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Developing Criteria for Priority Ranking of Bridges:

A Case Study of Bagmati Province

by

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ABSTRACT

In our country, prioritizing the projects for its implementation has been seen with great importance after institutionalization of federalism. At present, federal, provincial and local level government is executing infrastructure development in their respective jurisdiction. The main objective of this thesis is to identify the criteria for selection of bridges by federal, provincial and local government.

Criteria are identified based on prevalent practice of multi criteria prioritization on bridge sector on national & international level and discussion with officials from bridge project implementing organizations on national level like DOR and LRBP. Sub criteria is developed with the help of secondary data on traffic, population, cost of bridge, all weather road length collected from online sources, DOR and LRBP and use of multi criteria analysis techniques like linear value function, series of verbal pair wise assessments and direct rating. AHP analysis is done to provide weights to criteria for which pair wise comparison form are developed and are made to fill from panel of 12 professionals related to bridge sector comprising of elected representatives, academic professionals, government officials and practicing consultant on bridge sector.

Three criteria for federal level, five criteria for province level and four criteria for local level are identified. Among three criteria for federal level, strategic importance of road weighs 58.1%, AADT weighs 28.4% and project readiness weighs 13.5%. For province level matrix, strategic road importance weighs 34.3%, access to socio-economic activities weighs 22.9%, all-weathered road length weighs 16.6%, present traffic volume weighs 14.9% and per capita investment weighs 11.3 %. For local level matrix, road closure duration weighs 34%, strategic importance of road weighs 27.1%, present traffic volume (VPD) weighs 21.4 % and all weathered road length maintainable/operable by local level weights 17.5%. During ranking of 17 bridges to be implemented by DOR with help of federal level multi criteria, Sansare Bridge on MRM highway at Ch. 392+280 score 2.61 and lies on rank one.

Additional probable criteria were also put forward by the experts during study which however is not measurable at present context due to data insufficiency. Addition and omission of criteria however might be possible for real application accounting flexibility of multi-criteria analysis based on experts and stakeholders opinion.

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ABBREVIATIONS

AADT	Average Annual Daily Traffic
AHP	Analytic Hierarchy Procedure
BMS	Bridge Management System
BIMS	Bridge Information Management System
BIMP	Bridge Improvement and Maintenance Program
CBS	Central Bureau of Statistics
DOLI	Department of Local Infrastructure
DOLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DOR	Department of Roads
DTMP	District Transport Master Plan
DRCN	District Road Core Network
ED	Executive Director
IDO	Infrastructure Development Office
IOE	Institute of Engineering
LRBP	Local Road Bridge Program
LRBSU	Local Road Bridge Support Unit
LRN	Local Road Network
MC	Motorcycle
MOPIT	Ministry of Physical Infrastructure and Transport
MH	Municipality Headquarter
PCI	per Capita Investment
PPP	Public Private Partnership
PMU	Project Management Unit
SCBA	Social Cost Benefit Analysis
SDE	Senior Divisional Engineer
SNRTP	Strengthening National Rural Transport Program
SRN	Strategic Road Network
TID	Transport Infrastructure Directorate
VPD	Vehicle Per Day
WB	World Bank

CHAPTER ONE: INTRODUCTION

1.1 Introduction

The constitution of Nepal, 2015 defines Nepal as an independent, indivisible, sovereign, secular, inclusive, democratic, socialism oriented, federal democratic republican state where central government will be divided into three levels viz Federal Government, Provincial government and Local Government. At present, there are one federal government, seven provinces, local bodies comprising of 6 metropolitan cities, 11 sub metropolitan cities, 276 municipalities and 460 rural municipalities with altogether 753 local bodies in Nepal.

It is evident from the review of recent policy documents and guidelines published by Nepal government after institutionalization of federalism that; the prioritization of infrastructure projects before its implementation is seen with great importance and considered as one of the significant factor which can prevent selection of sub-optimal projects and can result in wise spending of scarce funds to maximize socio-economic benefits.

At present, DOR and DOLI (LRBP) owns a multi-criteria analysis (MCA) priority tools for prioritizing the new motorable bridges for implementation within the country. Due to introduction of federalism in the country, the scope of both the organizations has changed. Three level of government (federal, province and local level) are implementing bridges in their respective jurisdiction. DOR is implementing bridges in federal level whereas DOLI, TID & IDO offices are working in province level and office of municipality, rural municipality are working on local level. Existing priority matrix used previously needs to be modified and aligned with newly developed scenario, so that it can reflect the needs of each level of government and prioritization of bridges to be constructed by each level of government can be made more effective.

In this research, three criteria namely strategic importance of road/government priority policy, traffic volume (AADT), and readiness of project are selected for federal level. Similarly, five criteria's namely strategic importance of road/government priority policy, traffic volume (AADT), per capita investment, all

weathered road length, and access to socio-economic activities are selected for province level. Similarly, four criteria's namely strategic importance of road/government priority policy, traffic volume (AADT), all weathered road length operable/maintainable by local level and road closure duration were selected for local level.

1.2 Statement of Problem

For prioritization of new crossings for ongoing BIMP program in DOR, multi-criteria analysis is in use. Though BMS is operational in DOR, its effective use for project prioritization has not been exercised**.** In LRBP, three stages screening system (minimum, local/district& central) is in use for bridge selection and prioritization. One of the minimum conditions for bridge selection is that bridges to be constructed must lie on DRCN. However several bridges which are allocated budget and are being implemented do not fall under identified DRCN. At present, federal, provincial and local government are implementing bridges in their respective jurisdiction and modification of existing priority ranking using multi criteria is necessary for its effective application in bridge selection process.

1.3 Scope of Research

The developed matrix can be useful to government organization working in bridge construction field like DOR in federal level, TID & IDO office in province level and office of municipality & rural municipality in local levels.

Bridge related data from 13 districts of province no. 3 are collected and analyzed for the study purpose. Pair wise criteria comparison data for AHP analysis is taken from experts working on bridge related field in Nepal. The new bridges which are being implemented by DOR and TID office in province no. 3 in fiscal year 2076/77 are used to demonstrate the ranking from the developed tool.

1.4 Objectives of Research

The primary objective of this study is to identify the criteria for the selection of bridges by federal, provincial, and local government.

The specific objectives of the research are:

a) Identify criteria for prioritization of bridge projects.
b) Development of sub-criteria.
c) Deriving weight for the criteria.
d) Demonstrating the use of multi criteria and ranking of bridges in Bagmati province.

1.5 Rationale of research

Federalism gets institutionalized in our country dictating the failure of equal development within all nooks and corners of country under the concept of regionalism and unitary system of government. Federalism has been thought to end regional disparities, socio-economic discrimination and initialize proportionate development of country. In this context central, province and local government has been formed and they are provided the responsibility of triggering development within their area. Road and bridges are integrated for the development of any locality. Since the main mode of transportation is roadways in our country, road access is inevitable for socio-economic development of any region. Lack of access to the markets and service centers due to the absence of adequately maintained roads and lack of bridges connecting them is making life of people miserable. Without reliable motorable crossings on the rivers, maximum benefit from the roads constructed cannot be gained and also the investments made in road are not fully utilized. Because of the importance of bridges, there were thousands of bridges in demand and the process of selection of bridges for construction is rather ad-hoc, political and not scientific and transparent. At a same time, development funds are limited in our country and to achieve the best results from available resources and budget, well planned and prioritized investment approach is must.

In this context, the research primarily focuses to prioritize new bridges constructions within the country. The tool developed aid in decision making within the different level of government (central, province, local) for selection of new bridges for its implementation. The need for making new bridges can be inspired by different vision and goal they see for their jurisdiction area on these various levels of government. However, the new bridge construction works conducted on each level should not be inspired by vested political interest and needs of some particular group of people. The unwanted forces influencing the new bridge project needs to be neutralized and well

planned, prioritization approach is necessary for selecting appropriate bridges for implementation.

The developed tool provides clearer and simpler approach for each level of government to prioritize the identified bridge for implementation in their jurisdiction. Use of AHP to fix the weight age of each criterion has made the matrix development procedure more scientific and practical. Sub-criteria are also calibrated using available data and no subjective judgment is applied. Though the study consists of some limitations, some little further addition of knowledge in this study can result in an effective tool which can be conveniently and effectively used in all level of governments for new bridge prioritization purpose.

1.6 Limitations:

- The prioritization matrix is applicable for new motorable bridge construction.
- Sub-criteria scoring for road link classification is done based on expert opinion and judgment only.
- Present traffic volume is taken for analysis since prediction of traffic will be complex and beyond the scope of the study.
- Population of whole local level is assumed as benefited by the bridge and used for producing value in per capita investment criteria.
- Prioritization matrix is developed/evaluated only for province number 3.
- Road Closure duration sub criteria is taken as previously used by DOR.

1.7 Report Organization

This report has been presented in six chapters. First chapter deals with introduction and objectives of study, chapter two provides literature review regarding theories and research works whereas chapter three presents the methodology adopted for developing the priority matrix. In chapter four, data collection, its analysis and development of MCA priority matrix for each level is discussed. In chapter five, results and discussion are presented and finally on chapter 6, conclusions and recommendations made are summarized. After that, the report contains the references. List of annexes are presented after that.

CHAPTER TWO: LITERATURE REVIEW

2.1 Federalism in Nepal

2.1.1 Introduction

Federalism is a political philosophy in which a group of members are bound together with a governing representative head. The term 'federalism' is also used to describe a system of the government in which sovereignty is divided between a central governing authority and constituent political units (like states or provinces). Federalism is a system in which the power to govern is shared between national and central (state) governments, creating what is often called a federation and the proponents are often called federalists (Bishnu H. Pandit, 2009). In federal system, a written constitution divided power between national government and entities like state or province.

Government of twenty-seven countries in world isstructured in federalist principles which account almost half the territory of the world and residence for more than forty percent of world population. Nations like United States, Switzerland, Germany, Belgium, Canada, Australia, India, Nigeria &Malaysia are successfully running federal system. (Gyawali, 2018)

Federalism was included in forty-point agenda by Maoist when the insurgency began in 1996. CPN-M declared several autonomous regions like Tharuwan, Tamuwan, Tamang Saling, Kirat and Madesh which conceptualize the autonomous federal states in the country. The Madhesi population which has bargaining leverage of its ability to halt the influx of goods to Kathmandu from India facilitates introduction of federalism to mainstream politics.

The combination of the political effects of the armed conflict and the People's Movement of April 2006 brought down the autocracy with the hope of developing Nepal into a modern, inclusive and federal republican state. Several rounds of negotiations, understanding and agreements have culminated into the last concluded 23- point agreement reached between the Seven Party Alliance (SPA) and the Maoists which led to a final agreement to declare Nepal a Federal Democratic Republic and its

incorporation in the third amendment to the Interim Constitution (IC) 2007. (Kailash Nath Pyakurel, 2008).

Nepal adapted federalism on its own necessity which can address the diversity i.e. multi-ethnic, multi-lingual, and multi-cultural aspects within the state; balance in development i.e. healthy, sound competitive and proportional development of all the nooks and corners of the country; sharing and transferring the power to the provincial and local level and best mobilization and allocation of the resources for balanced and justifiable development.

2.1.2 Federalism and development visions

Federal system of governance can facilitate the nation with higher economic growth by formulating and implementing proper policies. Potential exists in the form of conventional sectors such as hydropower, agriculture, tourism and hospitality, forestry and herbal, minerals etc. Extensive fiscal autonomy and resource mobilization and management responsibilities are entrusted to the local bodies by the Constitution. Building administrative capacity and skills of planning and managing budget will continue to remain a challenge for the local leadership. One of the main objectives of the federal system is to develop equally and as per equitable manner to the grassroots level. Nepalese constitution has assumed that all sectors would be developed with the participation of local people at all spheres of the development (Basnet, 2017).

States are certainly going to compete with each other in the federal system either in positive or negative way. If the states encourage and promote industries and businesses and adopt policies to attract investments, the competition will positively impact the overall economic development of the country. But if the federal units compete with each other only for the federal budget provided by the central government, the competition will definitely have a negative impact (Sharma 2016).

Whatever shape and structure the federal structure takes, once it is instituted, the roles of the central government, the federal states, as well as of the non-government entities will have to be more clearly defined.

Nepal's post-conflict development has to contribute to achieve the aim of developing a peaceful, politically stable, economically prosperous and socially just federal

republic. Therefore, new development policies, strategies, implementation modalities and planned outcomes have to focus on contributing to this aim.

Nepal's federal system should involve a simple but 'nested' or polycentric decision-making arrangements (versus neatly hierarchical) being carried out concurrently across a range of political decision-making levels (e.g. central, provincial, local) and horizontally across a fragmented array of territorial and sectoral areas. (Bishnu H. Pandit, 2009)

2.1.3 The Constitution of Nepal

The present constitution of Nepal was published in Nepal Gazette 20 September 2015 (2072.6.3).Constitution of Nepal dictates in its policies relating to achieve economic prosperity by way of optimum mobilization of the available means and resources, to provide for the farmers' access to agricultural inputs, agro-products at fair price and market. to enhance investment in the transportation sector, while ensuring simple, easy and equal access of the citizens to transportation facilities, while according priority to the environment friendly technologies by maintaining the relations between the Federal Units on the basis of cooperative federalism.

The main structure of the Federal Democratic Republic of Nepal shall be of three levels, namely the Federation, the State, and the Local level. The Federation, State and Local levels shall exercise the power of State of Nepal pursuant to this Constitution and law.

The powers of the Federation shall be vested in the matters enumerated in Schedule-5, and such powers shall be exercised pursuant to this Constitution and the Federal law. Similarly, the powers of a State shall be vested in the matters enumerated in Schedule-6, and such powers shall be exercised pursuant to this Constitution and the State law. The concurrent powers of the Federation and the State shall be vested in the matters enumerated in Schedule-7. The powers of the Local level shall be vested in the matters enumerated in Schedule-8.

For transportation sector, the constitution of Nepal schedule 5 assigns responsibility of national transportation policies, management of railways and national highways to federation. Similarly, in schedule 6 of constitution the responsibility of state highways

is assigned to states. Though schedule 7 does not speak directly on transportation sector, federation and state are provided concurrent powers on tourism, poverty alleviation, industrialization, employment,industries, mines & physical infrastructures. Similarly, in schedule-8, responsibility of local roads, rural roads & agro roads are assigned to local level.

2.2 Province no. 3

2.2.1 History

On account of its location, at the heart of Nepali civilization, Province no. 3 has been the centre for economic development and political upheavals in the country during different periods of history.

In the era before the first millennium, the area covered by this province was under the rule of the Kirat. In the first millennium, most of the areas under this province came under Lichhavi rule, which had a fairly advanced system of administration in the contemporary times. During the early second millennium, the areas of this province were ruled by the Mallas, who later divided into various smaller kingdoms, including the three kingdoms in the Kathmandu Valley. Outside the valley, there were smaller kingdoms including Dolakha in the east ruled by Malla kings and Makawanpur in the south ruled by the Sen Kings. The Mallas contributed to the growth of the cultural, artistic, and architectural heritage of the valley which is assets for this province. After the unification of Nepal in 1767 under King Prithvi Narayan Shah, the areas under this province came under the rule of the Kingdom of Nepal. Under Panchayat period (1961-90), most of the areas covered by this province were included in the erstwhile Central Development Region of the country. This province contributed to democratic political movement in 1950, 1990, 2006, and in the political transformations from 2008 onwards that changed Nepal into a “Federal Democratic Republic”

2.2.2 Background Information:

Province No. 3 is centrally located and includes the national capital Kathmandu, the cradle of Nepal’s ancient civilization, culture, art, architecture, and diversity. Because of this relatively better concentration of resources, population, physical infrastructure and economic and industrial activities, the province has many good prospects and

opportunities to ensure rapid socioeconomic development. Theprovisional capital is located inHetauda, which was also the headquarters of the erstwhile Central Development Region.

Province No. 3 covers 13 of the 77 districts of Nepal and 119 of the country's 753 local bodies. It provides 66 constituencies to the Provincial Assembly and 33 constituencies to the House of Representatives in the national parliament. At the local level, there are three metropolitan cities, one sub-metropolitan city, 41 municipalities and 74 rural municipalities in this province.

With an area of 20,300 sq. km., this province occupies 13.79 per cent of the total area of the country (147,181 sq. km.). Province No. 1 lies to the east of the province, Gandaki Province to the west and Province No. 2 to the south. This province touches the Tibet Autonomous Region of China in the north and the state of Bihar in India in the South.

The province extends across three ecological regions including five Himalayan districts (Dhading, Rasuwa, Sindhupalchowk, Ramechhap, and Dolakha), two mountain districts (Kavrepalanchowk and Nuwakot), three districts in the Kathmandu Valley (Kathmandu, Bhaktapur, and Lalitpur), and three Inner Terai districts (Makawanpur, Sindhuli, and Chitwan).

This province is drained by two main river systems including the Koshi River in the East and the Narayani River in the West. The Koshi River system consists of its tributaries: Sunkoshi, Bhotekoshi, Tamakoshi, and Likhu (in the East) and the Narayani River system consists ofthe Trishuli, Budhi Gandaki and Narayani Rivers (in the West). Bagmati and Kamala are the two other main rivers in the region. There are 10 sub-basin systems in the river systems of this province.

With a total population of 5.5 million, Province No. 3 is the most populated among the seven provinces of Nepal. It makes up 20.87 per cent of the national population. The province also has a higher population growth rate (1.91) than the national growth rate (1.35). The population density in the province (272 per sq. km.) is significantly higher than the national population density (180 per sq. km.). This province is home to nearly a quarter (23.42 per cent) ofthe total number of households in the country. (Province Policy & Planning COmmision (PPPC) 2018)

Province No. 3 is relatively well connected with other provinces. The state of transport infrastructure, including road networks is better in this province than other provinces in Nepal. All 13-district headquarters in this province are connected with blacktopped road. Road networks touch most rural and urban municipalities. Major highway networks, including the East-West Highway and the Mid-Hills Highway pass through this province. Route A42 of the Asian Highway that connects border towns with India (via Birgunj) and China (via Kodari) crosses through this province.

Urban and rural road networks are relatively well connected in this province. This province has a network of 2,452 km (19 per cent) of the national road network and 14,479 km (25.12 per cent) of rural roads in the country. The main North-South road corridor linking India and China (via Kodari and Rasuwa) passes through this province. (Province Policy & Planning COmmision (PPPC) 2018)

This province produces nearly a third of the electricity in the country Major hydropower projects located in this province are: Kulekhani I (60 MW), Kulekhani II (32 MW), Khimti (60 MW), Bhote Koshi (36 MW), Sunkoshi (10.5 MW), Trishuli (24 MW), and Devighat (14 MW). Hydropower projects under construction in this province include Upper Tamakoshi (309 MW), Upper Trishuli (128 MW), Upper Trishuli A (60 MW), Upper Trishuli B (37 MW), andKulekhani III (14 MW). The province also has the highest number of hydropower projects under construction in the country. Various hydropower projects with a total capacity of over 335MW have been approved for private investment in this province. (Province Policy & Planning COmmision (PPPC) 2018)

There are 7,469 schools at the basic education level (18.54 per cent of the country) in the province. Likewise, there are 1,920 public schools (21.27 per cent of the country) at the secondary level (Grades 9-12) in this province. (Province Policy & Planning COmmision (PPPC) 2018) The GoP aims to increase access to quality education for all communities, develop vocational and technical education and training, and support continuous improvement and innovation in the education sector.

There are 885 public health facilities, including hospitals (34), primary health centres (43), health posts (640), urban health centres (90),community health units (61), and

other health facilities (18) in the province. There is a concentration of private sector health facilities, mostly in the Kathmandu Valley, in this province.

Province No. 3 is the economic hub of the country. The province contributes to nearly a third (31.90 per cent) of the country's Gross Domestic Product (GDP). Nearly 81 per cent of the province's GDP comes from non-agricultural sectors, mainly services, industry, and manufacturing.

There are 5,064 large industries in this province constituting more than two-thirds (67.60 per cent) of the country's large industries. There are 964 medium-sized industries in the province, comprising 12.81 per cent out of the 4,076 in total in the country.

Eight of Nepal's ten cultural heritages listed in the World Heritage List – the famous temples ofPashupatinath and Changu Narayan, the Buddhist stupas of Swayambhunath and Bouddhanath, the three Durbar Squares of the Kathmandu Valley, and the Chitwan National Park – are all located this province. Other famous religious and cultural sites in the province include Kalingchok, Gosaikunda, Palanchok, Devghat, Namobuddha etc. There are many trekking, hiking and mountaineering routes and other tourist attractions in this province. This province also has historical forts at Makawanpurgadhi, Rasuwagadhi, and Sindhuligadhi. Four of the country's 12 national parks are located in this province. There is immense potential for further developing the tourism industry and services in the province to create more opportunities for income and employment.

Though this province is ahead in most economic and social development indicators and infrastructure development, there is a marked unevenness and disparity within the province in the same. This is because of the legacy of an unbalanced approach to development and the marginalization of rural and backward areas of the province.

2.2.3 Possibilities

Upon completion, the proposed 190 km Thori-Kerung corridor is going to have a transformative impact on the development of this province as well as that of Nepal's connectivity with its neighbours India and China. This road also has historic significance in reviving the traditional trade entrepot through Nepal.Upgradation of

highways linking Kerung, construction of a dry port at Rasuwagadhi, and extension of the railway from Tibet to Kathmandu as well as the development of ports and other facilities along the border with China will be of immense importance for the development of this province. There is also the prospect for developing connectivity with Tibet in China through Lamabagar in Dolakha district. The completion of the Hulaki Rajmarg (Postal Highway), being constructed with assistance from the Government of India, will also be of immense significance for increasing road connectivity with other provinces.

Province No. 3 has ten ongoing "national pride projects" within its geographical area which are upper Tamakoshi hydropower project, Budhi Gandaki hydropower project (also extends to Gandaki Province), Melamchi Drinking Water Project, Rashtrapati Chure Conservation Project, Middle Hill Highway (extends to other provinces except Province No. 2), Kathmandu-Nijgadh Fast Track Road (also extends in Province No. 2), Postal Highways, Pashupati Area Development and Galchhi-Rasuwagadhi Road Project.

