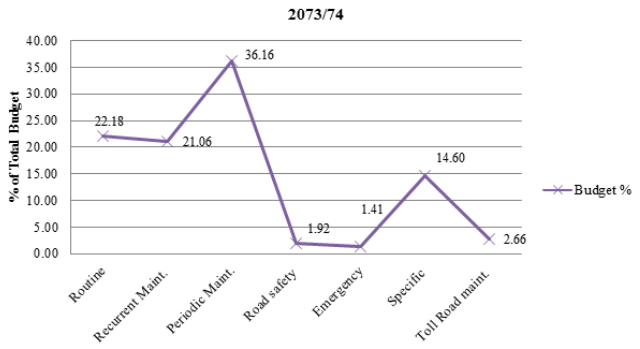

Figure 5: Maintenance budget (%) for different types of maintenance (073/74)

5.2 Data from Questionnaires

Majority respondents are unsure about use of vegetation management policies available in Nepal. Majority respondents (80%)are unaware of Integrated approach in RSVM. 91% of respondents said that IRVM is required in the policies. 87% are supportive about importance of IRVM in future. When asked if our policies incorporate the RSVM while designing, constructing and maintaining any road the majority answered “No”. However, EIA and Bio-engineering are often considered as the management tools for answering ’Yes’ in this case.80% of respondents agreed that poor IRVM adversely affect the maintenance of road and ultimately the life span of the road. Very few (11%) are positive about public relation survey done by their departments. In this case, they meant involvement of local people during EIA . As per the respondents: the state of public opinion on IRVM is found to be: Very strong- 5%,Strong-18%, Moderate-32%,Weak-22%,Very weak-5%and No response-18%.Regarding the control methods; the proper knowledge other than mechanical methods are lacking in most of the respondents. And 48% do not use any control methods for VM. The average numbers of cuts (trees) per year in (nos. /year) have no record in most cases. Kathmandu Valley Road Improvement project office answered approximately 100 nos. /year. Banepa – Sindhuli – Bardibas Road Project office answered 10 nos./year. There is no cost estimate for application of fertilizer. There is the cost estimate for mowing of grasses, brushes, trees as per 9% respondents, which they were unsure about. There is no assigned value(in rupees) of any environmental benefits

(like mowing over using fertilizers) by majority of respondents.GESU and Dhulikhel-Sindhuli-Bardibas project office practice re-vegetation once a year with 80% and 90% of native vegetations respectively. There is no provision of irrigation while re-vegetating of newly established plants as per high majority of respondents while very few said there is by nursery department of DOR, division offices. Incorporation of GIS/GPS is not done in VM by 84% of respondents. Regarding performance measurement during planning, design, construction ,maintenance phase as well as public relation aspects majority of respondents answered "No" and many skipped the questions. No written BMPs are followed.

5.3 Based on Literature Review

The IRVM is divided into below four stages in case of Nepal. The frame work of best management practices (BMP's) has been shown below taking references from analysis part of the research.

5.3.1 Planning Phase

Best Management Practices Framework	Major Legal Bodies (Government)
1. Develop an Integrated Roadside Vegetation Management Plan. • Site preparation and assessing existing conditions of road, roadside vegetation, environment, forests, agricultural lands etc. • Roadside vegetation categories and strategies. • Planning for installation of roadside disaster control equipment's. • Developing a Plan on land-acquisition within ROW. • Plan for responsibility maintenance manpower and staff. • Plan Implementation	1. Ministry Of Physical Infrastructure and Transportation (MoPIT). • Department of Roads (Planning and Design branch (GESU) is the main legislation body for IRVM in co-ordination with below bodies if required the planning can be done in a well-organized way. 2. National Planning Commission (Social development division, Infrastructure development and PPP Division, Agriculture, forest and local development Division) 3. Ministry of Agriculture Development (Planning and Human resource) 4. Ministry of Population and Environment (Department of Environment, Environment Protection Council) 5. Ministry of Forests and Soil conservation (Department of forest)
2. Develop a Public Relation Plan • Public awareness • Public participation • Media awareness	
3. Weed Management Plan • List of vegetation to be used. • Methods of control of noxious weed, invasive weed. • Fire control plans. • Plan for responsibilities, planting schedule and works.	