This Province is endowed with abundant natural resources including water, forests, herbs, biological resources, natural beauty, mines, and minerals.

There is some coffee farming in Lalitpur, Sindhupalchowk, and Kavrepalanchowk districts of this province. Prospects for organic fruit and vegetable farming, livestock, meat production, fish farming, dairy, and poultry are high in this province, as is the cultivation of herbs and flowers. This province produces more than half (53.8 per cent) of chicken eggs produced in Nepal. It contributes nearly one-fourth of the corn, millet, buckwheat, potato, and meat production, and nearly half of poultry produced in the country.

2.2.4 Development Visions

Project whose feasibility study, DPR, and technical drawing, design is ready will be given high priority. Similarly, projects & program will be selected based on demand by public& government priorities. Projects that are directly demanded from public are included in the program with high importance. 119 local levels in Province no. 3, 13 rural municipality has main administrative centre of 11 districts among 13 districts in P3 are not connected to district headquarters.

One of the aims of the budget was implementation of balanced program based on public demand. Also, the projects demanded by elected representative were to be included based on priority. 'Chief Minister Rural road program' in province 3 incorporates a target to connect local body's main administrative centre to district HQ or SRN with blacktopped roads within 3 years. Modernization and mechanization of agriculture, Tourism promotion and development, Energy and Infrastructure Development, Easy access to health services, Quality education development Industrialization and productivity growth are some of the priorities of the budget. *Source: The budget speech of the Minister of Economic Affairs and Planning for FY 2018/19*

2.3 DOR/Bridge Branch:

Department of Road (DOR) is a government agency, established in 1970 splitting from Public Works Department (PWD), whose main purpose is to translate government policies for the roads sub-sector in terms of provision of service to the general public of Nepal for the fulfillment of its mission states as " To contribute Towards the Betterment of Living Conditions of the People through Effective, Efficient, Safe and Reliable Strategic Road Connectivity".

Managing Roads for National Integration and Socio-Economic Development" is the vision for development of roads in Nepal. The overall goal is to contribute in achieving sustainable socio-economic development by providing safe affordable public road infrastructure services through building of a cost-effective, efficient, and reliable road network system.

The mission statement for the Department of Roads is "To Contribute Towards the Betterment of Living Conditions of the People through Effective, Efficient, Safe and Reliable Road Connectivity"

One of the major efforts towards efficient management of bridge was establishment of bridge unit under planning & design branch in 1994 as central agency for coordinating with divisions & projects for bridge management process in DOR.

As a part of the new organizational restructuring for DoR under the institutional strengthening component of World Bank Project Road Sector Development Project,

the earlier Bridge Unit under the Planning and Design Branch was restructured into Bridge Project headed by the Superintendent Engineer. Earlier, Bridge Project was established in 1994 with assistance from ODA (UK).

2.4 BIMP Project

Under the financing of World Bank, BIMP Project is initiated in 2012. The Project Development Objective is to improve uninterrupted movement of traffic along Nepal Strategic Roads Network through support to the Government of Nepal for program of bridge development and maintenance and to strengthened bridge management. Bridge Improvement and Maintenance Program Support (BIMPS) is being prepared and is proposed for World Bank financing using the Program for Results (PforR) lending instrument to address the problem regarding gaps in SRN due to non-existent and inadequate bridge structure.

A bridge management system or BMS is a means for managing bridges throughout design, construction, operation, and maintenance of the bridges. Bridge management systems is helpful in building inventories and inspecting databases, planning for maintenance, repair and rehabilitation (MR&R) interventions in a systematic way, optimizing the allocation of financial resources, and increasing the safety of bridge users. The major tasks in bridge management are collection of inventory data; inspection; assessment of condition and strength; repair, strengthening or replacement of components; and prioritizing the allocation of funds. A BMS is a means of managing bridge information to formulate maintenance programs within cost limitations.BMS includes four basic components: data storage, cost and deterioration models, optimization, and analysis models, and updating functions.

2.5 LRBP/LRBSU

Government of Nepal (GoN), Ministry of Federal Affairs and Local Development has given priority to improving access, by building roads and bridges connecting them. In this context, upon the GoN"s request, Swiss Development Corporation (SDC) agreed to provide a Technical Assistant (TA) to support the implementation of Local Roads Bridge Program (LRBP). Bilateral Agreement for Local Roads Bridge Program (LRBP) was signed on 23rd March 2011 between Government of Switzerland and

Government of Nepal for the 1st phase. The duration of the 1st phase is 4 years from February 1, 2011 to November 30, 2014.

Considering high priority to bridge construction work and its continuation, GoN and SDC extended 1st phase of LRBP till, May 31, 2016.Similarly LRBP 2nd Phase was signed on May 13, 2013 for 9 months period from June 01, 2016 to February 28, 2017. LRBP 3rd phase was signed on January 26, 2017 for 3 years 5 months period from March 01, 2017 to July 31, 2020.

2.6 SNRTP Project

It is a bilateral agreement signed between the Department of Local Infrastructure Development (DoLI), Ministry of Federal Affairs and Local Development (MoFALD), with ILO. This is the fund from the World Bank granted to the DoLI, MoFALD.

The project aims to enhance the availability and reliability of transport connectivity for rural communities in the thirty-six (36) districts in Nepal. It assists in building bridges and maintenance, rehabilitation and upgrading of the local road networks and river crossing. The project contributes at improving rural accessibility. Its key components are institutional strengthening and. maintenance and upgrading of rural transport infrastructure. It employs local workers, mainly women and in coordination with financial institutions and service providers on skill development training on road maintenance and income generation to improve the economic situation. There are two outcomes targeted from this project which are increased access to all-weather transport connectivity and improved reliability of rural transport infrastructure.

2.7 TID/IDO

To carry out the Infrastructural Development including Provincial Road, Bridge, Over Bridge in 13 districts of province 3, Transport Infrastructure Directorate was established on7th of Mangsir 2075 in Hetauda, Makwanpur. Under this Directorate there are 6 Infrastructure Development offices and 2 provincial Road Division offices which are as follows:

1. Provincial Road division Office, Nuwakot Jurisdiction districts (Nuwakot, Rasuwa, Dhading, Chitwan, Makwanpur, Lalitpur and Kathmandu)

2. Provincial Road division Office, Khurkot Jurisdiction districts (Ramechhap, Sindhuli, Dolakha, Kavrepalanchok and Bhaktapur)
3. InfrastructureDevelopment Office, Ramechhap
4. InfrastructureDevelopment Office, Sindhupalchok
5. InfrastructureDevelopment Office, Kavrepalanchok
6. InfrastructureDevelopment Office, Lalitpur
7. InfrastructureDevelopment Office, Chitwan

2.8 Politics and infrastructure sector (roads & bridges) of Nepal

Without successful project identification, preparation and implementation, development plans are no more than wishes and developing nations would remain stagnant or regress. Recent assessments of development planning and administration, and of the lending practices of assistance agencies by international evaluation commissions highlight the importance of well prepared and executed projects. (Rondinelli, 1976)

Leader is to lead the society and establish a just society, but in Nepal it means to become political elite. Due to erosion in political ideology, that teaches how to establish justice and build a harmonious society, in all parties, they look like an informal club group/s, like that the shape of ginger. Local politicians, the wealthiest people, bureaucrats, privileged people, district party committee members, the security persons, teachers and some health workers as well as the businessmen and the contractors are the main actors of local level. An influential leader or MP keeps the whole district under its control, by distributing government resources managing benefits for his/her supporters only.

The continued vacuum at local level has personalized and centralized the planning and selection of the projects. Due to partial and incomplete political socialization, local values of Nepalese society like equality, common good, accountability towards society, consensus over common development goals are pushed down the hill. They are creating in new political culture, which is contributing more prone to political instability and more disruption. At central level, conflict also emerge between the Prime Minister and the National Planning Vice –Chairperson over lists of the projects ‘selection. These projects are chosen without consideration of feasibility (Chetri).

Forecasting development of roads and other major infrastructure is very uncertain due to fluid political situation of the country. (Sagar Raj sharma, Bishnu Raj upreti, kailash Pyakurel, 2012).

In this present scenario, the demands of local road bridges come to DDCs from different sources like local peoples, local political leaders and so on. This lead to the situation that the local authorities like DDCs face a huge list of bridge demands. And due to absence of proper and rational method to sort these demands, there is high possibility that undue influences and discussion arise while choosing the bridge for further studies /implementation. Political and other pressures to select bridges leads to selection of wrong bridges, or bridges that are socially and economically not justifiable (LRBP).

The policy and practice do not match within DOR for bridges selection process. As per policy of DOR, prefeasibility and feasibility study needs to be carried out and priority ranking needs to be done after discussion among the stakeholders before getting formal approval of the rolling plan from concerned authority. Detailed engineering survey of selected bridges in rolling plan is then conducted in order of priority. There is formal design acceptance process in which Regional Directorate (RD) and Division Road Offices(DRO's) are assigned for field verification followed by design check by bridge unit and design acceptance by concerned authority. Finally,on the basis of priority, bridge project is selected. However, in real practice, the selection and approval process of bridge project is highly centralized and politicized. Each year National Planning Commission decides ultimately which bridge is to be constructed and includes in the RED book. But the procedure and criteria for selection is not clear. Red book allocates budget for construction in an ad-hoc basis without knowing whether the bridge is technically or economically feasible or not. There are large numbers of cases where the budgets have been allocated on the basis of demand of politician. There are cases where division staff of DOR could not find where a particular crossing lies in their territory. It indicates that bridge planning is centralized; there is little relevant input from the divisions of the local level.Prefeasibility and feasibility studies are done merely to fulfil some unnecessary formalities. The results are neither used for planning and budgeting nor for detailed design and construction. (Mulmi 2013).

Mulmi, 2013 points out ad-hoc planning as one of the main problems in bridge projects implementation and focusses on scientific and organised selection and approval of projects. He also recommends prioritizing the bridge on basis of need assessment of bridge for project selection for feasibilityand detailed study. Project selection for construction procurement of only that project whose feasibility and detailed survey was conducted on ranking basis.

2.9 Bridges & its context in Nepal:

A bridge is a vital structure which allows uninterrupted traffic flow in all weather. (Mulmi, 2013). Nepal Bridge Standards, 2067 defines bridge as a structure that spans a body of water, a valley, or a road and affords passage for pedestrians, or vehicles of all kinds, or any combination thereof.

Superstructure, bearing, substructure,appurtenances and site related structures are major components of the bridge.The structural components above the level of bearing are classed as superstructure. Super structure provides base for moving vehicles, trains and pedestrians. Wearing surface, deck, primary and secondary members are components of superstructure. The wearing surface is that portion of deck, which resists traffic wear. In most instances this is a separate layer made of bituminous material. The deck is the physical extension of the roadway across the obstruction to be bridged. In most instances this is a Reinforced Concrete Slab.Primary members are those, which distribute bridge loads longitudinally. Primary members consists of beam, truss, arch or frame. Secondary members are bracing between primary members help to distribute loads transversely. The mechanical device placed between superstructure and substructure to transmit vertical and horizontal load to substructure, allowing some translational and rotational movements. Appurtenances is the part of a bridge or bridge site, which are non-structural components and serve in the overall functionality of the structure. Embankment and slope protection structure, Approach slab, River training structure are bridge appurtenances. According to the type of superstructure, bridge can be classified as Slab Bridge, T-beam Bridge, Box Girder Bridge, Frame Bridge, Truss Bridge, Arch Bridge, Suspension Bridge and Cable Stayed Bridge.

Nepal Bridge Standards, 2067 cclassify bridges as follows: Culvert: Length up to 6 m, Minor Bridge : When length ≤ 50 m (with span ≤ 25 m), Major Bridge : When span >25 m or length >50 m(with smaller spans), Special Bridge: Bridges that require special design considerations, whose construction features(e.g. concrete girder bridges with >50m span, steel trusses > 100m span, arch bridges, suspension bridges, cable-stayed bridges and other nonstandard bridges). It furthers clarifies that carriageway width standards of bridges in highways and urban roads shall be designed with a minimum carriageway width of 7.5m. Similarly, all bridges in Feeder Roads shall be designed with a minimum carriageway width of 6.0m. Also, no permanent bridge shall be designed with a carriageway width of less than 6.0m except on minor (district and village) roads having length less than 25m.

Road Diary 2075/76 states that there are about 2200 motorable bridges in SRN of Nepal. As per thematic map of state 3 published by LRBSU, construction of 56 bridges has been completed, 12 substantially completed and 31 bridges are under construction in local road networks of province no. 3 by DOLI.

As per Redbook 2076/77 MOPIT, for local road bridge construction projects under budget head 33701122, 4 Arab 57 crore 13 lakh budget is allocated for 1137 bridges all over 77 districts of Nepal by MOPIT. Similarly, for strategic road bridge construction& preservation program under budget head 33701132, Rs. 3 arab, 5 crores 1 lakh is allocated by MOPIT. The redbook dictates the project selection are aligned with aim, vision, strategy and working procedure as directed by 15th approach paper published by NPC.

2.10 Bridge management system in Nepal

At present two separate bridges management system are currently in practice in Nepal. The Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads has developed the web based software in Bridge Management System (BMS) under BIMP programme supported by World Bank for the improvement in the bridge inventory management, systematic planning and prioritization for the bridge sector investments in SRN. Similarly, Government of Nepal (DOLIDAR) in collaboration with Swiss Agency for Development & Cooperation, under LRBP program has introduced Bridge Information Management

System (BIMS) which manages and disseminates the Local Roads Bridge Information within the country.

The bridge management system is described by both the agency (DOR, DOLI) in their own way as per the features available and user scope. Bridge Management System is defined as a web-based tool that contains a detailed inventory and condition assessment for each SRN bridge also contains information on gaps in the SRN and details of bridges under construction. All BMS entries are geo-referenced and include available histories of work previously undertaken on each bridge, any design documentation, and photographs. The SRN Bridge Program will use BMS data to develop priority investment plans, which will be available on DOR's external website. (World Bank 2012)Bridge Information Management System (BIMS), is the web-based information management, share and dissemination system for Local Roads Bridges. This is an integrated database system of local roads motorable bridges. This includes the different modules of bridge demand, bridge prioritization/ selection, construction and maintenance of local roads bridges. (LRBP 2013).

2.11 Project Prioritization trend

2.11.1 International practices

Evidence suggests that prioritization is often based on a politics, loose qualitative assessments, or professional judgment, but without clear principles underpinning selection (Petrie, 2010). More problematic, in some contexts, prioritization is not based on formal appraisal at all, with projects approved or disapproved on a rolling, ad hoc basis. The unstructured path to project approval in many countries leaves room for corruption, inefficiency, and particularistic infrastructure policy that is unlikely to effectively serve development needs.

Trends on project prioritization (more transport related) in some different countries of world are discussed below.

India face huge infrastructure challenges where poverty and density have make these issues more pronounced than in many other countries, but the underlying question is how to prioritize the infrastructure they need with the limited funding resources? The planning and prioritization of infrastructure projects typically falls under state

jurisdiction in India, with central government approval. A unit is established by the Ministry of Finance for the examination, approval, and financing of public-private partnership projects (Chism, 2016).

Chism, 2016 further suggests that there is a need for a "single window process" for planning and approval to minimize bureaucratic procedures and an empowered infrastructure unit which would oversee and coordinate the country's development and execution strategy across the traditional silos of government by prioritizing projects and coordinating strategies among different infrastructure related ministries.

In UK National Investment Plan, managed by the Treasury's infrastructure unit,40 lists of projects are marked for priority government support and investment based on the following criteria; strategic importance, capital value, regional priority, Demonstrator(innovative or novel and could improve future delivery), unlocking investment (enables significant private sector investment) (HM Treasury, 2014).

In Australia, a federal statutory board established under the Department Infrastructure and Transport, is tasked with planning and coordination cross-state road and public transport projects. In order to prioritize proposed projects, the agency applies a two-state process of project "profiling" and "appraisal." Profiling, as a first filter, qualitatively assesses key issues and problems of proposed initiatives along a scale of "highly beneficial" to "highly detrimental" with respect to stated policy goals. Thereafter, CBA is employed as the primary tool for project appraisal. Following CBA, benefits and costs that cannot be demonetized (e.g., visual / landscape, social cohesion, heritage or cultural impacts) are classified along a spectrum from "highly beneficial" to "highly detrimental". These two inputs are used to inform selection, which is based on expert review and consensus of a panel of eleven members.

New South Wales has developed a major Projects Assurance Framework inclusive of an additive multi-criteria model. The framework assesses proposed projects at several stages of project planning and prioritizes projects according to assessed performance along two dimensions. Performance with respect to strategic objectives is measured by alignment with investment themes, value for money, the project's ability to afford citizens "a better life" (by reducing cost of living and improving livability), and economic efficiency. Performance with respect to the project assurance objective is

based on sufficiency of the analysis, cost-benefit analysis, professional assessments of the suitability of project management, and risk assessment. Cost-benefit analysis is augmented by professional review and qualitative inputs. Qualitative assessments are numerically scored on a scale from 3 (strongly positive) to -3 (strongly negative) and added using a system of weights decided by a panel of professionals. Projects are classified as short-, medium-, and long-term, depending on their collective scores.

The Republic of Korea employs cost-benefit analysis supplemented by multi-criteria decision methods to prioritize a large number of projects across different sectors. Using the AHP structured expert pair wise technique; experts decide the weights of decision criteria. AHP has also been used to rank projects sub-sectoral (primarily in transport) in the US, Indonesia, China, Turkey, India, and Palestine.

During 2014-2015, Indonesia's Committee for Acceleration of Priority Infrastructure Delivery (KPPIP) employed a three-level infrastructure prioritization approach, including multi-criteria analysis. Following a screening for basic project requirements, an additive multi-criteria model was to identify 22 priority infrastructure projects from amongst thousands of proposed projects. The indicators for project scoring and ranking with associated additive weights included project purpose (25%), feasibility of implementation (30%), socio-economic impact (30%), and environmental impact (15%). The scoring and ranking outcomes were used as a basis of "committee discussion" that resulted in the short listing of 22 projects.

2.11.2 National Practices

When governments must prioritize and select projects under conditions of restricted information and capacity, there is a risk that they may fall back on unsystematic, ad hoc selection. In these cases, decision frameworks based on multi-criteria analysis can be helpful to systematize prioritization based on key development goals, make best use of available (or reasonably attainable) information across the set of proposed projects, to control propagation of wasteful "white elephant" projects and identify important missing information to improve project appraisal and data collection looking forward. Such decision support frameworks can help alleviate pervasive problems such as poor or reactive planning, regressive investment, over-commitment, information asymmetries, corruption, and high degrees of political interference.

Project prioritization is crucial for Nepal because of its huge investment demand and limited resources to finance the infrastructure gap. Global competitiveness report 2016 ranks Nepal in 130 position of 138 in infrastructure in which country's low connectivity is significant factor. (Dixit, 2017)

The approach paper for 14th plan (2073/74-2075/76) published by National Planning Commission of Nepal highlights strategy of safe and comfortable transport facilities to improve province level access and economic development. It also emphasizes on extension of transport system focusing access improvement on agriculture, industry, commerce, hydropower, tourism, health, and education.

The five years strategic plan (2073-78) published by DOR has enlisted in its fundamental concept "all year-round access for people to province and central headquarters". Connecting Kathmandu (country capital) with each province capital with at least one four lane road and other alternative road is also enlisted as five years strategy of DOR.

For the prioritization of several projects nationwide five sectors are identified among which infrastructure sector on which lies road & bridge sector. For prioritization of projects six basic criteria & two sector wise criteria are identified. Six basic criteria weigh 65% and two sector wise criteria weighs 35%. Projects are prioritized as Priority 1-P1 and in case it scores more than 75% and priority 2-P2 if it scores less than 75%. Also, in case more than two-third of projects in any sector falls under P1 on any sector, then the score required to be P1 shall be revised. (National Planning Commision)

The six basic criteria are inclusive economic development goal (15%), SDG's achievement contribution (15 %), Inclusion (public, NGO's, UC), (local level / province), (private sector), inclusiveness (regional & social) (10%, 5/5), projects previous work progress, time of completion, readiness for further work. (20 %) Similarly, two sector wise criteria are result obtained as per project aim/target. (20%) and SDG's

Similarly for the project selction in local level, the guidance for annual plan and annual budget estimation for local level published by NPC listed following criteria for project prioritization purpose which are 1.Role in poverty alleviation (20%) [a. Direct

Contribution:20 points, b. Indirect contribution: 10 points c. neutral: 5 points], 2. Production friendly, fast output generation capability:[a. can be completed in same fiscal year: 15 points, b. completion in next fiscal year: 10 points, c. others: 5 points] 3. Income &employment generating projects :(15%) [a. Direct Contribution:15 points, b. Indirect contributuion:7.5 points, c. neutral: o points], 4. Investment participation possible projects. (15 points) [50% or more participation:15, 20-50% :10 Up to 20%: 5, no investment anticipation: 0], 5. Local materials, resources, skill utilization in projects (10 points) [All:10, Up to 50%: 7.5, others:5], 6. Inclusive development [a. Direct Contribution:10 points, b. Indirect contributuion:5 points, c. neutral: o points], 7. SDG & environment protection: [a. Direct Contribution:10 points, b. Indirect contributuion:5 points, c. neutral: o points], 8. local language, culture development: [a. Direct Contribution:5 points, b. Indirect contribution: 3 points, c. neutral: o points].

2.12 Decision making & Multi-criteria Analysis

2.12.1 Introduction:

The decision-making process is a complex task, with large amounts of information, it is extremely difficult or even impossible to take a rational decision, due to the number of intervening variables, their interrelationships, potential solutions that might exist, diverse objectives envisioned for a project, etc.; therefore, some help is called for, and some strategy is required to organize, classify, and evaluate this information (Springer 2011). The multi-criteria decision making (MCDM) approach, drawing on multi-attribute utility theory (Keeney &Raiffa, 1976), which has been used in a number of policy contexts, is ideally suited to complex decision problems characterized by multiple stakeholders with multiple conflicting objectives. Multi-criteria analysis establishes preferences between options by reference to an explicit set of objectives that the decision-making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved. MCA offers a number of ways of aggregating the data on individual criteria to provide indicators of the overall performance of options. A key feature of MCA is its emphasis on the judgment of the decision making team, in establishing objectives and criteria, estimating relative importance weights and, to some extent, in judging the contribution of each option to each performance criterion (Department of

communities and local Government: London 2009).Multi-criteria decision approaches/methods (MCDA/M) aim to formalize the inclusion of non-monetary and/or qualitative factors into decision analysis (Marcelo 2015).

There is no *normative* model of how individuals should make multi-criteria choices that is without critics. The one that comes closest to universal acceptance is based on multi-attribute utility theory (Department of communities and local Government: London 2009).

A prioritization matrix is a simple tool that provides a way to sort a diverse set of items into an order of importance. It also identifies their relative importance by deriving a numerical value for the priority of each item. The matrix provides a means for ranking projects (or project requests) based on criteria that are determined to be important. This enables a department to see clearly which projects are the most important to focus on first, and which, if any, could be put on hold or discontinued.

Deciding how to prioritize and separate the high priority projects from lower priority projects can be daunting. Since emotions often run high when making these kinds of decisions, a structured and objective approach can be helpful in achieving consensus and balancing the needs of the department and its customers and stakeholders. Using a prioritization matrix is a proven technique for making tough decisions in an objective way.

Social Cost Benefit analysis (SCBA) is used extensively in the US, New Zealand, England, Australia, Singapore, Chile, Ireland, and many other countries to assess and prioritize alternative infrastructure projects, particularly those that demand significant investments. But in the past five years, the UK, Australia, and many US states have also published notes and guidance on the application of multi-criteria decision analysis (MCDA. Some countries, such as Ireland, have imposed thresholds to guide when government should apply SCBA, multi-criteria analysis, or more simple assessments, depending on the size of the proposed investment.

Multi-criteria decision analysis has gained traction as a way of systematically structuring investment decisions when multiple aspects associated with proposed investments must be reconciled. Multi-criteria decision approaches formalize the inclusion of non-monetary and qualitative factors into decision analysis and can be

useful when information or analytical resources are limited. Indeed, MCDAs are currently included in government and multilateral project appraisal and selection practice in regions including the Pacific Island Countries and Argentina, as well as in countries with longstanding and established programs of economic project assessment, including Chile, Ireland, and the UK.MCDAs have the added benefit of flexibility, since they can be recalibrated to accommodate improved data as it becomes available. (Darwin Marcelo, 2016)

A prioritization matrix supports structured decision-making in the following ways:

- Helps prioritize complex or unclear issues when there are multiple criteria for determining importance.
- Provides a quick and easy, yet consistent, method for evaluating options.
- Takes some of the emotion out of the process
- Quantifies the decision with numeric rankings

Multi-criteria Analysis, A manual published by Department for Communities and Local Government of United Kingdom in 2009 insights basic concept on MCA which are as follows.

In practice the most generic form of analysis in government is cost effectiveness analysis(CEA), where the costs of alternative ways of providing similar kinds of output are compared. Less common, although widely used in transport and health and safety, is cost benefit analysis(CBA), in which some important non-marketed outputs are explicitly valued in money terms.

Monetary-based techniques for decision making.

- Financial analysis: An assessment of the impact of an option on the decision-making organization's own financial costs and revenues. If the impacts are spread over future years, the net impacts in each year need to be *discounted* to a present value, and this applies equally to cost effectiveness and cost-benefit analysis.
- Cost-effectiveness analysis. An assessment of the costs of alternative options which all achieve the same objective. The costs need not be restricted to purely financial ones.

- Cost-benefit analysis. An assessment of all the costs and benefits of alternative options. CBA is criticized on political or philosophical grounds, to the effect that it is the role of government to apply judgments that are not necessarily a reflection of current preferences. In addition, there may be impacts which cannot readily be quantified in a way which could be set against a scale of monetary values.

2.12.2 Multi criteria analysis techniques

All MCA approaches make the options and their contribution to the different criteria explicit, and all require the exercise of judgment. They differ however in how they combine the data. Formal MCA techniques usually provide an explicit relative weighting system for the different criteria. The main role of the techniques is to deal with the difficulties that human decision-makers have been shown to have in handling large amounts of complex information in a consistent way.

The reason for different types of MCA technique to be present are there are many different types of decision which fit the broad circumstances of MCA, the time available to undertake the analysis may vary, the amount or nature of data available to support the analysis may vary, the analytical skills of those supporting the decision may vary, and the administrative culture and requirements of organizations vary.

Any MCA technique selected should have internal consistency and logical soundness, transparency, ease of use, data requirements not inconsistent with the importance of the issue being considered, realistic time and manpower resource requirements for the analysis process, ability to provide an audit trail, and software availability, where needed

There are many advantages of MCA over informal judgement which can be listed as below.

- it is open and explicit
- the choice of objectives and criteria that any decision-making group may make are open to analysis and to change if they are felt to be inappropriate

- Scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values, and amended if necessary
- Performance measurement can be sub-contracted to experts, so need not necessarily be left in the hands of the decision-making body itself
- It can provide an important means of communication, within the decision-making body and sometimes, later, between that body and the wider community, and
- Scores and weights are used, it provides an audit trail.

2.12.3 Key features of MCA

2.12.3.1 Performance matrix

The performance matrix or a consequence table is a standard feature of multi-criteria analysis, in which each row describes an option and each column describes the performance of the options against each criterion. The individual performance assessments are often numerical but may also be expressed as 'bullet point' scores, or colour coding.

In a basic form of MCA this performance matrix may be the final product of the analysis. The decision makers are then left with the task of assessing the extent to which their objectives are met by the entries in the matrix. Such intuitive processing of the data can be speedy and effective, but it may also lead to the use of unjustified assumptions, causing incorrect ranking of options. In analytically more sophisticated MCA techniques, the information in the basic matrix is usually converted into consistent numerical values.

It is a common (although often sub-conscious) intuitive misuse of the performance matrix to either:

- add recorded performance levels across the rows (options) to make some holistic judgement between options about which ones are better
- Eliminate (or prioritize) options that record weak (or strong) performance levels on particular criteria.

2.12.3.2Scoring & Weighting

Scoring: the expected consequences of each option are assigned a numerical score on strength of preference scale for each option for each criterion. More preferred options score higher on the scale, and less preferred options score lower. In practice, scales extending from 0 to 100 are often used, where 0 represents a real or hypothetical least preferred option, and 100 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 100.

Weighting: numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.

2.12.3.3Analytic Hierarchy Procedure:

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making which aid the decision maker to set priorities. Series of pair wise comparisons and synthetisation of the results is carried out for inclusion of both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process. (Saaty 1980)

In this study, Klaus D. Goepel version 11.10.2017 AHP Spreadsheet Template is used to calculate the weights for different criteria selected which have salient features as described below.

1. The requirements considered for producing the template are easy-to-use, working without macros and not relying on external links to other workbooks. The template should be flexible in the number of criteria, the number of participants and level of accepted inconsistency in the matrix. In addition, each questionnaire should fit on one page for printing and manual completion.

2. Following are some features of spreadsheet template which were incorporated in the template.

- The workbook consists of 10 (or more) input worksheets for pair-wise comparisons, a sheet for the consolidation of all judgments, a summary sheet to

display the result, a sheet with reference tables (random index, limits for geometric consistency index GCI, judgment scales)and a sheet for solving the eigen value problem when using the eigenvector method (EVM).

- Within the input worksheets (questionnaires), priorities are calculated using the row geometric mean method (RGMM).
- Two consistency indices (the consistency ratio CR and the geometric consistency index GCI) are calculated. The level of consistency needed is implemented as a variable input field and can be set between zero and one.
- If CR exceeds, the top 3 inconsistent pair-wise comparisons are highlighted, to allow the participants an adjustment of their judgments.
- Final priorities are shown in a summary sheet; their calculation is based on the eigen vector method (EVM).
- For the solution of the eigen value problem the power method algorithm (*e.g.* Larsen, 2013) is applied with a fixed number of 12 iterations.
- Different judgment scales are implemented.
- Either individual participants, or an aggregation of individual judgments (AIJ) based on the geometric mean of all participants' judgments (Aull-Hyde *et al*., 2006), can be selected.

Some limitations of spreadsheet template are as under.

- The template does not include the hierarchy of the decision problem and the final aggregation of weights, *i.e.* it is only suitable for finding the weights in each category or sub-category.
- Another limitation is the lack of sensitivity analysis of the final result. (Goepel 2017)

2.12.4 Different types of MCA

2.12.4.1Multi-attribute utility theory

There is no *normative* model of how individuals should make multi-criteria choices that is without critics. The one that comes closest to universal acceptance is based on multi-attribute utility theory. While this work provided powerful theoretical insights, it does not directly help decision makers in undertaking complex multi-criteria decision tasks.

The breakthrough in this respect is the work of Keeney and Raiffa, published in 1976.They developed a set of procedures, consistent with the earlier normative foundations, which would allow decision makers to evaluate multi-criteria options in practice

There are three building blocks for their procedures. First is the performance matrix and the second is procedures to determine whether criteria are independent of each other or not. The third consists of ways of estimating the parameters in a mathematical function which allow the estimation of a single number index, *U*, to express the decision maker's overall valuation of an option in terms of the value of its performance on each of the separate criteria.

2.12.4.2Linear additive models

If it can either be proved, or reasonably assumed, that the criteria are preferentially independent of each other and if uncertainty is not formally built into the MCA model, then the simple linear additive evaluation model is applicable. The linear model shows how an option's values on the many criteria can be combined into one overall value. This is done by multiplying the value score on each criterion by the weight of that criterion, and then adding all those weighted scores together. However, this simple arithmetic is only appropriate if the criteria are mutually preference independent. Most MCA approaches use this additive model. Models of this type have a well-established record of providing robust and effective support to decision-makers working on a range of problems and in various circumstances.

2.12.4.3Outranking methods:

One option is said to outrank another if it outperforms the other on enough criteria of sufficient importance (as reflected by the sum of the criteria weights) and is not outperformed by the other option in the sense of recording a significantly inferior performance on any one criterion. The outranking concept does, however, indirectly capture some of the political realities of decision making. In particular it downgrades options that perform badly on any one criterion (which might in turn activate strong lobbying from concerned parties and difficulty in implementing the option in question). It can also be an effective tool for exploring how preferences between

options come to be formed. However, on balance, its potential for widespread public use seems limited,

2.12.4.4Procedures that use qualitative data inputs

Reliable and transparent support for decision making is usually best achieved using numerical weights and scores on a cardinal scale. Decision makers working in government are frequently faced with circumstances where the information in the performance matrix, or about preference weights, consists of qualitative judgements.

2.12.4.5MCA methods based on fuzzy sets

Fuzzy sets attempt to capture the idea that our natural language in discussing issues is not precise. Options are 'fairly attractive' from a particular point of view or 'rather expensive', not simply 'attractive' or 'expensive'. Fuzzy arithmetic then tries to capture these qualified assessments using the idea of a membership function, through which an option would belong to the set of, say, 'attractive' options with a given degree of membership, lying between 0 and 1.

These methods tend to be difficult for non-specialists to understand, do not have clear theoretical foundations from the perspective of modelling decision makers' preferences and have not yet established that they have any critical advantages that are not available in other, more conventional models. They are unlikely to be of much practical use in government for the near future.

2.12.5 Other contexts in MCA:

2.12.5.1Number of alternatives

An important initial consideration in the choice of MCA technique is that of the number of alternatives to be appraised. Solving problems involving optimizing infinitely variable quantities requires quite distinct types of procedure. Where the number of options is finite, it does not matter in principle whether this number is small or large. However, it is important to bear in mind that each option that has to be considered has to be appraised to determine how well it performs on each of its criteria. Gathering and processing these data will consume resources, the more so if a large number of criteria have been identified. In choosing whether to implement one

of the simpler or one of the more detailed MCA decision support procedures, this is a factor to bear in mind.

In MCA problems with a finite number of options, each of which is assessed in terms of a given number of criteria, the initial frame of reference is essentially the performance matrix. MCA procedures are distinguished from each other principally in terms of how they process the basic information in the performance matrix.

2.12.5.2Dominance:

Dominance occurs when one option performs at least as well as another on all criteria and strictly better than the other on at least one criterion. In principle, one option might dominate all others, but in practice this is unlikely. When it does occur, it is helpful to ask if there is some advantage of the dominated option that is not represented by the criteria; this may reveal new criteria that have been overlooked.

Once any dominance analysis has been concluded, the next stage is for the decision-making team to determine whether trade-offs between different criteria are acceptable, so that good performance on one criterion can in principle compensate for weaker performance on another.

If it is not acceptable to consider trade-offs between criteria, then there are a limited number of *non-compensatory MCA* techniques available. In general, they are not highly effective in distinguishing between options in real applications.

Assuming that all the estimates of criteria scores are accurate, if option A dominates option B, then B cannot be the single best one available. Thus, if the purpose of the MCA is to recommend a single best option, B may be removed from consideration. If the purpose is short-listing, then it is possible, but rather unlikely, that a dominated option would be taken through to a later stage in the selection process. In practice, dominance is rare. The extent to which it can help to discriminate between options and so to support real decisions is correspondingly limited.

2.12.5.3The limitations of human judgments

Research on human judgments and decision-making shows that the simplifications which we make to enable us to deal with complex problems sometimes do not work

well. We are inclined for example to be biased in our assessments of alternatives that can more readily be linked to what is familiar (the 'representativeness heuristic'), and to be unduly influenced by recent, memorable, or successful experience (the 'availability heuristic').

MCA techniques are designed to help overcome the limitations by imposing a disciplined structure which directs attention to criteria in proportion to the weight which they deserve.

Multi Criteria Decision Analysis is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. The options may differ in the extent to which they achieve several objectives, and no one option will be obviously best in achieving all objectives.

2.12.6 Stages in MCDA

1. Establish the decision context.

1.1 Establish aims of the MCDA and identify decision makers and other key players.:

What is the purpose of the MCDA? Get this wrong and you can provide a wonderful analysis for the wrong problem. Clarity about the aims of the MCDA helps to define the tasks for subsequent stages and keeps the analysis on track.

A key player is anyone who can make a useful and significant contribution to the MCDA. Key players are chosen to represent all the important perspectives on the subject of the analysis. One important perspective is that of the final decision maker. These people are often referred to as stakeholders, people who have an investment, financial or otherwise, in the consequences of any decisions taken. No MCDA is ever limited just to the views of stakeholders. Additional key players participate because they hold knowledge and expertise about the subject matter. That includes people within the organization, and often includes outside experts, or people with no investment in the final decision but who hold information that would assist the analysis. Designers of the MCDA will need to consider what stakeholders and other key players should be involved, and the extent of their participation in the analysis.

1.2 Design the socio-technical system for conducting the MCDA.

Facilitated workshops might last for only a few hours for relatively straightforward decisions. For complex decisions, two or three-day workshops may be required, or even a series of workshops over a period of several months.

1.3 Consider the context of the appraisal.

What is the current situation? What goals are to be achieved? Could a different frame for the issues and problems provide a recasting of the situation that would make it easier to attain the goals? What strengths can be mobilized to achieve the goals? What weaknesses might impede progress? What opportunities exist now or may appear on the horizon to facilitate progress? What threats could create obstacles? Describing the current situation and then being clear about the goals to be achieved establishes the discrepancy between now and the vision for the future which will clarify the role of the MCDA. SWOT analysis is particularly useful in developing options.Other aspects of context concern the larger political, economic, social, and technological (PEST) environments in which the analysis is to be conducted.

2. Identify the options to be appraised.

Whether the options are given or have to be developed, those conducting the MCDA should be open to the possibility of modifying or adding to the options as the analysis progresses.

3. Identify objectives and criteria.

3.1 Identify criteria for assessing the consequences of each option.

Criteria express the many ways that options create value. If options are already given, then a ‘bottom-up’ way to identify criteria is to ask how the options differ from one another in ways that matter. A ‘top-down’ approach is to ask about the aim, purpose, mission, or overall objectives that are to be achieved. Criteria are specific, measurable objectives. They are the ‘children’ of higher-level ‘parent’ objectives,

Deciding on criteria to incorporate in the MCDA is very much a matter of judgment and can require some tricky approach to facilitate measurement. Identifying criteria requires considering the underlying reasons for the organization’s existence, and the core values that the organization serves.

Procedures to derive criteria

An effective way to start the process of identifying criteria is first briefly to recapitulate “Is it possible in practice to measure or judge how well an option performs on these criteria? and then to brainstorm responses to the question “What would distinguish between a good choice and a bad one in this decision problem?” Responses should all be noted down uncritically. A second approach is to examine policy statements and secondary information sources from the various interest groups and to analyze these to derive criteria to reflect their concerns. Typically, in the process of eliciting criteria, after an initial hesitation, suggestions start coming thick and fast. At the end of a relatively brief period, it is normal to have a substantial list of potential criteria.

The number of criteria should be kept as low as is consistent with making a well-founded decision. There is no ‘rule’ to guide this judgment and it will certainly vary from application to application. Large, financially, or otherwise important choices with complex technical features (such as a decision on where to locate a nuclear waste facility) may well have upwards of a hundred criteria. More typical, however, is a range from six to twenty.

The first consideration in setting up consistent numerical scales for the assessment of criteria is to ensure that the sense of direction is the same in all cases, so that (usually) better levels of performance lead to higher value scores. It is conventional to allot a value score to each criterion between 0 and 100 on an interval scale. The advantage of an interval scale is that differences in scores have consistency within each criterion, although it does not allow a conclusion that a score of 80 represents a performance which on any absolute standard is five times as good as a score of 16.

The first step in establishing an interval scale for a criterion is to define the levels of performance corresponding to any two reference points on the scale, and usually the extreme scores of 0 and 100 would be used. One possibility (global scaling) is to assign a score of 0 to represent the worst level of performance that is likely to encounter in a decision problem of the general type currently being addressed, and 100 to represent the best level. Another option (local scaling) associates 0 with the

performance level of the option in the currently considered set of options which performs least well and 100 with that which performs best.

Once the end points are established for each criterion, there are three ways in which scores may be established for the options. The first of these uses the idea of a value function to translate a measure of achievement on the criterion concerned into a value score on the 0 – 100 scale. The value functions used in many MCA applications can for practical purposes be assumed to be linear. The second approach to scoring performance on an interval scale is direct rating. This is used when a commonly agreed scale of measurement for the criterion in question does not exist, or where there is neither the time nor the resources to undertake the measurement. Direct rating uses the judgment of an expert simply to associate a number in the 0–100 range with the value of each option on that criterion. A third approach to scoring the value of options on a criterion is to approach the issue indirectly, by eliciting from the decision maker a series of verbal pair wise assessments expressing a judgment of the performance of each option relative to each of the others.

Grouping of Criteria

It can be helpful to group together criteria into a series of sets that relate to separate and distinguishable components of the overall objective for the decision. This is particularly helpful if the emerging decision structure contains a relatively large number of criteria (say eight or more).The main reasons for grouping criteria are: (a) to help the process of checking whether the set of criteria selected is appropriate to the problem (b) to ease the process of calculating criteria weights by assessing weights firstly within groups of related criteria and then between groups of criteria; and (c) to facilitate the emergence of higher level views of the issues, particularly how the options realize trade-offs between key objectives.

Requirements of criteria

Completeness

Have all important criteria been included? This needs some care as it is not necessarily obvious from the beginning what the important criteria are. It is necessary to ask if any major category of performance is overlooked. Similarly, are all the

criteria necessary to compare the options' performance included and if the criteria capture all the key aspects of the objectives needs to be sorted.

Redundancy

Are there criteria which are unnecessary? The MCA team may also wish to delete a criterion if it seems that all the available options are likely to achieve the same level of performance when assessed against it. If this were the case, then omitting it would not affect any ranking of options and would economize on analytical input.

Operationality

It is important that each option can be judged against each criterion. The assessment may be objective, with respect to some commonly shared and understood scale of measurement, like weight or distance. Optionally, it can be judgmental, reflecting the subjective assessment of an expert. The strength of MCA is its ability to accommodate and use simultaneously both forms of assessment of options. It can sometimes be helpful to break a criterion down into a further sublevel of more explicitly defined criteria, if assessment at a particular level is problematic.

Mutual independence of preferences

The options are independent of each other from one criterion to the next. The key idea is simple: can you assign preference scores for the options on one criterion without knowing what the options' preference scores are on any other criteria? If the answer is yes, then this criterion is preference independent of the others.

Double counting

Public sector decisions can be particularly prone to double counting, especially of effectiveness or benefits. Double counting should not be allowed in MCA, since double counted effects are likely to be given more weight in the final overall decision than they deserve.

Checking for independence of preferences will reveal double counting: if criteria X and Y really reflect the same value, then when scoring options on Y, one will wish to look at scores given to X.

Size

An excessive number of criteria leads to extra analytical effort in assessing input data and can make communication of the analysis more difficult.

Impacts occurring over time

Good decision facilitating practice would ensure that participants in any decision-making exercise had their attention drawn to time-differentiated impacts and gave thought to how these were to be consistently accommodated in the assessment.

3.2 Organize the criteria by clustering them under high-level and lower-level objectives in a hierarchy.

The most important trade-off between the objectives appears at the top of the hierarchy. Top-level tradeoffs could be between costs and benefits, risks versus benefits, benefits to consumers versus benefits to suppliers, long-term benefits versus short-term benefits, and so forth. This hierarchical representation is often referred to as a value tree.

4. 'Scoring'. Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion.

4.1 Describe the consequences of the options.

The easiest approach is to write a simple qualitative description for each option taking into account each criterion. For complex problems that involve a value tree, it may be necessary to construct a separate consequence table for each option

4.2 Score the options on the criteria.

Relative preference scales will be illustrated. The most preferred option is assigned a preference score of 100, and the least preferred a score of 0. These are relative judgements comparing differences in consequences, and they are often easier for people to make than absolute judgements.

What do these preference scores represent? The difference-scaling method results in numbers that represent relative strength of preference. Such a measure expresses the value associated with the option's consequence on a particular criterion.

4.3 Check the consistency of the scores on each criterion.

This stage is usually accomplished during the process of assessing scores but is included here separately to emphasize its importance. The method for checking consistency depends on the type of scale used. For the relative scales used in this chapter, the approach is to compare differences on a given scale. If the scale has been constructed properly, then comparing differences was a part of the scoring process, so the scale should be consistent.