Figure 6: BMPs in Planning Phase

5.3.2 Design Phase

Best Management Practices Framework	Major Legal Bodies (Government)
1. Design of Roadside vegetation, landscapes for wildlife and vehicle safety considering visibility permits.	1. Ministry Of Physical Infrastructure and Transportation (MoPIT). • Department of Roads (Planning and Design branch(GESU)is the main responsible legislation body for IRVM. 2. Ministry of Population and Environment (Department of Environment, Environment Protection Council)
2. Design of vegetation cutting methods and policies establishing sustainable vegetation using native and introduced grasses within ROW.	
3. Design of Infrastructure for roadside safety using civil engineering techniques in combination with vegetations.	

The bio- engineering reference manual is also to be followed in this stage.

Figure 7: BMPs in Design Phase

5.3.3 Construction Phase

Best Management Practices Framework	Major Legal Bodies (Government)
1. Construction and placement of fences in roadside for vegetations.	1. Ministry Of Physical Infrastructure and Transportation (MoPIT) (Department of Roads).
2. Integrated construction practices including soil placement and vegetation protection.	

Figure 8: BMPs in Construction Phase

5.3.4 Maintenance Phase

Best Management Practices Framework	Major Legal Bodies (Government)
1. Guidelines of maintenance of roadside vegetation with methods of control.	1. Ministry Of Physical Infrastructure and Transportation (MoPIT) (Department of Roads, Maintenance Branch). The co-ordination with below legislations is very beneficial during the highway maintenance. 2. Ministry of Agriculture Development (Planning and Human resource) 3. Ministry of Population and Environment (Department of Environment, Environment Protection Council) 4. Ministry of Forests and Soil conservation (Department of forest)
2. Roadside vegetation management and habitat management.	

Figure 9: BMPs in Maintenance Phase

5.4 Implication of IRVM in Noise Pollution Reduction

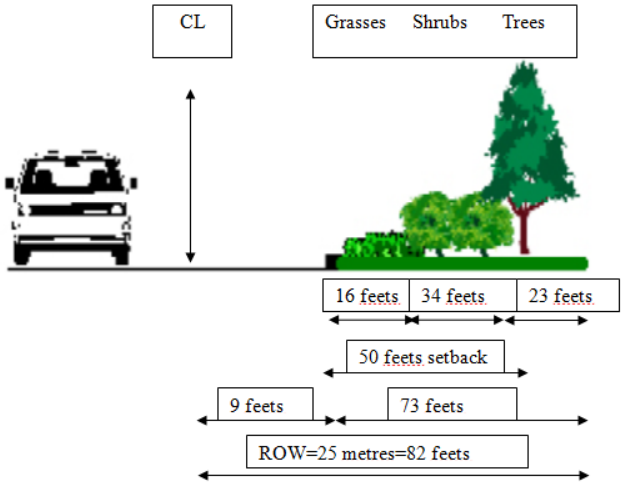

Figure 10: General Road side Vegetation Planting Pattern of case study site having intermediate lane

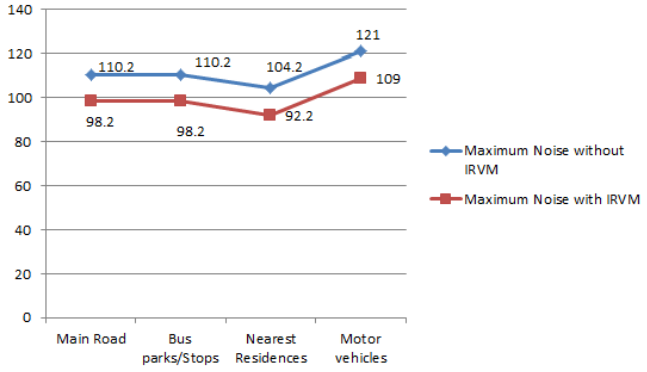

Figure 11: Maximum Noise pollution with and without IRVM implications.