The initial assessment of scores often reveals inconsistencies, both within and between criteria. Several iterations may be needed until the key players feel that there is enough consistency in their preferences.

5. 'Weighting'. Assign weights for each of the criterion to reflect their relative importance to the decision.

If the MCDA model includes only a few criteria, then the weights can usually be found quickly with agreement from participants. With many criteria, it may be necessary to use a paired-comparison process: compare criteria two at a time for their preference deviations. The process of deriving weights is fundamental to the effectiveness of an MCDA. Often, they will be derived from the views of a group of people. They might reflect a face-to-face meeting of key stakeholders in which weights are derived individually, and then compared, with an opportunity for reflection and change, followed by broad consensus.

6. Combine the weights and scores for each option to derive an overall value.

6.1 Calculate overall weighted scores at each level in the hierarchy.

Multiply an option's score on a criterion by the importance weight of the criterion, do that for all the criteria, then sum the products to give the overall preference score for that option. Then repeat the process for the remaining options.

6.2 Calculate overall weighted scores.

7. Examine the results.

An MCDA can yield surprising results that need to be digested before decisions are taken. It may be necessary to establish a temporary decision system to deal with unexpected results and to consider the implications of new perspectives revealed by the MCDA. This temporary system consists of a series of working meetings which eventually produce recommendations to the final decision making body. When MCDA throws up surprises, it is tempting to ignore this post-MCDA stage, to demean the analysis, and find some other basis for supporting decisions. But it is important to recognize that if discrepancies between MCDA results and people's intuitions have not been explored, the MCDA model was not 'requisite'

8. Sensitivity analysis.

8.1 Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options?

Sensitivity analysis provides a means for examining the extent to which vagueness about the inputs or disagreements between people makes any difference to the final overall results. Interest groups often differ in their views of the relative importance of the criteria, and of some scores, though weights are often the subject of more disagreement than scores. Using the model to examine how the ranking of options might change under different scoring or weighting systems can show that two or three options always come out best, though their order may shift. There is a potentially useful role for sensitivity analysis in helping to resolve disagreements between interest groups.

8.2 Look at the advantage and disadvantages of selected options and compare pairs of options.

An advantage is a high score on a heavily weighted criterion; a high score on a relatively unimportant criterion is not really an advantage because it does not contribute to overall preference. A disadvantage is a low score on an important criterion. Disadvantages are important because they reduce the overall preference, whereas low scores on unimportant criteria do not. Understanding the advantages and disadvantages helps to point to areas where options might be capable of improvement.

Another helpful comparison is between the option that scores best on benefits, and the one that is least costly.

8.3 Create possible new options that might be better than those originally considered.

Comparison of the most beneficial option with the least costly one may show how to create a new option with many, though not quite all, of the benefits of the most beneficial option, but is less costly. Sometimes this is accomplished by reducing the benefits, and thus the cost, on those criteria that do not carry much weight. Reducing the cost in this way may more than compensate for the loss of benefit, giving an option that is quite beneficial without being too costly.

8.4 Repeat the above steps until a 'requisite' model is obtained.

A requisite model is one that is simply good enough to resolve the issues at hand. An important characteristic of MCDA models is that they are often remarkably insensitive to many scores and weights. This is easily demonstrated in sensitivity analysis, but until this insensitivity has been experienced, people often find it difficult to live with rough-and-ready inputs. Imprecision is so well tolerated in MCDA models is that the scores on many of the criteria will show high statistical correlation, and thus the weights on those criteria can be distributed amongst the correlated criteria in any way. In addition, changes in scores on individual criteria are often swamped by the scores for the same options on other criteria. Thus, the structure of any model that includes many criteria creates this lack of sensitivity. As experience is gained of MCDA, models become simpler and increasingly requisite.

2.13 Use of MCA in bridge sector:

2.13.1 International practice

Bridge projects are evaluated on eight criteria with two criteria carrying a double weight in the ranking score: Current status in the Twelve year Program, Inclusion on the Bridge Bill Program, Bridge Sufficiency rating, Relationship to Economic/Conservation Goals, Local request, support and readiness, AADT volume served, Length of detour, if bridge is posted or closed (double weighted), Structural

Status (posted weight limit) (double weighted) (Cambria Country Long range transpotation plan, 2015-2040 n.d.).

For selecting type of superstructure for proposed bridge, identification of criteria was done using Delphi technique. Eleven top-rated criteria were selected which included time, money, safety, shape, traffic data, hydraulic data, labour availability, performance, maintenance provisions, environmental impact, site selection and site conditions (Dr. N. B. Chaphalkar 2013).

AASTHOWARE bridge management system uses structural condition, mobility, risk, and timing of when work occurs as criterion for bridge management purposes (Johnson 2017).

For determining bridge maintenance priority bridge condition, roadnarrowing, transportation strategic area, traffic volume, bridge function, bridge maintenance history, socio-culturalstrategic area, tourism strategic area, bridge material, budget allocation and the inclusion in the strategic planning were considered. (Putu Alit Suthanaya, 2017).

Structural Condition, remaining service life and average daily traffic were considered as evaluation criterion for ranking of bridge replacement projects(Saito).

For the selection of bridge type to be constructed six criteria namely engineering feasibility, capital cost, maintainence, aesthetics, environmental impact and durabilty were considered(Farkas, 2011).

For the selection of bridge maintainence actions perfomace goals were set as to provide safe and reliable network where reliability and safety were performance aspect and condition rating reliabilty rating and number of casualities caused by traffic accidents were the performance indicators. In the same way, other performance goals were to protect from extreme events, to provide responsive and sustainable network, to minimize agency costs and to minimize its negative impact on users, local communities and the environment. Their respective performance aspect were safety, availability, economic aspect, societal and environmental aspects and their respective performance indicators were scour vulnerability rating, earthquake vulnerabiltity rating, other disaster vulnerability rating; avalilability of road (% of

time), downtime (traffic delays caused by maintainence works); owners costs (LCC, Initial costs, maintainece costs, replacement costs etc.), impotance on the network (traffic intensity), user delay costs, societal costs, environmental impacts.(Bukhsh, 2017)

For newmarket level crossing removal, criteria economy (capital cost, renewal/operating costs), safety (traffic safety, CPTED), environemtal (stormwater, landscape/visual, ecology, earthworks, urban design, noise), cultural (Maori value analysis, heritage effects), social (level of service, wider community impact, contruction impact, resident feedback) were considered(Public Transport Capital Improvements, An Auckland Council Organisation).

For the multi-criteria selection of bridge rehabilitation strategy The evaluationcriteria are the agency cost, the user cost, the bridgesafety, the bridge deck useful life and the environmentalimpact of each rehabilitation strategy while the available alternatives are replacement of the deck, majorrehabilitation and minor rehabilitation(Saleh Abu Dabous, 2010).

Bridge condition, ADT, number of public and social facilities, population, area , bridge lengthbridge width were the criteria used for handling bridge maintainence in Kudus district (Zhang, 2009).

2.13.2 National practice:

DTMP guidelines 2012 use per capita investmentas criteria for the purpose of prioritization of DRCN road. The costs of al the interventions on conservation, improvement or new construction is summed up and divided by population served by the road. The population served was defined as the total population of all VDCs linked by the road excluding VDCs of which the headquarters are linked directly to the strategic road network. Once the costs of the different interventions are known, the roads can be ranked according to priority. Population data is required for the prioritization of interventions, where priority is given to those interventions with the lowest cost per capita.

DOR has developed matrix for prioritization of new crossings. The criteria selected were government priority policy, road link classification/ strategic importance of road,

traffic volume, population served or bridge in a link serving major economic activity-mineral extraction, hydropower, tourist centers, pilgrimages places and road closure duration.

Government priority policy is assigned weights of 0.25. In this criterion, if there are bridges in link connecting regional/district headquarter or bridges in all-weather roads or roads under upgrading to all weathered road program is assigned score 4. Similarly, bridges in fair weathered roads or track opened roads are assigned score 2 and bridges in road links/sections where no track is opened is assigned zero score. The maximum point a bridge can get in this criterion is 1 (4*0.25) and minimum is zero.

Road link classification/ strategic importance of road is assigned weights of 0.25. In this criterion, bridges in national highways scores 4, bridges in feeder roads scores 3, bridges in urban roads also scores 3 and bridges in other roads score 1. The maximum point a bridge can get in this criterion is 1 (4*0.25) and minimum point a bridge can get is 0.25 (1*0.25).

Traffic Volume is assigned weights 0.3. Traffic volume more than 1000 scores 4, between 300 to 1000 scores 3, 150 to 299 scores 2, 50 to 149 scores 1 and less than 50 scores 0 in this criterion. The maximum point a bridge can get in this criterion is 1.2 (4*0.3) and minimum is zero.

Criteria 'Population served or bridge in a link serving major economic activity-mineral extraction, hydropower, tourist centers, pilgrimages places' is assigned weights 0.05. If the bridges serve more than five lakh population or bridges is in a link serving major industry or commercial activity or hospitals or touristic/pilgrimage places it will get score 4. Similarly, if population between 1.5 lakh and 5 lakh is served or if the bridges lies in the link serving industrial or activity of local significance or if the bridge is in link to health posts it will get score 3. Similarly, if population between 50 thousand and 1.5 lakhs is served then the bridge scores 2, population between 15 thousand to 50 thousand scores 1 and bridges serving less than 15000 is assigned zero score. In this criterion, a bridge can get maximum point of 0.2 and minimum zero.

The last criterion taken was road closure duration which was assigned weight age of 0.15. If the road is closed more than three months in a year due to absence of bridge,

then such bridge scores 4. If road closure is 2 to 3 months in a year the bridge scores 3. Similarly, if road closure is 1 to 2 months in a year, the bridge scores 2. 10 days to a month road closure score 1 and less than 10 days scores zero. The maximum point a bridge can get is 0.6 and minimum is zero.

So, from all the criteria a bridge can score maximum 4 points and minimum 0.25 points.

To cope with large demand of bridges in local road of Nepal, LRBP has developed a bridge screening and prioritization criteria which involves 3 stages for screening, selection and prioritization of bridges. The bridge has to fulfill three minimum conditions which consist of provisions that bridges should lie on road which are included in DTMP, in case the proposed bridge lie on strategic road, an understanding with DOR should be reached and district council should have approved the bridge requirement. The then DDC was assigned the task of data collection and screen the bridges for either meeting minimum conditions or not. In second stages, bridge are prioritized at local level (DDC/DTO) for which four criteria namely number of people living in ZOI, kilometers of road that the proposed bridge will make all weathered, number of vehicle plying along the roads at both sides of river and length & sections of district roads on which bridges are proposed are maintained and operable by concerned DDC's were taken. The data shall be collected by means of walkover survey of the proposed bridge site and alignment of road stretch which will be all weathered due to proposed bridge.

For prioritization of new crossings, DOR has developed the prioritization matrix under Bridge Improvement and management project funded by World Bank. The matrix consists of five criteria with subsequent sub criteria's which are assigned certain score regarding its importance. The matrix has been used to prioritize the crossings that are to be constructed under BIMP project.

Table 2. 1Existing Priority Matrix in DOR

S. N	Criteria	Weight	Sub-criteria	Scores
1	Government Priority Policy	0.25	a. Bridges in Link connecting regional/district headquarter or	4

S. N	Criteria	Weight	Sub-criteria	Scores
			bridges in all-weather roads or roads under the upgrading to all-weather roads programme.	
			b. Bridges in fair weather roads or track-opened roads.	2
			c. Bridges in a road links/sections where no track opened.	0
2	Road Link Classification/Strategic importance of road	0.25	Bridges in national highway	4
			Bridges in feeder roads	3
			Bridges in Urban roads	3
			Bridges in other roads	1
3	Traffic Volume	0.3	0-49	0
			50-149	1
			150-299	2
			300-1000	3
			Above 1000	4
4	Population Served or bridge in a link serving major economic activity-Mineral Extraction/Hydropower/Tourist Centers/Pilgrimage Places	0.05	Population of less than 15000	0
			Population between 15000-49999	1
			Population between 50000 and 149999	2
			Population between 150000-500000 or bridges in a link serving industrial or activity of local significance or bridges in a ling to health posts	3
			Above 500000 or bridge in a link serving major industry or commercial activity or hospitals or touristic/pilgrimage	4

S. N	Criteria	Weight	Sub-criteria	Scores
			places	
5	Road Closure Duration	0.15	more than 3 months in a year	4
			2 to 3 months in a year	3
			1 to 2 months in a year	2
			10 days to 1 months in year	1
			less than 10 hours in a year	0

Similarly, a Local Roads and Bridge Programme (LRBP) under Department of Local Infrastructure Development and Agricultural Road (DoLIDAR) use multicriteria analysis for prioritizing the bridge demand in local level in Nepal. The matrix to be used in central level and district level has been used.

Table 2.2 Existing Prioritization matrix within LRBP (Central Level)

Criteria	Score	Definition	Scoring	Remarks
1.Number of people living in ZoI	50	ZOI: Area the people of which will be travelling through the proposed bridge	< 5000= 10.0 5000 - 10000= 20.0 10000 -20000=30.0 20000 - 30000=40.0 > 30000 = 50.0	The total scored will be multiplied by 2.0 for the remote hilly districts, 1.5 for hilly districts, to balance the unequal population distribution.
2.Kilometers of road that the proposed bridge will make all-weather	25	The length of road stretch (between 2 identifiable nodes)	< 20.0 km = 5.0 20.0 –30.0 km=10.0 30.0 –40.0 km=15.0 40.0 –50.0 km=15.0 >50.0 km = 25.0	

Criteria	Score	Definition	Scoring	Remarks
3.Location of bridge– potentials for inter district/regional linkages	25	Road stretch on which the bridge has been proposed	part of the Link between 2 major places / District HQ of 2 districts= 25.0 part of the link between two existing motorable roads: 20.0 Others: 15.0	

Table 2. 3Existing Prioritization Matrix within LRBP (Local/district level)

Criteria	Score	Definition	Scoring
1. Number of people living in ZoI (Zone of Influence)	40	ZOI: Area of which the peoplewill be travelling through the proposed bridge	<1000 =10.0 1000 - 3000= 15.0 3000 -5000= 20.0 5000 - 10000= 25.0 10000 -12000=30.0 12000 – 15000 =35.0 > 15000 =40.0
2. Kilometers of road that the proposed bridge will make all weather	20	The length of road stretch (between 2 identifiable nodes)	< 20.0 km=4.0 20.0 – 30.0 km=8.0 30.0 – 40.0 km=12.0 40.0 – 50.0 km = 16.0 <50.0 km = 20.0

Criteria	Score	Definition	Scoring
3. Number of vehicles plying along the roads at both sides of river	20	The number of vehicle thatwill cross immediately afterthe construction of the bridge(not projected or estimated, butalready arriving at the banksbefore bridge construction /during dry seasons)	None= 5 < 5= 7.5 5-10 = 10 .010-20 = 15.0 <20 = 20.0
4. Lengths and sections of district roads on which bridges are proposed are maintained and operable by concerned DDCs.	20	Part of the road length mentioned in the Criteria3 that will be maintained for vehicle plying.	All of the length: 20.0 Most of the length:15.0 about half: 10.0 less than half: 5.0 only some: 2.0

CHAPTER THREE: METHODOLOGY OF RESEARCH

The Methodology includes 1) Identifying research problem, theoretical framework, aims & objectives.2) Review of literature and development of arguments, 3) Development of multi-criteria priority for each central, province and local level 4) Results &Discussion5) Conclusion& recommendation. The flowchart of methodology is as shown as under:

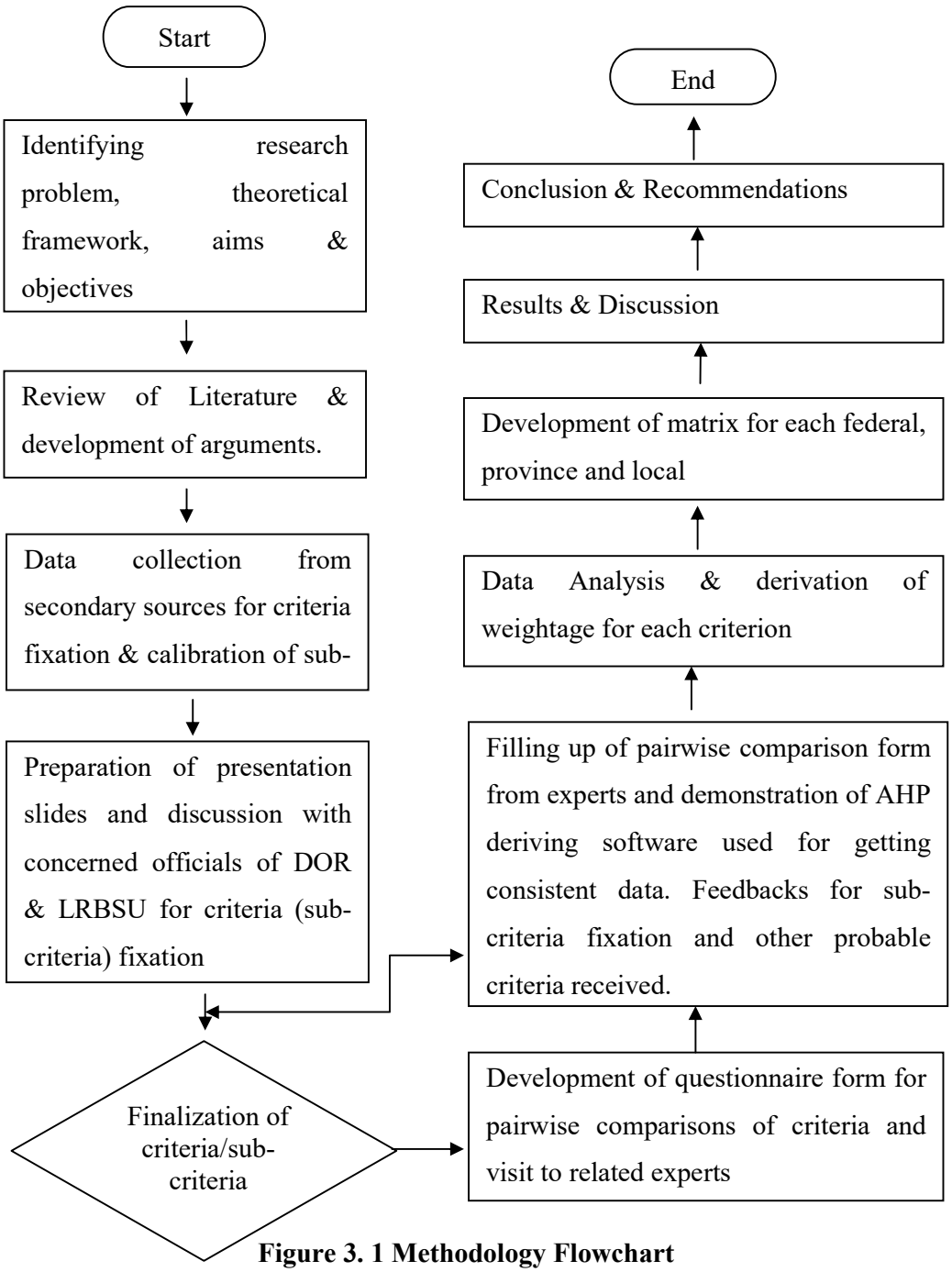

Figure 3. 1 Methodology Flowchart

Outline of discussed above are briefly given below.

3.1 Identifying research problem, theoretical framework, aims & objectives.

Research problem, theoretical framework, aims and objective that should be focused on the study were comprehensively discussed with project supervisors and by the means of literature review and collection of information from DOR & LRBSU and from online sources, research problem, theoretical framework aims and objectives were identified for the study.

3.2 Review of Literature

Relevant literatures are collected and studied from various sources for the study purpose. Selection of criteria that could significantly reflect the need and different social, economic, financial, and technical aspect of bridge construction need to be identified. For the same, the need, scope and capacity of federal, provincial, and local government were studied. The literature on federalism was studied to sort out the prospects of development in federal practice. Current policy directives, guidelines published by Nepal Government, NPC related to infrastructure development policies were thoroughly reviewed. Next to that, existing project prioritization and selection practices in Nepal were reviewed focusing more specifically in bridge management System in Nepal and prioritization trend of new motorable bridge. Existing multi criteria matrix used for the bridge prioritization in DOR and LRBP were reviewed. The international practices of using multi criteria analysis on bridge sector were also reviewed. in use, presently are also thoroughly reviewed. Similarly, literature on multi criteria analysis and analytic hierarchy process are reviewed as well. The purpose of the literature review was setting out the context for development of MCA matrix and identification of relevant criteria.

3.3Development of Multi-Criteria Priority Matrix for Central, Province and Local Level

The multi criteria priority matrix for prioritization of new crossings in SRN developed by DOR under BIMP project and priority matrix formed by Local roads and bridge programme (LRBP) for local roads bridges form the basis for the development of proposed matrix in this research. The slides were prepared demonstrating the attempt

for criteria selection for each three level and presented in DOR/Bridge branch and LRBSU office. Feedback was obtained from concerned officials regarding the criteria proposed.

Based on literature review and expert opinion, three criteria namely strategic importance of road/government priority policy, traffic volume (AADT), and readiness of project are selected for federal level. Similarly, five criteria's namely strategic importance of road/government priority policy, traffic volume (AADT), per capita investment, all weathered road length, and access to socio-economic activities are selected for federal level. Similarly, four criteria's namely strategic importance of road/government priority policy, traffic volume (AADT), all weathered road length operable/maintainable by local level and road closure duration were selected for local level.

For the calibration of criteria strategic importance of road/government priority policy, the document 'Standards for classification& allocation of development program and projects falling under jurisdiction of federation, state and local levels, 2076' published by office of prime minister & council of minister was referred which clearly dictates the jurisdiction of road & bridge sector for each three level of government. The jurisdiction of roads is different for each three level and self judgment and experts' opinion were taken to provide scoring to each links. Though the suggestion for providing score based on AHP was received from one of the experts Bharat Mandal, it cannot be done due to time limitations and is one of the limitations of this research. For the calibration of traffic volume in federal level, the latest data on AADT available (2015/16) was taken for the analysis from DOR Road Diary 2075/76.For the calibration of traffic volume for province and local level, DTMP report of all the 13 districts of province no. 3 was referred. From the table 'required cross drainage structure' of DTMP reports, the DRCN which need bridges are identified and from the present traffic volume table respective traffic volume were obtained. DRCN requiring culverts and causeways are not taken for the analysis. For criteria per capita investment calibration, several types of bridges which construction are completed/ongoing by LRBP in province no. 3 are taken from the spreadsheet data available online on LRBP website. For calibration of all weathered road length criteria, the all weathered road length data of bridges were collected by visit to

LRBSU office at Manbhawan, Lalitpur. For the road length maintained and operable by concerned local level criteria, details of routine maintenance carried on LRN of province no.3 were collected from PMU office of SNRTP project located at Hetauda.

After finalization of criteria and sub-criteria, for the purpose of providing weights to each criterion, panel of expert's comprising of 15 members from different stakeholder organization was selected. Number of participants for AHP survey can range from few experts to hundreds of interviewed people. (ISAHP 2016). In our case limited number of experts from DOR, DOLI, TID, Local level, academic personnel from IOE, Pulchowk Campus, consultant and contractor working in bridge related field were selected and personally met and the questionnaire enlisting criteria and sub-criteria description were distributed and procedure to fill the weight deriving software (internet based K. D. Goepel Version 11.10.2017) for producing the consistent data set were described individually. During the visits, the experts suggest many other probable criteria that could be included. However, the experts also agree to the fact that sub-criteria fixation of the criteria suggested is not possible at present due to data unavailability and presently selected criteria would be requisite. Some data were gathered at the spot while some were received later from e-mails.

The finalized set of criteria and sub criteria along with their respective weights derived from the means of AHP produces a completed MCA priority matrix.

The SRN Bridge data for which budget is allocated in the present fiscal year was collected from DOR bridge branch. 17 bridges from province no 3 which are to be built in SRN are selected for the study.

Similarly, bridges data which will be implemented in 13 districts of province 3 in the present fiscal year 2076/77 was collected from TID office, of province no. 3 from Hetauda.

The data regarding road link are ascertained from the list as the bridge list consists of road in which it lies. The road name was done tally with SRN mentioned in road diary to know in which road link the bridge lie. Similarly, AADT data were obtained from GIS map available on BMS website armp.aviyaan.com/bms/ from where AADT of road link can be obtained. The project DPR availability was ascertained by visit to DOR bridge branch.

The data of bridges to be implemented by province 3 has been requested for in LRBSU office, Manbhawan, Lalitpur. The data will be used for the ranking of bridges using province and local level matrix if available.

Data analysis of each bridge is done to ascertain on which sub criteria the bridge lie, so that appropriate score can be provided to that crossings. Similarly, the criteria comparison form received from relevant personnel are analyzed with AHP calculating excel sheet. Ranking of each bridge is determined and checked for fulfilling objectives.

3.4 Result & discussion

Results were presented and discussed after then.

3.5 Conclusion and Recommendation

The necessary conclusions and recommendations were made based on the outcome of the result of my research study.

CHAPTER FOUR: DATA COLLECTION & ANALYSIS

4.1 Introduction

Data related to bridges required for the study purpose is collected from various sources for the following three purposes in this study.

1. To calibrate identified criteria's sub-criteria

AADT of 160 traffic stations, DRCN data of 13 districts of province 3, all weather road length data of bridge constructed in province 3, bridge type and cost data, population of local level of province 3, RMG's data in province 3 were collected for calibration of sub criteria from secondary sources.

2. To fix weight of selected criteria:

AHP questionnaire was prepared and pairwise comparison data of identified criteria from panel of experts from 15 personnel from DOR, DOLI, TID, Local level, academic personnel from IOE, Pulchowk Campus, consultant and contractor working in bridge related field were collected to fix the weightage of criteria identified.

3. To demonstrate ranking of bridges

The SRN bridge data for which budget is allocated in the present fiscal year and data regarding bridges which will be implemented by province level in 13 districts of province 3 in the present fiscal year 2076/77 were collected.

4.2 Study Area

The study area is Province no. 3of Nepal.

4.3 Data Collection:

Data collection is done through secondary sources, visit to concerned office (DOR, DOLI, LRBSU, MOPIT, TID, PMU SNRTP etc.) and interview with related experts.

4.4 Data Preparation

Screening of available data obtained from secondary sources for getting data required for analysis and use of valid MCA techniques were done to calibrate sub-criteria. Internet based AHP software is used to produce consistent data from AHP questionnaire and to derive weights for ranking purpose. Priority ranking data collected from secondary sources were compiled to provide scoring to each bridge taken for study purposes.

4.5 Data Analysis and matrix formation

4.5.1 Setting a decision Context

By the means of literature review, following important arguments were concluded which form the basis for setting the context of forming a priority matrix.

1. Federalism in Nepal has envisioned balanced development in all nooks and corner of the country and constitution has provided a roadmap for execution of different level of governments.

2. The ad-hoc practices in selection of bridges for implementation mainly influenced by political interests is prevalent resulting in low utility bridges causing sub-optimal utilization of scarce resources and minimal positive influence on socio economic activities.

3. After institutionalization of federalism, project prioritization is given utmost importance which is reflected in recent policy documents regarding infrastructure developments and many different models to prioritize the projects are available.

4. MCA matrix being used by DOR and LRBP are produced based on discussion and brainstorming and criteria selection and weights are based on judgement of experts on the field.

5. Criteria for priority matrix should be kept as minimum as possible and at a same time need to easily measurable.

6. AHP is used worldwide for the MCA matrix preparation purpose and could be effective tool to incorporate the vision and opinion from different stakeholder working on a same field.

7. MCA is always flexible, and the criteria can be added or removed based on present need.

Following are some of the reasons justifying the need of MCA matrix on all three level of governments of Nepal.

1. Present MCA developed by both DOR and LRBP needs modification to align with need of federal, province and local level.

2. DOR MCA matrix for new bridges construction has some features which are significant to mention. (based on interview of DOR experts)

- The criteria weightage is provided based on judgment.
- Sub-criteria for traffic volume, population and road closure duration criteria are based on judgments and no calibration was done.
- Population related criteria were given extremely low weights of 0.05 subjecting weak sub-criteria classification in DOR matrix.
- Though BMS is operational in DOR, its effective use for project prioritization has not been exercised and bridge selection is more largely governed by political interests.

3. LRBP MCA matrix for new bridges construction has some demerits which are significant to mention. (based on interview of LRBSU experts)

- The criteria weightage is based on judgements.
- Sub criteria were also based on judgements.
- Though BSPC is operational in LRBP for screening & prioritization purpose, no bridges were prioritized in previous & present fiscal year due to transition and un clarity of implementing agency in local and province level.
- Although there are three stages for bridge screening in LRBP matrix among which one is 'bridges to be constructed must lies in DRCN' however several bridges which are allocated budget and are being implemented do not fall under identified

DRCN which also clearly reflects political or other undue influence on bridge selection process.

Following things are kept in mind while developing the criteria's and their respective sub-criteria's and for making it more useful practically with the consent of leading practitioners in Nepal for each government level:

1. Previously used criteria by DOR and LRBP are used as they are screened and included in the present matrix through comprehensive study and workshops working in a related field and being practiced and are measurable and their inclusion helps to simplify the matrix and the completeness of the matrix as a whole.

2. The criteria selection has been tried to keep aligned with the policy directives developed recently after institutionalization of federalism in the country.

3. Sub-criteria for different criteria used previously were calibrated based on data available although there are some limitations.

4. The prevalent practices on project prioritization on national/international level found on several policy documents and journal are tried to be incorporated; at a same time, trying to keep the criteria as minimum as possible.

4.5.2 Options Identification

DOR & DOLI are government departments which are currently being involved in the bridge construction. The identified bridges to be implemented by different government agencies in upcoming years within province no 3 are options for this study and the aim of the study is to prioritize among several options which can be aid for budget allocation purpose and discourage political influence on bridge selection purpose.

However, 17 bridges to be implemented by DOR and 69 bridges to be implemented by province no. 3 in present fiscal year is taken as options for demonstration of priority ranking purpose in this study.

4.5.3 Objectives/Criteria/Sub-criteria Identification

Each matrix proposed in study uniquely has to fulfill their own objectives in each level.

1. Federal level matrix should up rank those bridges which:

a. lies in relatively more important links which are under jurisdiction of federal governments.

b. serves more AADT value.

c. detailed project study has been carried out.

2. Province level matrix should up rank those bridges which:

a. lies in relatively more important links which are under jurisdiction of provincial governments.

b. serves more VPD.

c. requires relatively less per capita investment.

d. makes relatively more road length all weathered.

e. provide access to more socio-economic activities.

3. Local level matrix should up rank those bridges which:

a. lies in relatively more important links which are under jurisdiction of local governments.

b. serves more VPD.

c. results in relatively more all weathered road length that can be maintained and operable by concerned local level.

d. eradicates relatively longer road closure duration.

It is particularly important to describe at this stage about the flexibility and practicality of the MCA techniques that:

1. All the stakeholders are not convinced that these could be the only criteria or objective considered. There might be other objectives as well that could be have significant impact on bridge selection process. However, the experts also agree to the fact that calibration of sub-criteria of the criteria suggested is not possible at present due to data unavailability and presently selected criteria could be requisite. This was a concern raised by almost all the AHP participant involved in the study. Some of the participant even put the opinion that this much of criteria might not be needed as well. Some of the arguments worth mentioning are as below.

- During federal level presentation of criteria in DOR bridge branch, the argument arise that either how much inclusive or complete MCA matrix we build or propose, the MCA matrix should always provide some space for political inputs. This can be addressed by separating some reasonable weights to political input by the means of forceful prioritization of bridges. If this can be incorporated somewhere in the MCA matrix it could be a tricky solution to a complex problem.
- Regarding applicability of proposed MCA matrix in DOR there was a discussion among DOR personnel which concludes that DOR, Bridge branch practical scope for use of proposed MCA matrix are bridges to be implemented by Road division office and bridge sector offices as the bridges to be implemented by those offices are scattered in several links and needs to be prioritized. However, bridges in north south and east west highways like Postal Highway and Mid hill highway need not prioritize using MCA matrix as they already lie in strategically significant road link and should have separate and guaranteed budget funding mechanism which has to be set out in internal project goals.
- During province and local level presentation in LRBSU, the concept of replacing ZOI population by per capita investment was discussed. Replacing population served by per capita investment can be incorporated based on a concept that the absence of the bridge in any locality can have similar impact to all who has lack easy access. However using per capita investment instead of ZOI can lead to smarter decision approach relating to optimal use of scarce and limited resources for maximizing social benefits because wherever the bridge is built some people are definitely going to get the access and access to many people by smaller investment cannot be considered a bad idea.

- During AHP filling process, one of the experts suggest that there should be suitable data collection format for collecting all the data required for prioritization. The same is prepared and attached in annex.
- Similarly, one of the experts puts his opinion that traffic volume is the only factor that significantly justifies the need for the bridge in any location. However he also agrees that if that was only the case the MCA matrix shall not have come to practice and his greater affinity towards criteria traffic volume is reflected in pair wise comparison for deriving weightage for each criteria.
- Similarly, another expert put the opinion that for building any bridge the question 'How far in upstream and downstream is there another motorable bridge?' should be asked. it should be one criterion for bridge ranking. However, he also agrees to the fact that there is no database available to providing a score to bridge and can lead to subjective judgment.
- Similarly, another expert argues that the how safe bridge structure (bridge structure safety) can we built should be one of the criteria. He argues that the bridge relatively in safer location needs to be given more priority.
- Another expert suggests that the road standard (earthen, gravel or blacktop) should be the means of prioritizing the bridge structure because upgradation of pavement directly reflects utility level of that road. So, the bridges lying on road link with higher standard pavement should be given higher priority.

Above discussion simply illustrates that there could be several criteria that could be considered for solving any complex decision making problem like selection of bridge for implementation and there is also no hard and fast rule to set the criteria.

However it is also important to note that opinion like this can be in infinite number and fixation of criteria in presence of every concerned stakeholder by listening what they have to say in particular subject matter and reaching in a consent and proposing a set of criteria can be smart way to deal with complex problem for giving the win-win solution and removing personal vested interest and political influence. The above discussion could be utilized as a further scope of this researches well.

4.5.3.1 Criteria/Sub-criteria fixation of federal level

The detail discussion on each of the criteria proposed along with sub criteria for federal level will be presented below:

4.5.3.1.1Strategic Importance of road link/Government priority policy:

In the present DOR matrix, the first criteria were government priority policy. In this criterion, bridges in link connecting regional/district headquarter or bridges in all-weather roads or roads under upgrading to all weathered road program is assigned highest score of 4. Similarly, bridges in fair weathered roads or track opened roads are assigned score 2 and bridges in road links/sections where no track is opened is assigned zero score. In another criteria, road link classification, bridges in national highways scores 4, bridges in feeder roads scores 3, bridges in urban roads also scores 3 and bridges in other roads score 1.

Under new jurisdiction to federal level as per responsibility of roads as per included in schedule 5 of constitution of Nepal, short & rapid link connecting east west highways to state capital's & federal capital, north-south highways connecting international borders, commercial links connecting federal/state capital from east-west highway to north south highways, links connecting federal/state capital & Pushpalal highway, links connecting national highway to projects of national pride, bridges in national highway, tunnel roads, roads which are handed over to federation upon state request, link connecting national road network to district headquarters are upon federal level.

In the above context, the argument was placed that grouping of road links as per judgements and experts' opinion and providing the scores to bridges on those road link can justify the above two criteria. They should be merged into one criterion as Strategic importance of road/Government Priority Policy.

For government priority policy, context like fair weathered roads and all weathered roads and track opened roads are more pronounced on province and local level. Also, bridge on link connecting regional district headquarter fall under federal government jurisdiction. Similarly, in road link classification criteria, bridges in national highways falls under present jurisdiction to federal government. Many feeder roads fall on province jurisdiction and urban roads are under jurisdiction of local level.

So, road link importance is sorted out with the help of limited AHP with personnel from DOR and grouping was done as shown in Table 4.1 to provide subsequent score.

The criteria are proposed as below:

Table 4.1Stratetegic importance of road criteria (Federal)

Criteria	Weights	Sub criteria	Scoring
Strategic importance of road/Government Priority Policy.	?	Bridges in national Highways/in links connecting east west highways to state capital's & federal capital/north south highways connecting international borders	4
		Bridges in link connecting federal/state capital to Pushpalal highway & Links connecting national highway to projects of national pride/ link connecting national road network to district headquarters.	3
		Commercial links connecting federal/state capital from east-west highway to north south highways.	2
		Bridges on roads handed over on state request	1
		Bridges on other roads	0

Weightage is later put from AHP results and scoring is done from 4 to 0 following the previous practice adopted in DOR priority matrix.

4.5.3.1.2 AADT (Present Traffic Volume)

In the present DOR matrix, the third criterion was traffic volume. The interview with DOR Bridge Branch SDE Mr Naresh Man Shakya was done to make sure that the traffic volume was in terms of AADT. In this criterion, bridges serving above 1000 AADT was given highest score 4, 300-100 was assigned score 3, 150-299 was assigned score 2, 50-149 was scored 1 and less than 50 was assigned 0. The interview also comes to know that it was decided on best judgment from experts during workshops.

In this research, for the same the traffic AADT data of year 2015/16 was collected from DOR road diary. From the available data, the maximum ten AADT value excluding motorcycle and rickshaws as shown in Table 4.2 and minimum ten AADT value excluding motorcycle and rickshaws as shown in Table 4.3 were taken for the analysis as motorcycle and rickshaws are more frequently used for shorter distance in city areas and particularly represent urban traffic. Similarly, 23 traffic stations inside Kathmandu valley were also not considered in the study.

The maximum and minimum ten AADT values were as follows

Table 4.2Maximum AADT 2015/16 (Source: Road Diary)

S.N.	Station no.	Link no.	Location	AADT	AADT excl. MC & rickshaws
1	15	H0804	Itahari North	23603	11338
2	13	H0108	Itahari East	20123	12275
3	89	H1002	Butwal South	17681	8978
4	48	H0134	Narayanghat East	14859	8182
5	117	H0124	Kohalpur South	14525	7032
6	85	H0138	Gaidakot	13807	9516
7	90	H0146	Butwal West	13505	6173
8	6	H0105	Damak West	13387	6081
9	44	H0132	Hetauda West	13313	9780
10	12	H0803	Itahari South	13082	9140
Average				**15788.5**	**8849.5**

Table 4.3: Minimum AADT 2015/16 (Source: Road Diary)

S. N	Station no.	Link no.	Location	AADT	AADT excl. MC & rickshaws
1	18	F04004	Basantpur East	66	39
2	153	H1304	Khulalu South	81	74
3	107	F01401	Chakchake east	133	89
4	149	F05301	Basantpur North	134	107
5	108	F01303	Chakchake North	167	124

S. N	Station no.	Link no.	Location	AADT	AADT excl. MC & rickshaws
6	144	F14001	Salyan North (Shitalpati West)	177	86
7	38	F03301	Tamakoshi south	278	162
8	97	F01102	Gorusinge North	303	181
9	152	H1106	Shitalpati North	311	156
10	138	H1411	Satbanjh North	331	254
Average				**198.1**	**127.2**

The average of maximum ten AADT values excluding MC and rickshaws as seen in table 4.2 ; 8849.5 was taken as upper limit for AADT sub-criteriaand assigned score 4 and average of minimum ten AADT values as seenin table 4.3; 127.2 was taken as lower limit and assigned score 0. Assuming a linear function the value for scoring were obtained from following equations.

$$\frac{Req.\ AADt - Min.AADT}{Max.AADT - Min.AADT} = \frac{Req.Score - Min.Score}{Max.Score - Min.Score}$$

Solving for score 1,

min AADT=127.2

Max. AADT=8849.5

Req. Score=1,2,3

Max Score=4

min Score=0

(AADT (1)-127.2)/ (8849.5-127.2) = (1-0)/ (4-0),

we get AADT for score 1=2308. In the similar fashion, AADT for each score is obtained and illustrated in figure 4.1.

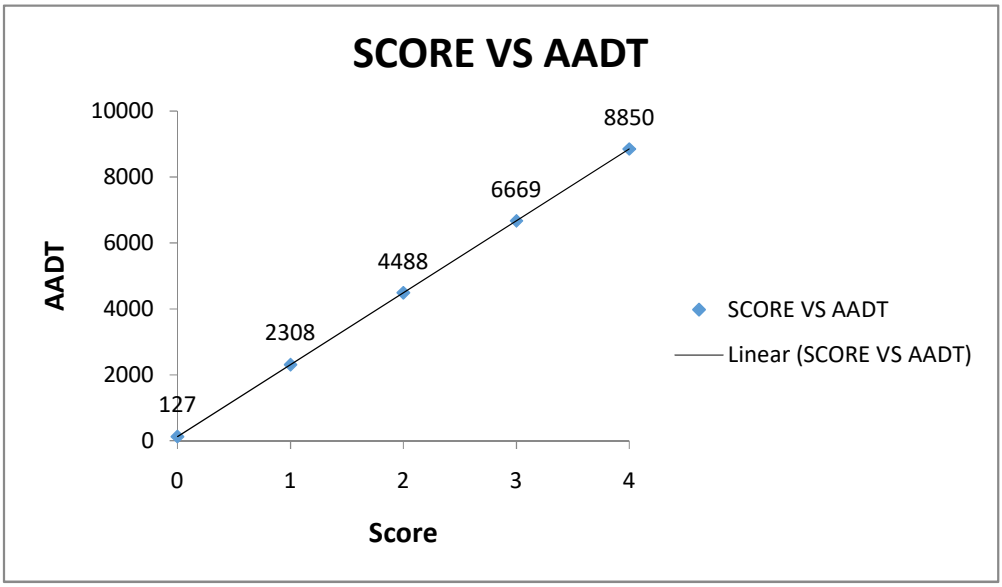

Figure4.1Score vs AADT

To align more to previous practice and from the suggestion from the experts the range is focused for lower side of the value. Hence, AADT from 0-149 is assigned 0, AADT between 150-2499 is assigned 1, 2500 to 4499 is assigned score 2, 4500 to 7000 is assigned 3 and more than 7000 is assigned score 4. (*If focused from the higher range more than 8850 would be assigned score 4, 7000 to 8000 would have been assigned 3 and so on.). The criteria are as shown in Table 5.4 below.

Table 4.4: Traffic Volume Criteria (Federal)

Criteria	Weights	Sub criteria	Scoring
Traffic Volume	?	Above 7000	4
		4500-7000	3
		2500-4499	2
		150-2499	1
		0-149	0

4.5.3.1.3 Readiness of project.

This was the new criteria proposed for the federal level matrix.Some of the arguments for including project readiness as competent criteria for bridge prioritization in federal level were:

1. For Cambria County Long Range Transportation Plan, 2015-2040 bridge projects were evaluated on eight criteria among which one criterion was "Local request, support and readiness".
2. Preparatory Survey for PPP Infrastructure Development Projects in the Republic of the Philippines outlined project readiness as evaluation item, current status of project as evaluation indicator where evaluation details were detail design n-going/Completed gets score 8, projects whose feasibility study is completed, on-going or committed gets score 7' projects whose pre-feasibility study is completed, on-going, or committed scores 5 and projects which are in conceptual stage scores 2.
3. In the budget speech of province 3, it was announced that government of province no. 3 will give high priority to projects whose feasibility study is already carried out and whose technical drawing, design and estimates are available.
4. Similarly Budget, Annual Development Program and three years medium term expenditure planning directives for fiscal year 2076/77 published by NPC has identified 'Projects previous work progress, time of completion, readiness for further work' as one of the basic criteria among 6 criteria's and provided weights 20% for nationwide project prioritization purpose.
5. In the study published by Mulmi regarding bridge construction in DOR: A review of Policy and practice he recommends bridge project selection for construction procurement of only those whose feasibility and detailed survey was conducted on ranking basis.
6. From DOR source it was come to idea that there are more than 2000 bridges DPR is available and yet are not in the process of implementation. It was also came to known that in each fiscal year the DPR is prepared for several bridges as per budget allocation in red book however in next year, with change in government and political interest, the budget is allocated for other new bridges previous bridges project whose certain level of study was done are left unattended.