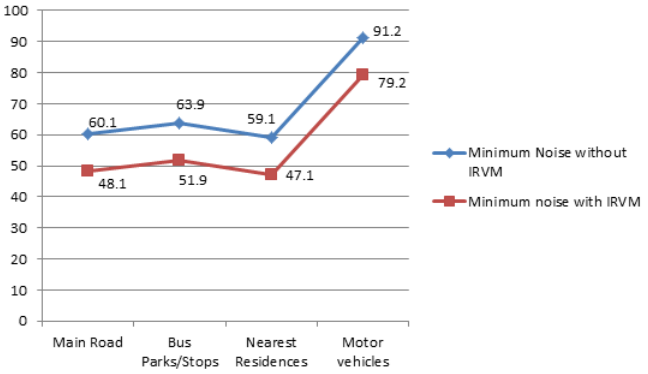

Figure 12: Minimum Noise pollution with and without IRVM implications.

The grasses, shrubs, trees above used should be between terai to 1500 m altitude in B.P highway case study site. Some of the vegetation are similar to that are presented in our bio-engineering reference manual are quantified for noise reduction in International researches [6] [7].They are listed in Figure13.

S.No.	Plant Names	Plantation Width	Distance to Sound Source	Noise Reduction	Altitude Range
1	*Thuja orientalis*	2 row	1 m	2 dB(A)	Terai – 1500m
2	*Berberis asiatica*	5 m	1 m	4.8 dB(A)	1500-3000m
3	*Pyracantha Crenulata*	2 row	1 m	2 dB(A)	1500-2500m
4	*Berberis aristata*	5 m	1 m	4.8 dB(A)	1500-3000m
5	*Populus ciliata*	25 m	-	3 dB(A)	2000-3000m
		50 m		2.5 dB(A)	
		75 m		2.4 dB(A)	
6	*Pittosporum tobira+Prunus laurocerasus +Cupressus atlantica cv. Glauca*	3 row	6 m	5 dB(A)	500-2400 m
7	*Pinus roxburghii*	25 m		9.3 dB(A)	500-1950 m
		50 m		5.3 dB(A)	
		75 m		5.7 dB(A)	

Figure 13: Vegetation plantation method for noise reduction of Nepal

The general design of vegetation plantation method for noise reduction is obtained for the case study site which is resulted as in Figure 12. [8].The maximum of 121 dBA for motor vehicles is reduced to 109dBA in the site [9] [10] .

6. Conclusion

The incorporation of IRVM in all the stages of highway planning, design, construction and maintenance is must in a developing country like Nepal. The maintenance budget trend shows that the budget components directly linked with IRVM (bio-engineering maintenance budget and routine maintenance budget) are in increasing order which shows a huge amount is spent because of poor road condition. Hence, we can conclude that IRVM affects the durability of road and its proper implementation could save huge amount of maintenance budget and help to develop sustainable roadside management. There is a need of IRVM policy document considering best management practices to be incorporated in the working documents of DoR, Nepal. There is a need of incorporation of IRVM concept in planning, design, construction and maintenance phases of highway in a legalized form which is planning and design gap in case of Nepal. The perspectives of various groups of intellects show some gap according to questionnaire analysis. So far, the analysis shows that the concept of IRVM is completely new in context of Nepal. The research intends to enforce the implementation of Best Management Practices (BMP's) along the highways of Nepal. The proposed framework of BMP's during highway construction works in planning phase, design phase, construction phase & maintenance phase must be implemented in Nepal. The benefits from the implication of IRVM analyzing the noise pollution are found to be beneficial for the safe and sustainable road transportation sector and environment. This benefit is quantified using the case study site of Dhulikhel - Sindhukli - Bardibas Road with general design of road side vegetation management to reduce the noise pollution. Hence the introduction of IRVM with proposed framework and its importance regarding durability.

7. Recommendation

The case study site of Dhulikhel –Sindhuli-Bardibas road was taken as per the availability of the road data rather than the most problematic site.It is recommended to use as many as case study sites. IRVM affects the durability of road is shown using maintenance data but quantification is to be recommended. Only few benefits of IRVM are quantified showing the values in reduction of noise pollution The detail quantification can be done considering most aspects. Only few vegetations from bio-engineering books are listed for quantified values of reduction in noise pollution. It is recomended to study as many as vegetattion for more diverse results.

Acknowledgments

The authors are grateful to every single person who contributed directly or indirectly in the research.

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