The first two arguments show the use of this criterion in international level for project prioritization purpose. Similarly, arguments 3 and 4 show the importance gained by project readiness in national context. While the 5th and last arguments show the present situation and potentiality of project readiness criteria for addressing this significant issue.

Based on above information the criteria project readiness along with sub-criteria as shown in Table 4.5 is prepared:

Table 4.5: Project Readiness Criteria (Federal)

Criteria	Weights	Sub criteria	Scoring
Project Readiness Level	?	Detailed survey/design/IEE ongoing or completed.	4
		Detailed Feasibility Study completed / ongoing committed.	3
		Pre-feasibility Study ongoing/committed	2
		Conceptual stage	0

The same was proposed during presentation at DOR where incredibly positive feedback for inclusion of project readiness as an important criterion was discussed. The experts also add faster implementation and quick return of investment as some advantage of project readiness.

4.5.3.1.4 Omission of Population and road closure duration criteria

Following arguments were placed for omission of population & road closure duration from federal level matrix.

- The jurisdiction provided to federal level clearly indicates bigger goals of national connectivity issues are assigned to federal level. This is clearly reflected by jurisdiction provided like north-south and east-west highways, highways connecting federal capital to province capital and province to province capital etc. In such a context the bridges in federal roads also need to be made with bigger goals of strategic importance and justification of how much population a bridge will serve is not relevant for already strategically important bridges. That is why, the population criteria should be removed in federal level matrix and population factor in its economic version should be proposed in province level matrix.
- The population criterion was assigned weights of 0.05; though being animportant criterion, relating its imperfection in sub-criteria calibration previously.
- Also, the criteria road closure duration is less relevant in federal case as link, origin and destination are much clear for federal roads and connection of origin and destination in as per NRS is essential and almost all the bridges has equal

importance regarding the link functionality. It can be more pronounced in case of local level matrix and is included in same.

4.5.3.2 Criteria/Sub-criteria fixation for Province level

The matrix was tried to be kept aligned in the same line as that of federal level for uniformity and simplicity of use and understanding. The detail discussion on each of the criteria proposed along with sub criteria for province level is presented below:

4.5.3.2.1 Strategic Importance of road link/Government priority policy:

The importance of road link is tried to justified in LRBP central level screening, where 'location of bridge–potentials for inter district/regional linkages' with total weight age 25 out of 100 was set as an criteria, Sub-criteria were 'part of the Link between 2 major places / District HQ of 2 districts with score 25.0, part of the link between two existing motorable roads with score 20 and others 15.

As per the present jurisdiction, province government is responsible for roads as per schedule 6 of constitution, projects previously handled by DOLIDAR, major links connecting state capital with main administrative centre of local levels, links connecting two or more than 2 local level headquarters, Bridges on state highways and trail bridge.

Although the province is assigned the responsibility as above it cannot be certainly said all the road links can get equal priority by government. For example, the projects previously handled by DOLIDAR could get more attention than links connecting two or more local level headquarter. So, road link importance is sorted out with the help of limited AHP with related personnel and grouping was done as shown in table 4.6 to provide subsequent score.

Table 4.6: Strategic Importance of Road (Province)

Criteria	Weights	Sub criteria	Scoring
Strategic Importance of Road	?	1. Road link connecting National Highway/Feeder road/State highway to local level HQ.	4

Criteria	Weights	Sub criteria	Scoring
		2. Road link connecting district HQ & local level HQ	3
		3.Road link connecting two or more than 2 local level HQ	2
		5.Other roads	0

4.5.3.2.2 Per Capita investment:

In LRBP matrix, 'number of living in ZOI' is given greater importance than other criteria. ZOI is area of which the people will be travelling through the proposed bridge. Among the four criteria for scoring in local/district level it carries weight age 40 out of 100. Similarly, at central level among three criteria it carries weight age of 25. The sub-criteria was set as <1000 =10.0,1000 - 3000= 15.0, 3000 -5000= 20.0, 5000 - 10000= 25.0, 10000-12000=30.0,12000 – 15000 =35.0 and > 15000 =40.0 in local/district level. Similarly, in central level the sub-criteria are< 5000= 10.0, 5000 - 10000= 20.0, 10000 -20000=30.0, 20000 - 30000=40.0, > 30000 = 50.0. As per LRBSU source, at present, no spatial analysis is carried out for determining ZOI and population of VDC in which the bridge lie is taken as ZOI for present scoring purpose. However, the ZOI of province no. 1 has been already determined from spatial analysis and GIS maps at present and the procurement for consulting works on determining the ZOI of road and bridge is in progress and will be available soon.

In the proposed matrix, a concept of per capita investment is tried to be introduced. This concept utilizes two factor ZOI and cost of the bridge in a sense that every people of remoter parts who are not getting the easy access due to absence of bridge are facing the similar difficulties wherever they are. At a same time in country like ours there are numerous demands for the bridge from nooks and corners of the country. SO the better solution is that if we calculate the per capita investment required (by dividing population of ZOI by cost required for the bridge) and give priority to the lesser per capita investment value, it could be a smarter way to utilize the scarce fund and resource.

This concept was utilized while preparing DTMP as well. The cost to build a road link is divided by people getting direct benefits from the road (Population of VDC touched by the road) and the roads scoring minimum get higher priority.

For setting of this criterion, first of all per meter cost needs to be assumed. For the same purpose, the 13 several types of bridges whose construction is completed by LRBP in province no. 3 are taken for the analysis. The estimated cost of bridge is divided by total length of the bridge to get per metre cost of the bridge which comes around 14 lakh/metre. Inflation of cost is not considered which is one of the limitations.

After getting the cost per metre of the bridge, the next stage is to calibration of sub criteria. For the same, 98 bridges which are under construction, substantially completed and construction completed are taken for the analysis. The bridge length is divided by per metre cost to get the cost of the bridge. Then, the population of the municipality rural municipality in which it is to be constructed is taken as population benefited for the analysis. Bridge cost is divided by population to get 98 different per capita investment values. Among which maximum was of Samari Khola Bridge 1in Makwanpur district with value 7054.34 and minimum value was 123.67 of Gangatte Khola (Dhapakhel) Bridge in Lalitpur District. Use of entire population of municipality or rural municipality instead of ZOI for analysis is one of the limitations of this research. However, it was came to know during the visit to LRBP office for research work that, the ZOI of province no. 1 has been already determined and the procurement for consulting works on determining the ZOI of road and bridge for province no. 3 is in progress within LRBP. So, due to such limitations, for the demonstration purpose of the concept, population of municipality or rural municipality is considered.

Table 4.7: **Per Capita Investment maximum & minimum**

S. no	District	Bridge Name	Bridge Length	Bridge Cost	Mun/Rur. Mun.	Population	Per capita Investment
1	Makwanpur	Samari Khola Bridge 1 (Kalikhola)	127.88	179032	Makawanpurgadhi	25379	**7054.34**
2	Lalitpur	Gangatte Khola (Dhapakhel) Bridge	7.1	9940	Godawari	80376	123.67

The maximum value 7054.34 is assigned minimum value of zero and minimum value 123.67 is assigned maximum score 4 for calibration purposes.

$$\frac{Req.\ PCI - Max.PCI}{Min.PCI - Max.PCI} = \frac{Req.Score - Min.Score}{Max.Score - Min.Score}$$

Solving for score 1(req. score),

Max. PCI=7054.34

Min PCI=123.67

Max. Score=4

Min Score=0

We get PCI for score 1=5322. In the similar fashion, PCI for each score is obtained and the linear relation of PCI values for different score are illustrated in figure 4.2.

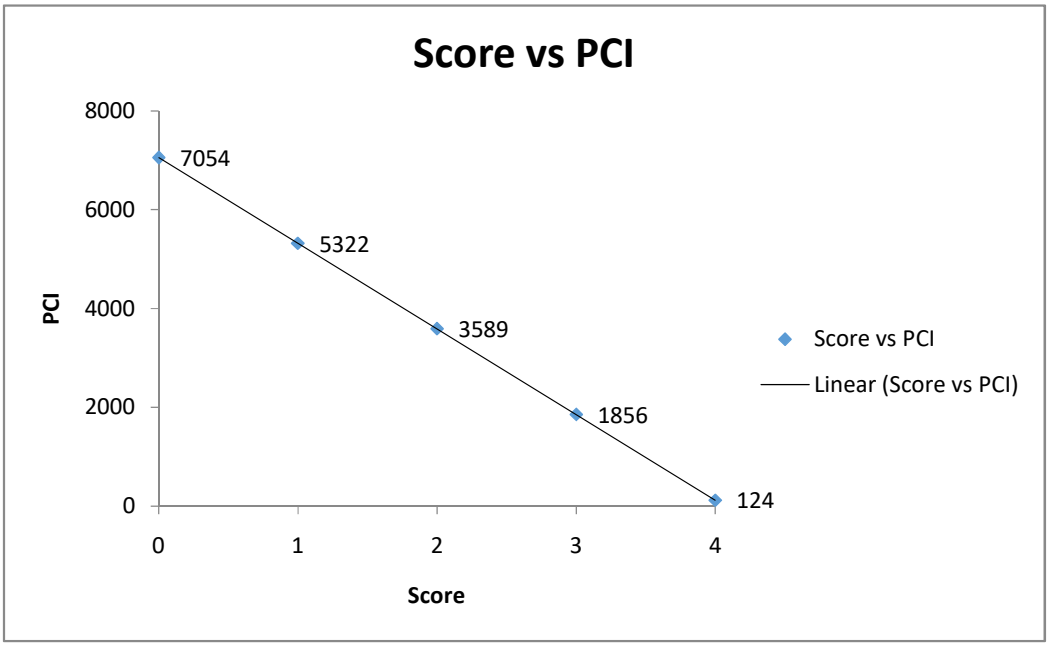

Figure 4. 2: Score vs PCI

For the simplicity of the matrix the PCI obtained are rounded off to nearest zero values. PCI from 0-149 is assigned 4, PCI between 150-2000 is assigned 3, 2000 to 3500 is assigned score 2, 3500 to 5500 is assigned 1 and more than 5500 is assigned score 0. This forms the criteria per capita investment (PCI) as illustrated in table 4.8 below.

Table 4.8Criteria Per Capita Investment (Province Level)

Criteria	Weights	Sub-criteria	Scoring
Per Capita Investment	?	0-149	4
		149-2000	3
		2000-3500	2
		3500-5500	1
		Above 5500	0

4.5.3.2.3 Present Traffic Volume (VPD):

In LRBP matrix, local/district level screening, 'number of vehicles plying along the roads at both sides of river' is set as a criterion with weight 20 out of 100. It was defined as the number of vehicle that will cross immediately after the construction of the bridge (not projected or estimated, but already arriving at the banks before bridge construction/during dry seasons). The sub-criteria scoring was done as none= 5, < 5= 7.5, 5-10 = 10.0, 10-20 = 15.0, <20 = 20.0. It was come to know during interview with LRBSU Deputy Team leaderthat these sub-criteria are set based on informed judgement basis.

In this study, for the calibration of this criteria, DTMP report of 13 districts of province no. 3 are referred. From the table '*required cross drainage structure'*, DRCN requiring bridges are sorted out. For example, in DTMP report of Ramechhap district out of 23 DRCN identified, 11 DRCN requires bridges in it. The DRCN requiring slab culvert, causeway and pipe culvert are not considered in the analysis. Those 11 DRCN are taken for analysis. From the '*traffic data*' table of same report VPD of each road is taken. In the similar fashion, the DRCN requiring bridges and VPD in such links are taken. The tables showing maximum and minimum VPD in DRCN of districts in province 3 are illustrated in table 4.9 and 4.10respectively.

Table 4.9: Maximum & VPD in DRCN (Source: DTMP report of 13 districts of province 3)

S. N	District	DRCN Code	Road Name	Road length (Km)	Bridge length (m)	VPD
1	Makwanpur	31DR008	Pashupatinagar – Padampokhari –Handikhola – Rajaiya	24.27	120	39
2	Ramechhap	21DR005	Puditar-Tharbhanjyang - Alchidhunga-Alampur	14.12	90	0
3	Ramechhap	21DR009	Majhuwa (Dadhuwa) NigalbasTimu	12.74	120	0
4	Ramechhap	21DR015	Manthali-Gelu-Pokharidanda	17	30	0
5	Ramechhap	21DR016	Khimti-Betali-Dharapani	34.5	150	0
6	Ramechhap	21DR020	Dilauri-Sabra- Kaileshor-Bamti	16.16	240	0
7	Makwanpur	31DR004	Manahari – Rupachuri – Siladhuni –Silinge (Kankada) Road	10.88	50	0
8	Makwanpur	31DR011	Pandrang – Ichung - Budhichaur Road	8.08	70	0

Status Paper in Road Safety Nepal, 2013 published by CBS mentions growth rate of different type of vehicles in Nepal which is shown in table 4.10 below. The average growth rate of vehicles was found to be 8.36%. Also, the maximum VPD 39 comes out from one of the DRCN's of Makwanpur District. DTMP of Makwanpur District was prepared in year 2015, so for the present analysis the VPD is inflated to year 2019 using the formula

$P=A\ (1+i)^{n}$

Where, P= Present VPD

A=VPD in 2015 (39)

i=traffic growth rate (8.36%)

n=4

Solving, we get, P=54

Table 4.10: **Traffic growth rate based on type of vehicles.**

S. No	Description	Growth rate
1	Bus/Minibus/Micro Bus	9.20%
2	MC	17.50%
3	Light Vehicle	7.90%
4	Truck	7.20%
5	Tractors	11.30%
6	Tempo	0.80%
7	Others	4.60%
Average		**8.36%**

The maximum value 54 is assigned maximum score 4 and minimum value 0 is assigned zero score for calibration purposes. Linear function is assumed for scoring for simplicity. Following linear equation is solved to get the values for consecutive scores 1,2 & 3. $\frac{Req.\ VPD\ -Min.VPD}{Max.VPD-Min.VPD} = \frac{Req.Score-Min.Score}{Max.Score-Min.Score}$

Solvingfor score 1,

Min VPD=0

Max.VPD=54

Min Score=1

Max Score=4

we get VPD for score 1(Req. VPD) =10. In the similar fashion, VPD for each score is obtained and the linear relation between VPD values for score 1, 2, 3 are illustrated in figure 4.3 below.

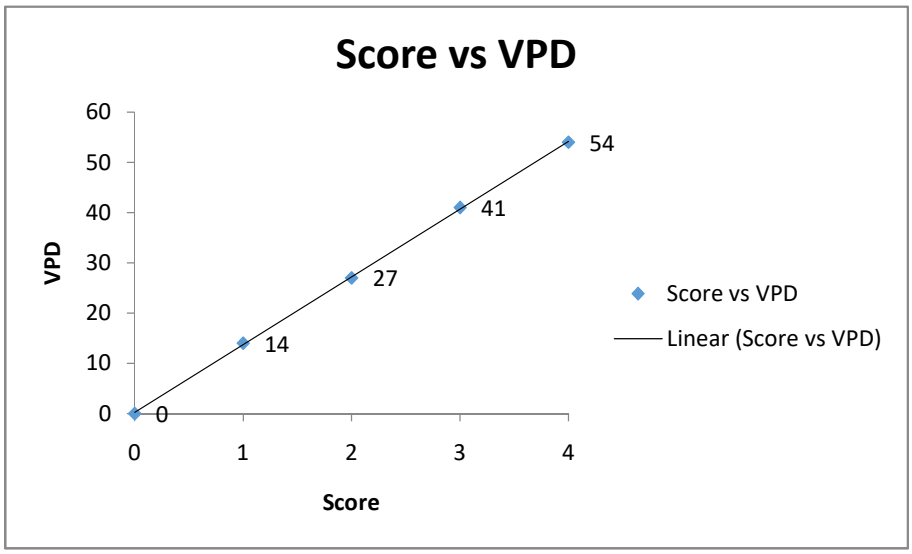

Figure 4. 3: Score vs VPD (Province & local)

For the simplicity of the matrix the VPD obtained are rounded off to nearest zero values. VPD 0 is assigned 0, VPD 1-15 is assigned 1, 16 to 30 is assigned score 2, 31 to 40 is assigned 3 and more than 40 is assigned score 4 and the resulting criteria is illustrated in table 4.11 below.

Table 4.11: Criteria present traffic volume (VPD) (Province)

Criteria	Weights	Sub-criteria	Scoring
Traffic Volume	?	None	0
		1-15	1
		16-30	2
		31-40	1
		More than 40	0

4.5.3.2.4 All weathered road length:

In LRBP matrix, local/district level screening, 'kilometers of road that the proposed bridge will make all weather' is set as a criterion with weights 20 out of 100. The same is placed in central level criteria with total weight age 25 out of 100. It was defined as 'The length of road stretch (between 2identifiable nodes)'. The sub criteria in local/district level screening is further classified as less than 20.0 km=4.0, 20.0 – 30.0 km=8.0, 30.0 – 40.0 km=12.0, 40.0 – 50.0 km = 16.0 km, greater than 50.0 km = 20.0. Similarly, in central level, it is classified as < 20.0 km = 5.0, 20.0 –30.0

km=10.0, 30.0 –40.0 km=15.0, 40.0 –50.0 km=15.0, >50.0 km = 25.0. It came to know during interview with LRBSU Deputy Team leader Mr. Shakil Manandhar that these sub-criteria are set based on informed judgment basis from the practitioners working in LRBP.

For the present analysis, all weathered road length data of 29 bridges build in province no. 3 made available by LRBSU office is used. The maximum length all weathered was 30 km and the minimum length was 3km and the details regarding the bridge and district in which it lies are shown in table 4.12 below.

Table 4.12: Maximum & minimum all-weather roads in Km

SN	District	Bridge name	All weather roads (in km)
1	Ramechhap	Pharfu Khola Bridge	30
2	Kavre	Ladaku Bridge	3
3	Ramechhap	Sindhurpa Khola Bridge	3

The maximum value of 30 Km is assigned score 4 and minimum 3 km is assigned 0 score and the linear function is assumed for getting score value for 1,2 & 3.

$$\frac{Req.\ AWRL - Max.AWRL}{Min.AWRL - Max.AWRL} = \frac{Req.Score - Min.Score}{Max.Score - Min.Score}$$

Solving for score 1,

Max AWRL=30

Min. AWRL=3

Max Score=4

Min Score=1

We get, AWRLfor score 1 (req. AWRL) =10.In the similar fashion, AWRl for score 2 & 3 were derived, and their relation is illustrated in figure 4.4 below.

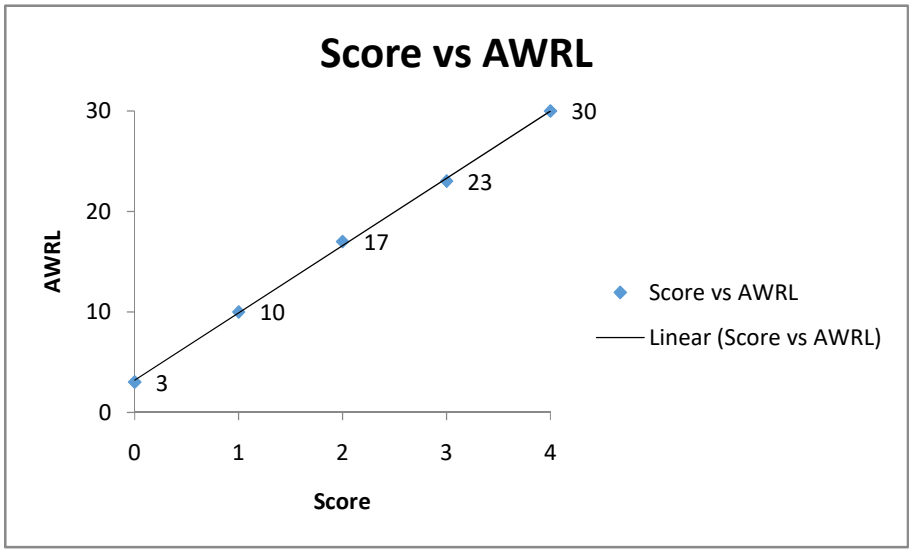

Figure 4.4: Score vs AWRL

Based on the above reasoning, the following matrix as shown in table 4.13 is proposed

Table 4.13: All weather road length criteria

Criteria	Weights	Sub-criteria	Scoring
All weathered Road Length	?	Less than 3 km	0
		3-10 Km	1
		10-17 Km	2
		17-23 Km	3
		More than 23 Km	4

4.5.3.2.5 Access to socio-economic activities:

Following arguments are placed for formation of this criterion.

- Criteria 'Population served or bridge in a link serving major economic activity-mineral extraction, hydropower, tourist centers, pilgrimages places' is one of the criteria placed in DOR matrix. As per information from experts of DOR, Bridge branch, these criteria are assigned low weights of 0.05 (out of 1) on judgmental basis accounting poor sub-criteria classification which have probability of having high measurability error. It has sub-criteria as if the bridges serve more than five lakh population or bridges lies in the link serving major industry or commercial

activity or hospitals or touristic/pilgrimage places it will get score 4. Similarly, if population between 1.5 lakh and 5 lakh is served or if the bridges lies in the link serving industrial or activity of local significance or if the bridge is in link to health posts it will get score 3. Similarly, if population between 50 thousand and 1.5 lakhs is served then the bridge scores 2, population between 15 thousand to 50 thousand scores 1 and bridges serving less than 15000 is assigned zero score. Mr Prashant Malla, who is enrolled in consulting works in this matrix formation, informs that the population range were fixed based on region of the country. The lesser population range of 50 to 15 thousand are put accounting for himalayan region, up to 1.5 lakh for hilly belt and up to 5 lakhs was for accounting Terai region population. He also added that due to its impreciseness it is given lesser weights. However, if we see the content of this criteria it could be probably seen as one of the important criteria and little weight age to it is not justified

- Report "Preparatory Survey for Public-Private Partnership (PPP) Infrastructure Development Projects in the Republic of the Philippines" has outlined project contribution to National/Regional Economic Development as an evaluation item and Major Existing and Potential industries along the corridor as an indicator with sub criteria's; Agro-fishery Industry = 1.0, Manufacturing Industry = 1.0, Business / Commercial Industry = 1.0, Tourism Industry = 1.0,(Two or more industries = add weights, Max = 2.0points). This report particularly focusses the road prioritization. In our case, the remoter part which is being all weathered by construction of bridge is taken for the study. The presence of any economic, commercial, social activities (agro, manufacturing industry, health centres, education centres etc.) in road link/section which is becoming all weathered by means of bridge constructed is considered.
- In DOR matrix, bridges lying in the link serving major industry or commercial activity or hospitals or touristic/pilgrimage places get score 4. Similarly, the bridges lying in the link serving industrial or activity of local significance or if the bridge is in link to health posts it will get score 3. Here the definition is tried to be made saying major industry and industry. The proposed matrix as in table 5.14 tries to place the following aspects more clearly.
- It is also necessary to add that, province government is responsible for easier access and better network within the local levels lying in the province. The jurisdiction provided to federal level focuses more on national connectivity issues

and hence the subject of providing access to business, tourism, agriculture and social activities like health & education centres in particular region seems more relevant for province level and hence criteria 'access to socio-economic activities' is proposed for province level as mentioned in table 4.14.

The criteria proposed is:'

Table 4.14: Criteria Access to socio economic activities

Criteria	Weights	Sub-criteria	Scoring
Access to socio-economic activities	?	Access to significant tourism/cultural/hydropower sites or access to at least 3 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	4
		Access to 2 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	3
		Access to single cottage industry (agriculture, livestock, manufacturing related)/ health centres/education centre.	2
		No kind of activities in all weathered road section.	0

Hence, the proposed matrix give highest score of 4 to bridges providing access to significant tourism/cultural/hydropower sites or access to at least 3 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres. The placing of minimum 3 cottage industries or health centres or education centre or their combination was placed as per experts' suggestions. Similarly, access to 2 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres is given score 3.Access to single cottage industry (agriculture, livestock, manufacturing related)/ health centres/education centre is assigned score 2 and no any kind of activities in all weathered road section scores 0.

4.5.3.3 Criteria/Sub-criteria fixation for Local level matrix:

4.5.3.3.1 Strategic Importance of road link/Government priority policy:

The importance of road link is tried to justified in LRBP central level screening, where 'location of bridge–potentials for inter district/regional linkages' with total

weight age 25 out of 100 was set as an criteria, Sub-criteria were 'part of the Link between 2 major places / District HQ of 2 districts with score 25.0, part of the link between two existing motorable roads with score 20 and others 15.

As per the present jurisdiction, local level government has jurisdictions per schedule 8 of constitution, local roads, rural roads & agro roads. In the equivalent way following matrix of province and federal level, following is proposed for the local level.

Table 4.15: Strategic importance of road (Local level)

Criteria	Weight	Sub-criteria	Score
Strategic Importance of Road/Government Priority Policy		1. Road Link connecting local level HQ/major settlements with National Highway/Feeder road/State highway.	4
		2. Road link connecting local level HQ and major settlements / cultural / economic / tourism destinations.	3
		3.Road link connecting two or more major settlements.	2
		4.Other roads	0

Although the local level is assigned the responsibility as above it cannot be certainly said all the road links can get equal priority by government. So, road link importance is sorted out with the help of limited AHP with related personnel.

4.5.3.3.2 Present Traffic Volume (VPD):

The traffic volume criteria and sub criteria are kept same to that of province as the VRCN traffic data is not available for calibration.
The matrix is:

Table 4.16: Present traffic Volume (VPD) (Local level)

Criteria	Weight age	Sub-criteria	Scoring
Traffic Volume	?	None	0
		1-15	1
		16-30	2
		31-40	1
		More than 40	0

4.5.3.3.3 All weather road length maintainable & operable by local level:

This criterion is previously used by LRBP where DDC were in the place of local level. The criteria were Lengths and sections of district roads on which bridges are proposed are maintained and operable by concerned DDCs' and was defined as Part of the road length all weathered that will be maintained for vehicle plying'. It was assigned total weight of 20 and have sub criteria All of the length: 20.0, Most of the length:15.0, about half: 10.0less than half: 5.0 and only some: 2.0.

This criterion tries to focus on maintenance capacity of the then DDC's for implementing bridges. The same approach is tried to incorporate in this matrix by replacing the DDC with local level in the newly developed context of federalism. Clearing of side drains, maintenance of culverts, clearance of small landslides and other routine maintenance activities has immense importance for up keeping serviceability of road. In absence of capability in local level to carry out routine and other maintenance activities in local level, the length of road all weathered can't keep significant meaning.

The maintenance capacity of local level might be affected with proximity of the road links to the headquarters, road importance and spending capacity of local level and many other factors. However, for present analysis, the capability of local level is associated with presence of RMG's in road section. RMG's are group of people who are engaged in routine maintenance activities in any road section. RMG's are mobilized by SNRTP project funded by World Bank with collaboration with ILO.

Table 4.17: **All weathered road length operable/maintainable by concerned local level (Local level)**

Criteria	Weights	Sub-criteria	Scoring
All weathered Road length operable by concerned local level.	?	All of the length	4
		Most of the length	3
		about half	2
		less than half	1
		only some	0

The sub-criteria are kept same as that previously used in LRBP matrix.

4.5.3.3.4 Road Closure Duration due to absence of bridge:

This criteria is used in DOR matrix assigning weights of 0.15 with sub criteria more than 3 months in year scores 4, 2 to 3 months scores 3, 1 to 2 months scores 2, 10 days to 1 months score 1 and less than 10 days road closure scores 0.

Mahesh Chandra Neupane, presently chief of planning section of DOLI and one of the experts consulted for the study suggests that local level will be mostly assigned the short bridges basically in river with small discharge and where occasional flash floods will occur. Longer bridges will be either implemented by province or federal level if we see the present scenario.

He also adds that the duration mentioned as in sub-criteria of DOR with 3 months maximum and 10 days minimum duration suits for Perennial River with significant discharge throughout the year. So, the sub-criteria need to be revised to suit the local level case.

At present the calibration of road closure duration is not possible due to time constraints and one of the limitations of this research. The sub-criteria similar to DOR matrix is set as one of the criteria.

The criteria are as follows:

Table 4.18: Road Closure duration due to absence of bridge (Local level)

Criteria	Weight	Sub-criteria	Scoring
Road Closure duration due to absence of bridge	?	more than 3 months in a year	4
		2 to3 months in a year	3
		1 to 2 months in a year	2
		10 days to 1 months in a year	1
		less than 10 days in a month.	0

4.6Providing Weights to Criteria

Analytic hierarchy process (AHP) is used to assign weights to each of the criteria. The fundamental input to the AHP is the decision maker's answers to a series of questions of the general form, 'How important is criterion A relative to criterion B?' These are

termed pairwise comparisons. Questionnaire is developed and used to establish, within AHP, weights for criteria in this study.

The excel sheet developed by K.D Goepel was taken for calculating the weights for each criterion. The AHP comparison sheet is prepared and provided to concerned stakeholders and experts for making pairwise comparisons of each of the criteria's selected. The information obtained from the experts is entered in the software to produce the weights for each of the criteria which were shown in Table 4.19, Table 4.20, Table 4.21 for federal, province and local level respectively. During AHP analysis, following are the weightage derived from each of the participant for federal level matrix.

Table 4.19: Weights of criteria (Federal level)

Participant/ Criteria	Road link classification/Government priority Policy (%)	Present traffic Volume (%)	Project readiness (%)	CR (%)
Participant 1	78.5	12.9	8.5	8
Participant 2	12.2	55.8	32	2
Participant 3	79.9	9.6	10.5	1
Participant 4	73.3	19.9	6.8	10
Participant 5	81.4	7.2	11.4	6
Participant 6	58.2	36.7	5.1	6
Participant 7	67.4	22.6	10.1	9
Participant 8	16.3	29.7	54	1
Participant 9	42.9	42.9	14.3	0
Participant 10	62.7	28	9.4	9
Participant 11	74	16.7	9.4	1
Participant 12	29	65.5	5.5	8

Other important indicators were:

Overall consistency ratio=0.9%

Consensus=62.4%

Similarly, for the province level criteria following are the weights derived from AHP analysis.

Table 4.20: Weights of criteria (Province level)

Criteria/Participant	Road link classification (%)	Per capita investment (%)	Present traffic Volume (%)	All weathered road length (%)	Access to socio economic activities (%)	CR (%)
Participant 1	60	4.6	15.8	13.4	6.2	
Participant 2	27	11.6	7.8	4	49.6	
Participant 3	41.4	6.1	10.1	37.5	4.8	
Participant 4	49.1	7.4	5.4	23.4	14.6	
Participant 5	53.6	7.4	8.4	9.5	21.1	9
Participant 6	18.7	16.4	3.7	3.8	57.4	9
Participant 7	22	18	10.1	44.6	5.3	9
Participant 8	5.2	16.8	15.2	11.3	51.5	10
Participant 9	18.2	6.3	22.1	10.7	42.7	
Participant 10	46	8.7	24.3	8.5	12.5	8
Participant 11	52.4	10	99.8	20.8	7	2
Participant 12	7.6	4.3	33	14.3	40.8	8

For local level, following are the weights derived from AHP analysis using excel based software.

Table 4.21: Weights of criteria (Local level)

Participant/Criteria	Strategic Importance of road	Present traffic volume (VPD)	All weather road length operable by concerned local level	Road closure duration due to absence of bridge	CR
Participant 1	49.2	14.6	22	14.2	8
Participant 2	4.2	50.3	10.5	34.9	8
Participant 3	36.8	12.3	9	42	10
Participant 4	20.8	5.3	10.4	63.5	10
Participant 5	6.5	20.8	14.2	58.5	6
Participant 6	53	4.7	13.7	28.7	4
Participant 7	14.7	5.9	29.4	50	8
Participant 8	23.1	57.2	11.2	8.5	8
Participant 9	11.7	48.5	11.7	28	7

Participant/Criteria	Strategic Importance of road	Present traffic volume (VPD)	All weather road length operable by concerned local level	Road closure duration due to absence of bridge	CR
Participant 10	56.8	15.7	4.8	22.7	7
Participant 11	57.6	24.2	12.5	5.8	1
Participant 12	10.3	17.3	38.3	34	8

4.7Assigning Weights/scores to option to get overall value

Federal level matrix is used to demonstrate the ranking of new bridge projects as shown in Table 4.22 identified for implementation by DOR in the present fiscal year. Road link data, project readiness status and AADT values are attached in annex. The demonstration of ranking by use of federal is shown below.

Table 4.22: Demonstration of use of matrix (Federal level)

SN	Bridge Name	Road name	Score in criteria (Weight)			Total Score
			Road link (58.1%)	AADT (28.4%)	Project readiness (13.5%)	
1	Sansare bridge	MRM Ch.392+280	4	1	0	2.61
2	Mamti Khola Bridge	BP Highway	4	1	0	2.61
3	Trisuli River Bridge	Pasang lamhu Road	3	1	0	2.03
4	Khani Khola Bridge	Tamakoshi Manthali Khurkot Bridge	3	1	0	2.03
5	Karmanasa Bridge	Thimi-Lokanthali-Tikathali-Manohara-Mahalakshmi na.pa. 18,	0	3	0	0.85

SN	Bridge Name	Road name	Score in criteria (Weight)			Total Score
			Road link (58.1%)	AADT (28.4%)	Project readiness (13.5%)	
		Imadol				
6	Ghatte River Bridge	Sallaghari-Katunje-Lubhu	0	3	0	0.85
7	Sankheshwari Bridge, Kavre	Gwarko-Panauti road	0	3	0	0.85
8	Hanumante Khola Bridge	Kaushaltar-balkot-Sirutar-Biruwa road, Su.na.pa. 3, Balkot	0	3	0	0.85
9	Budhigandaki River bridge	Trolleybus arniko highway Suryabinayak chamelidanda road	0	3	0	0.85
10	Mahadev River Bridge	Trolley bus Arniko Highway	0	3	0	0.85
11	Mahadev River Bridge	Sallaghari-Katunje-Sumlingtar Su. na. Pa. 5 & 7	0	3	0	0.85
12	Martal River Bridge	Dumre Khadi Chepang Marga	0	0	2	0.27
13	Gongar River bridge	Thakaltar Chepang marga	0	0	2	0.27
14	Tudi River Bridge	Chepang Marga	0	0	2	0.27
15	Reti RIver Bridge	Chepang Marga	0	0	2	0.27
16	Jhirti River Bridge	Chepang Marga	0	0	2	0.27

SN	Bridge Name	Road name	Score in criteria (Weight)			Total Score
			Road link (58.1%)	AADT (28.4%)	Project readiness (13.5%)	
17	Malekhu River Bridge	Chepang Marga	0	0	2	0.27

The same ranking for different bridge could lead to the decision maker with the options for forceful prioritization as discussed earlier.

Due to limitations in the matrix itself and unavailability of data at present, the demonstration of use of province and local level matrix is not possible and one of the limitations of the research.

CHAPTER FIVE: RESULT & DISCUSSION

The result of this study is the priority matrix formed for federal, province and local level government. The federal level matrix is presented in table 5.1. Similarly, province level and local level matrix are illustrated in Table 5.2 and Table5.3, respectively.

Table 5.1: Proposed federal level matrix

Criteria	Weight	Sub-criteria	Score
Strategic Importance of Road/Government Priority Policy	0.581	Bridges in national Highways/in links connecting east west highways to state capital's & federal capital/north south highways connecting international borders	4
		Bridges in links connecting federal/state capital to Pushpalal highway & Links connecting national highway to projects of national pride/ link connecting national road network to district headquarters.	3
		Commercial links connecting federal/state capital from east-west highway to north south highways.	2
		Bridges on roads handed over on state request	1
		Bridges on other roads	0
Present Traffic Volume (AADT)	0.284	Above 7000	4
		4500-7000	3
		2500-4499	2
		150-2499	1
		less than 150	0
Project readiness level	0.135	Detailed survey/design/IEE ongoing or completed.	4
		Detailed Feasibility Study completed / ongoing committed.	3
		Pre-feasibility Study ongoing/committed	2
		Conceptual stage	0

Table 5.2: Proposed Province level matrix

Criteria	Weight	Sub-criteria	Score
Strategic Importance of Road/Government Priority Policy	0.343	1. Road link connecting National Highway/Feeder road/State highway to local level HQ.	4
		2. Road link connecting district HQ & local level HQ	3
		3.Road link connecting two or more than 2 local level HQ	2
		4. Road excluded from above 3 sub-criteria & implemented by DOLIDAR previously.	1
		5.Other roads	0
Access to socio-economic activities	0.229	Access to significant tourism / cultural /hydropower sites or access to at least 3 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	4
		Access to 2 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	3
		Access to single cottage industry (agriculture, livestock, manufacturing related)/ health centres/education centre.	2
		No kind of activities in all weathered road section.	0
All weathered road length	0.166	Less than 3 km	0
		3-10 Km	1
		10-17 Km	2
		17-23 Km	3
		more than 23 km	4
Present Traffic Volume (VPD)	0.149	None	0
		1-15	1
		16-30	2
		31-40	3
		More than 40	4
Per Capita Investment	0.113	0-149	4
		149-2000	3
		2000-3500	2

Criteria	Weight	Sub-criteria	Score
		3500-5500	1
		Above 5500	0

Table 5.3: Proposed local level matrix

Criteria	Weight	Sub-criteria	Score
Road closure duration	0.34	more than 3 months in a year	4
		2 to3 months in a year	3
		1 to 2 months in a year	2
		10 days to 1 months in a year	1
		less than 10 days in a month.	0
Strategic Importance of Road/Government Priority Policy	0.271	1. Road Link connecting local level HQ/major settlements with National Highway/Feeder road/State highway.	4
		2. Road link connecting local level HQ and major settlements / cultural / economic / tourism destinations.	3
		3.Road link connecting two or more major settlements.	2
		5.Other roads	1
Present Traffic Volume (VPD)	0.214	None	0
		1-15	1
		16-30	2
		31-40	3
		more than 40	4
All weathered road length maintainable/operable by local level.	0.175	All of the length	4
		Most of the length	3
		about half	2
		less than half	1
		only some	0

Following are the discussions made regarding the results.

1. The criteria as utilized above for the matrix formation might not be the only criteria that could be used for the bridge prioritization which was made clear during previous discussion as well. It is a beauty of multicriteria analysis that it is

flexible enough for addition and omission of criteria based on stakeholders and expert's opinion and the utility context of matrix.

2. In the initial phase of the study certain hierarchy of criteria was assumed and for the pairwise comparison for AHP analysis criteria was ordered in that hierarchy. For federal matrix, among 3 criteria; strategic importance of road gets highest weights of 58.1%, AADT weights 28.4% and project readiness weights 13.5% which was same as previously assumed. The consensus of 62.4% among the participant during AHP analysis was found. From AHP analysis of province level matrix, strategic road importance gets highest weight of 34.3% while access to socio-economic activities (which was previously kept at the bottom of hierarchy in province matrix) weights 22.9%. In the comparable way, all-weathered road length weights 16.6%, %, present traffic volume weights 14.9%, while criteria per capita investment (which was assumed in 2nd order previously) weights least of 11.3 %. The consensus among participant during AHP analysis was 55.6%. For local level matrix, road closure duration (which was previously kept at the bottom of hierarchy) gets highest weight of 34%, strategic importance of road score 27.1%, present traffic volume (VPD) scores 21.4 % and criteria All weathered road length maintainable/operable by local level weights least (17.5%).
3. Due to limitations in criteria as discussed in chapter 5 within the criteria of province level and local level matrix level matrix.Some further study scope arise which can increase applicability of matrix in real scenario. Due to the same, demo prioritization for province and local level matrix was not possible.
4. During the study, it was found that most of the experts in the bridge sector are not used to with AHP analysis procedure. It was tried best possible during study to make the participant understand how the software works and how their views are reflected during AHP analysis. However, at a same time, it was felt that, setting of criteria and sub-criteria and AHP analysis for bridge priority for real application purpose must be set out from the comprehensive discussion between the related stakeholder by the means of workshops or conferences.

CHAPTER SIX: CONCLUSION & RECOMMENDATION

Following the results and discussion on the study, following conclusions related to the objectives are made.

1. Three criteria's strategic importance of road/government priority policy, traffic volume (AADT), and project readiness level are identified for federal level. Similarly, five criteria's strategic importance of road/government priority policy, traffic volume (AADT), all weathered road length, per capita investment and access to socio-economic activities are identified for province level and four criteria strategic importance of road/government priority policy, traffic volume (AADT), road closure duration, all weathered road length operable/maintainable by local level are identified for local level.
2. For criteria strategic importance of road/government priority policy in federal level, bridges in national highways/north south highways connecting international borders/link connecting national road network to district headquarters is assigned score 4, bridges in short & rapid links connecting east west highways to state capital's & federal capital and bridges in links connecting national highway to projects of national pride is assigned score 3. Similarly, commercial links connecting federal/state capital from east-west highway to north south highways and bridges in link connecting federal/state capital to Pushpalal highway is assigned score 2 and bridges on roads handed over on state request is assigned score1. For criteria traffic volume (AADT), AADT value above 7000 is assigned score 4, 4500 to 7000 is assigned score 3, 2500 to 4499 is assigned score 2, 150 to 2499 is assigned score 1 and 0 to 149 is assigned score zero. Similarly, for criteria project readiness level, project whose detailed survey/design/IEE ongoing or completed is assigned score 4, Detailed Feasibility Study completed /ongoing committed.is assigned score 3.Pre-feasibility Study ongoing/committedis assigned 2 Detailed Feasibility Study committed is assigned score 0.

   For criteria strategic importance of road/government priority policy in province level, road link connecting national highway/feeder road/state highway to local level headquarter is assigned score 4, road link connecting district headquarter & local level headquarter is assigned score 3, road link connecting two or more than 2 local level headquarter is assigned score 2 and road excluded from above 3 sub

criteria & implemented by DOLIDAR previously is assigned score1. For criteria traffic volume (VPD), VPD value above 40 is assigned score 4, 31 to 40 is assigned score 3, 16 to 30 is assigned score 2, 1 to 15 is assigned score 1 and none is assigned score zero. Similarly, per capita investment of 1-149 is assigned score 4, 149 to 2000 is assigned score 3, 2000 to 3500 is assigned score 2, 3500 to 5500 is assigned score 1 and above 5500 is assigned score zero. Similarly, all weathered road length distance less than 3km is assigned score zero, 3 to 10 km is assigned score 1, 10 to 17 km is assigned score 2, 17 to 23 km is assigned score 3 and more than 23 km is assigned score 4. Similarly, for criteria access to socio economic activities, access to significant tourism/cultural/hydropower sites or access to at least 3 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres is assigned score 4, access to 2 cottage industries (agriculture, livestock, manufacturing related)/ health centres /education centres is assigned score 3, access to single cottage industry (agriculture, livestock, manufacturing related)/ health centres/education centre is assigned score 2 and no any kind of activities in all weathered road section is assigned zero score.

For criteria strategic importance of road/government priority policy in local level, road link connecting local level HQ/major settlements with National Highway/Feeder road/State highway .is assigned score 4, road link connecting local level HQ and major settlements / cultural / economic / tourism destinations. is assigned score 3, Road link connecting two or more major settlements. is assigned score 2. For criteria traffic volume (VPD), VPD value above 40 is assigned score 4, 31 to 40 is assigned score 3, 16 to 30 is assigned score 2, 1 to 15 is assigned score 1 and none is assigned score zero. Similarly, for criteria all weathered road length distance operable/maintainable by local level,all of the length is assigned score 4, most of the length is assigned score 3, about half is assigned score 2, less than half is assigned score 1 and only some is assigned score 0.

3. For federal matrix, strategic importance of road weighs 58.1%, AADT weighs 28.4% and project readiness weighs 13.5%. For province level matrix, strategic road importance weighs of 34.3%, access to socio-economic activities weighs 22.9%, all-weathered road length weighs 16.6%, present traffic volume weighs

14.9% and per capita investment weighs 11.3 %. For local level matrix, road closure duration weighs 34%, strategic importance of road score 27.1%, present traffic volume (VPD) scores 21.4 % and all weathered road length maintainable/operable by local level weights least (17.5%).

4. During ranking of 17 bridges to be implemented by DOR in fiscal year 2076/77 with help of federal level multi criteria, Sansare bridge on MRM highway at Ch. 392+280 and Mamti Khola Bridge on BP Highway score 2.61 and lies on rank 1 & 2.

Recommendation:

It was found during the study that the prioritization as per bridge listed in BMIS or update of bridge to be implemented in BMIS is not observed and bridge selection is seen completely inspired by political influence within DOR. The same is the condition of DOLI/LRBP where several bridges whose one of the minimum conditions (bridge should lie on DRCN) for selection are not fulfilled are listed in the implementing phase in BMS database. The concept of giving forceful prioritization some weights for political interest emerged within DOR might be the result of such unwanted political interventions on infrastructure sector. The vulnerable scenario of undue political influence on infrastructure sector is reflected from the above-mentioned status.

In such a scenario, it should be first clear that who shall use this matrix. This decision aid tool can be useful to project selection and budget allocating organizations like National Planning Commission in federal and province level and infrastructure selection decision panel at local level.

REFERENCES

"Cambria Country Long range transpotation plan, 2015-2040."

Department of communities and local Government: London. "Multicriteria Analysis: A manual." 2009.

Department of Roads. "Five Years Strategic Plan (2073-78)." 2017.

District Transport Master Plan Guidelines of Nepal. Nepal: Department of Local Infrstructure Development and Agricultural Roads (DoLIDAR), 2012.

DOLIDAR. "DTMP Guidelines." 2012.

Dr. N. B. Chaphalkar, Prashant P. Shirke. "APPLICATION OF MULTI-CRITERIA DECISION MAKING TECHNIQUES FOR BRIDGE CONSTRUCTION." 2013.

"Final report: Updating of Bridge management system database." 2017.

Goepel, Klaus D. "IMPLEMENTING THE ANALYTIC HIERARCHY PROCESS AS A STANDARD METHOD FOR MULTI-CRITERIA DECISION MAKING IN CORPORATE ENTERPRISES – A NEW AHP EXCEL TEMPLATE WITH MULTIPLE INPUTS."

ISAHP. "A Style Guide for Paper Proposals To Be Submitted to the International Symposium of the Analytic Hierarchy Process." 2016.

Johnson, Josh. *AASHTOWare BrM 5.2.3 Multi-Criteria Decision Analysis for Bridge Management*, 2017.

Kantipur. *तिन तहलाई बाडीयो सडकको जिम्मेवारी*. 2018.

LRBP. "Bridge Information Management System-An approach Paper." 2013.

Marcelo, Darwin. *Prioritization of Infrastructure projects: A decision support framework*, 2015.

Mulmi, Abhiman Das. *Study of bridge project management in DOR: A review of policy and practice*, 2013.

National Planning Commision . "14th approach paper." 2017.

Omar, Wahid. "System Approach in Bridge Management."

Province Policy & Planning COmmision (PPPC). "Status Paper of the Province No. 3." 2018.

Road Maintenance Groups. Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR), March, 2016.

Saaty, T.L. McGraw-Hill, New York. "The Analytic Hierarchy Process." 1980.

Sharma, Sanjeev. *The Federal Challenge*, 2016.

Shrestha, Ashesh. "Virtues of Federalism." 2016: 1.

Springer. *A strategy for using multi-criteria analysis in decision making*, 2011.

Statistics of Local Road Network (SLRN) 2016. Kathmandu, Nepal: Department of Local Infrastructure Development and Agricultural Roads, Dec, 2016.

World Bank. "Appraisal Document for Bridge Improvement and maintainence programme." 2012.

ANNEXES

ANNEX I: Average Annual Daily Traffic (AADT 2015/16)

S. N	Station no.	Link no.	Location	Average annual daily traffic (AADT)	AADT excl. MC & rickshaws
1	1	F00101	Birtamod South	8204	4207
2	2	H0101	Charali East	10128	5578
3	3	H0102	Charali West	11352	6028
4	4	H0705	Charali North	8241	4156
5	5	F00201	Damak South	5684	1718
6	6	H0105	Damak West	13387	6081
7	7	F03801	Fikkal East	1859	1192
8	8	H0707	Fikkal West	3306	2292
9	9	H0709	Ilam North	2489	1261
10	10	H0711	Phidim North	779	401
11	11	F03901	Biratnagar East	3043	883
12	12	H0803	Itahari South	13082	9140
13	13	H0108	Itahari East	20123	12275
14	14	H0109	Itahari West	10581	6046
15	15	H0804	Itahari North	23603	11338
16	16	H0111	Koshi Barrage East	9133	6425
17	17	H0806	Dharan North	4509	1882
18	18	F04004	Basantpur East	66	39
19	19	F04001	Hile North	1633	791
20	20	H1807	Pakhribas	1045	699
21	21	F00301	Bhardaha South	2711	1124
22	22	F00401	Rupani South	3699	1261
23	23	H0115	Lahan East	11333	6450
24	24	H0901	Kadmaha North	4017	1703
25	25	F00501	Chouraha South	5238	1780
26	26	H05201	Mirchaiya North	2749	1399
27	27	F05203	Katari North	1667	968
28	28	F10901	Dharapani South	1178	263
29	29	H0604	Dhalkebar South	5457	2823
30	30	H0120	Dhalkebar East	4611	2288
31	31	H0121	Bardibas east	8635	4748
32	32	H0602	Dudhamati Bridge	5007	2036
33	33	F11401	Bardibas South	4855	2242
34	34	H0605	Bardibas North	3857	1739

S. N	Station no.	Link no.	Location	Average annual daily traffic (AADT)	AADT excl. MC & rickshaws
35	35	F00601	Nawalpur South	3800	2146
36	36	H0125	Karmaiya	6613	4404
37	37	F03204	Tamakoshi East	419	224
38	38	F03301	Tamakoshi south	278	162
39	39	F00701	Chandranigapur south	6689	2921
40	40	H0204	Pathlaiya south	8060	5919
41	41	H0128	Pathlaiya east	5642	4050
42	42	H0129	Pathlaiya North	6464	5018
43	43	F01801	Birgunj East	7098	2208
44	44	H0132	Hetauda West	13313	9780
45	45	H0205	Hetauda North	4303	2699
46	46	F01901	Bhainse Junction	1806	1053
47	47	F02001	Palung	538	250
48	48	H0134	Naranghat East	14859	8182
49	49	F07301	Naranghat West	11900	7174
50	50	H0503	Mugling South	7179	6243
51	51	H0404	Mugling East	8293	6808
52	52	H0405	Mugling West	4625	3429
53	53	H0310	Dhulikhel East	4828	2743
54	54	H0610	Dhulikhel South	4755	3514
55	55	F02901	Banepa South	6231	2858
56	56	H0311	Panchhkhal-Police Chauki	4990	3321
57	57	F00301	Panchkhal-Helambu	1909	1353
58	74	H0214	Nagdhunga	11872	9260
59	75	F03201	Lamosangu	1284	710
60	76	F03101	Dolalghat	457	261
61	77	H0315	Lamosangu/Barabise North	629	361
62	78	H0212	Naubise West (TRP)	1235	666
63	79	F06901	Galchhi North	2619	1437
64	80	F03401	Malekhu South	1502	831
65	81	F02106	Ranipauwa	676	205
66	82	F00801	Bardaghat south	5330	2106
67	83	H0141	Bardaghat west	9098	5441
68	84	F00901	Sunwal South	3487	1237
69	85	H0138	Gaidakot	13807	9516
70	86	F04401	Bhairahawa West	9962	5680

S. N	Station no.	Link no.	Location	Average annual daily traffic (AADT)	AADT excl. MC & rickshaws
71	87	F04501	Lumbini West	6661	4126
72	88	H0144	Butwal East	7919	4848
73	89	H1002	Butwal South	17681	8978
74	90	H0146	Butwal West	13505	6173
75	91	H1004	Butwal North	5028	2989
76	92	H0149	Jitpur West	6044	3471
77	93	F01001	Jitpur South	2533	1168
78	94	H0150	Gorusinge West	3384	1969
79	95	F01201	Chaunnauta South	2809	1824
80	96	H0151	Chanauta West	3810	2755
81	97	F01102	Gorusinge North	303	181
82	98	F04301	Tansen west	1842	1036
83	99	H1007	Bartung North	1641	1067
84	100	F03601	Dumre north	3205	1341
85	101	F03501	Abukhaireni North	2404	1045
86	102	H0411	Pokhara East	6763	4924
87	103	H1012	Pokhara South	3954	1714
88	104	F04101	Pokhara West	2624	918
89	105	F04202	Pokhara North	6251	2982
90	106	F04204	Kusma west	2826	1877
91	107	F01401	Chakchake east	133	89
92	108	F01303	Chakchke North	167	124
93	109	H0155	Bhalubang West	4452	2904
94	110	F01301	Bhalubang North	2937	1861
95	111	F01501	Lamahi North	2586	1617
96	112	F01505	Tulsipur east	3932	1580
97	113	H1101	Ameliya north	666	501
98	114	H0157	Ameliya West	1550	1260
99	115	H1103	Tulsipur North	2103	1085
100	116	F04602	Nepalgung West	6873	2871
101	117	H0124	Kohalpur South	14525	7032
102	118	H0159	Kohalpur East	5639	3589
103	119	H0160	Kohalpur West	12573	8145
104	120	H1205	Kohalpur North	7300	4008
105	121	F01601	BhuriGaun South	608	87
106	122	F04701	Chinchu East	1372	864

S. N	Station no.	Link no.	Location	Average annual daily traffic (AADT)	AADT excl. MC & rickshaws
107	123	H1208	Chinchu north	1865	1330
108	124	H1301	Surkhet West	6798	2398
109	125	F04801	Surkhet North	1015	291
110	126	F01701	Junga South	2300	817
111	127	H1402	Atteriya South	5527	3063
112	128	H0165	Attariya East	5176	2144
113	129	H0166	Attariya West	4967	2073
114	130	H1403	Attariya North	3710	2354
115	131	H1825	Sanfebagar (Midhill)	638	419
116	132	F14601	Sanfebagar North	367	302
117	133	F05101	Silgadhi Junction	533	316
118	134	H1406	Syaule South	836	656
119	135	H1501	Syaule East	794	552
120	136	H1407	Syaule North	810	522
121	137	F05001	Satbanjh West	375	302
122	138	H1411	Satbanjh North	331	254
123	139	F04901	Khodpe East	568	448
124	140	H1409	Khodpe North	604	452
125	141	H0704	Charali south	1995	897
126	142	F06801	Parwanipur West	2694	1513
127	143	F06201	Harimachod South	2472	853
128	144	F14001	Salyan North (Shitalpati West)	177	86
129	145	F05401	Duhabi West	5464	2358
130	146	F01101	Taulihawa North	2155	472
131	147	F13003	Bhairahawa East	5610	3482
132	148	F06001	Urlabari South	8753	1882
133	149	F05301	Basantpur North	134	107
134	150	F02108	Bidur North	4817	1669
135	151	F04206	Baglung North	483	235
136	152	H1106	Shitalpati North	311	156
137	153	H1304	Khulalu South	81	74

ANNEX II: DRCN With Bridges in Province No. 3

S.no	District	DRCN Code	Road Name	Road length (Km)	Bridge length (m)	VPD
1	Rasuwa	29DR017	Bogatitar-Simle-Bhorle-Parchyang	12.11	52	12
3	Chitwan	35DR011	Bashpur - Mayatar - Terse - Upardangadi – Saktikhor	21.6	100	1
4	Chitwan	35DR016	ChainpurChok (Highway) - Khaireni –Kumroj	5.4	25	33
6	Dolakha	22DR001	Bhorle- Jaintipur- Marbu	16	16	2
7	Dolakha	22DR004	Sunkhani- Sangwa	28.92	15	18
8	Dolakha	22DR006	Namdu- Jugu- Jhyaku- Bhorle	28.23	37	7
9	Dolakha	22DR010	Bhirkot- Gairimudi- Chhaude- Hawa	25	27	4
10	Dolakha	22DR012	Ghyawapani- Sera- Surke - Nigale	15	50	6
11	Dolakha	22DR013	Nayapul- Pawati- Dandakharka	28.12	24	12
12	Dolakha	22DR014	Mude- Melung- Sitali	51	25	16
13	Nuwakot	28DR007	Palastar, 9-Aangutar-Andherikhola-Akkare-Sole Road	8.53	40	26
14	Nuwakot	28DR010	Mandredhunga-Khadgabhanjyang-DangsingKaphalpani Road	25.59	80	36
15	Nuwakot	28DR023	Ranipauwa-Chaturale-Belkot-Tadipul Road	21.04	60	30
16	Nuwakot	28DR035	Chhahare-Shibalaya-Talakhu-Patibhanjyang (Lokmarga)	12.52	80	13
17	Nuwakot	28DR036	Gurje-AaitaramParti-Maidan-Chhap-Talakhu Road	23.04	50	10
18	Ramechhap	21DR001	Devitar-Doramba-Paseban-Koilibagar	50.5	50	14
19	Ramechhap	21DR002	Manthali-Galba-Chauri	65	90	10
20	Ramechhap	21DR003	Khairenighat-Bethan-Galba	30	40	12
21	Ramechhap	21DR005	Puditar-Tharbhanjyang - Alchidhunga-Alampur	14.12	90	0
22	Ramechhap	21DR009	Majhuwa(Dadhuwa) NigalbasTimu	12.74	120	0
23	Ramechhap	21DR010	Sitkha-Goganpani-Dhulebesi	15.2	30	5
24	Ramechhap	21DR011	Bhatauli-Dhulebesi-Mahakalsthan(Gagal)	13	30	6
25	Ramechhap	21DR015	Manthali-Gelu-Pokharidanda	17	30	0
26	Ramechhap	21DR016	Khimti-Betali-Dharapani	34.5	150	0
27	Ramechhap	21DR020	Dilauri-Sabra- Kaileshor-Bamti	16.16	240	0
28	Ramechhap	21DR030	Kukurkatte Bhanjyang GothgaunSirise	14	40	5
29	Sindhuli	20DR003	Hariwan-Kyaneswor- BhitriJamuneBoteni	23.35	150	12
30	Sindhuli	20DR004	Kapilakot-Madhubani-RampurNetrakali-KusheshworDumja	58	50	14
31	Sindhuli	20DR008	Sindhulimadi-BhimasthanChakmake—Bahuntilpung	45.6	100	23
32	Sindhuli	20DR011	Chakmake-Aambote-JinakhuJhankritar	30.75	80	5
33	Sindhupalchok	23DR001	F30-Chanaute-Ichok-Kutumsang	8	30	13
34	Sindhupalchok	23DR003	F30-Timbu-Doring Nakote/Helambu	8.78	25	6
35	Sindhupalchok	23DR004	Dauchet-Keureni-Banskhaka-JatanBaruwa	18.35	30	10
36	Sindhupalch	23DR006	Majhirumta Tar-Lekharka-Gunsa	11	20	10

S.no	District	DRCN Code	Road Name	Road length (Km)	Bridge length (m)	VPD
	ok					
37	Sindhupalchok	23DR015	H03-Balephi-Jalbire-Tembathan	28.7	120	33
38	Sindhupalchok	23DR016	Okhreni-Selang-Golche-Baikunthe	10	125	3
39	Sindhupalchok	23DR043	F31-Chautara-Sipaghat(F30)	11.9	30	23
40	Dhading	30DR001	Siktar-Budhathum-Baseri-Manbu-Lapa Road	19.5	60	5
41	Dhading	30DR004	Hepinge-Khahare-Rigne-SatdobatoChimjog-Ri Road	23.57	24	5
42	Dhading	30DR007	Hulakbhanjyang-Sadhbhanjyang-KhariBhunkotghat-Rampur Road	23.06	18	5
43	Dhading	30DR015	beshi-Bharyangbhurung-TharpuSemjong-Marpak Road	41.09	30	6
44	Dhading	30DR021	Mahadevbeshi-Ratmate-Kamrang-Agra Road	12.7	78	20
45	Lalitpur	25DR013	Lele(Birkhedhara)_Dalchoke_Ikudol_simle_gadi Bhanjayang_Road	24.91	30	31
46	Lalitpur	25DR016	Goganghari_malta_Road	6.1	15	13
47	Lalitpur	25DR021	Tungun_Cooridor_Road	9.01	20	13
48	Kavrepalanchok	24DR015	Katunjebesi-SikharAmbote-Roshikinar-Panauti	7.1	12	11
49	Kavrepalanchok	24DR020	Kavrebhangyang - Dapcha - Pipaltar-SikharAmbote-Sanjhakot-Tara KhaseLekhGokule	24.6	15	28
50	Kavrepalanchok	24DR021	Kamidanda Bhanjyang-Medhamsu-Falamsangu-SikharAmbote- Mahadevtar-Sisakhani (Pota Dhovan)	24.5	15	3
51	Kavrepalanchok	24DR022	Katunje-Sipali-Budakhani-Banakhu	20.9	15	3
52	Kavrepalanchok	24DR025	Tinpiple - Kalchhe- Bela (BP Highway)	9.9	12	13
53	Makwanpur	31DR004	Manahari – Rupachuri – Siladhuni –Silinge (Kankada) Road	10.88	50	0
54	Makwanpur	31DR005	Gairigaon –Pakani - Dadakharka –Bharta – Chainpur- Manahari Road	19.78	60	7
55	Makwanpur	31DR006	Simpani - Sarikhet Road	12.01	50	2
56	Makwanpur	31DR007	Chuniya – Namtar –Kalikatar-BhartaKhairang Road	28.5	155	5
57	Makwanpur	31DR008	Pashupatinagar – Padampokhari –Handikhola – Rajaiya	24.27	120	39
58	Makwanpur	31DR010	Bhimphedi – Kogate – IpaDeuraliSisneri Road	24.36	100	6
59	Makwanpur	31DR011	Pandrang – Ichung - Budhichaur Road	8.08	70	0
60	Makwanpur	31DR012	Samaripul – Dumrekuna – Sukaura Road (SahidBasudev Marg)	17.56	100	31

ANNEX III: All Weather Road Length in Province No. 3

(2012/13,13/14,14/15,15/16)

SN	District	Bridge name	All weather roads in km
1	Makawanpur	Deujar Khola Bridge	22
2	Makawanpur	Karra Khola Bridge	11
3	Makawanpur	Rapti River Bridge	8
4	Dhading	Kahare Khola Bridge	25
5	Kavre	Basdol Khola Bridge	15
6	Kavre	Ladaku Bridge	3
7	Rasuwa	Dhobi Khola Bridge	10
8	Kathmandu	Bishnumati Bridge	5
9	Kathmandu	Dhobi Khola Nilopul	8
10	Bhaktapur	Godwari Bridge	10
11	Nuwakot	Belkot Khola Bridge	10
12	Lalitpur	Khani Khola Bridge	12
13	Sindhupalchowk	Sindhu Khola Bridge	16
14	Ramechhap	Thado Khola Bridge	5
15	Chitwan	Kerunga Khola Bridge	24
16	Ramechhap	Khaire Khola Bridge.	6.75
17	Ramechhap	Bhatauli Khola Bridge.	29.5
18	Ramechhap	Chhahare Khola Bridge	8
19	Ramechhap	Burkhe Khola Bridge	11
20	Ramechhap	Sindhurpa Khola Bridge	3
21	Ramechhap	Lorkhu Khola Bridge	25
22	Ramechhap	Khani Khola Bridge.	9.25
23	Ramechhap	Darkha Khola Bridge	7
24	Ramechhap	Pharfu Khola Bridge	30
25	Chitwan	Gaidhap Khola Bridge	8
26	Chitwan	Budhi Rapti Bridge	10
27	Chitwan	Purbari Bridge at Dhungre Khola	10
28	Chitwan	Ladra Bridge at Ladari	6
29	Sindhuli	Chadaha-2 Khola Bridge	5
30	Kavre	Basdol Khola Bridge	15
31	Kavre	Ladaku Bridge	3
32	Rasuwa	Dhobi Khola Bridge	10
33	Kathmandu	Bishnumati Bridge	5
34	Kathmandu	Dhobi Khola Nilopul	8

SN	District	Bridge name	All weather roads in km
35	Bhaktapur	Godwari Bridge	10
36	Nuwakot	Belkot Khola Bridge	10
37	Ramechhap	Khani Khola Bridge.	9.25
38	Ramechhap	Khaire Khola Bridge.	6.75
39	Ramechhap	Bhatauli Khola Bridge.	29.5
40	Ramechhap	Chhahare Khola Bridge	8
41	Ramechhap	Burkhe Khola Bridge	11
42	Ramechhap	Sindhurpa Khola Bridge	3
43	Ramechhap	Lorkhu Khola Bridge	25
44	Chitwan	Gaidhap Khola	8
45	Chitwan	Budhi Rapti Bridge	10
46	Dhading	Kahare Khola Bridge	25
47	Kavre	Basdol Khola Bridge	15
48	Rasuwa	Dhobi Khola Bridge	10
49	Kathmandu	Bishnumati Bridge	5
50	Nuwakot	Belkot Khola Bridge	10
51	Chitwan	Kerunga Khola Bridge	24

ANNEX IV: Per Meter Cost of Bridge

S. N	Name of bridge	District	Type	Estimate Cost ('000)	Length	Per metre cost
1	Sunkoshi River Bridge (Khahareghat)	Kavre	Steel Plate girder with pile foundation	100685	101.87	988.37
2	Manahara Khola Bridge (Nare fat to Imadol connection Bridge)	Kathmandu		58539	35.60	1644.35
3	Dhade (Baramchi) Khola Bridge	Sindhupalchowk	RCC T beam with open foundation	42000	25.60	1640.63
4	Khani Khola Bridge (Kallon)	Lalitpur		30990	25.60	1210.55
5	Bagmati Khola Bridge (Khakana-Sokhal)	Lalitpur	Prestress bridge with pile foundation	106828	61.70	1731.41
6	Sapantirtha Khola	Kathmandu		48945	40.60	1205.54
7	Bagmati Khola Bridge (SikreDovan)	Makwanpur		131589	116.95	1125.17
8	Karra Khola Bridge (Hetauda)	Makwanpur		52699	43.90	1200.43
9	Punyamati Khola Bridge	Kavre	Box bridge with open/raft foundation	11167	6.90	1618.41
10	Ganggate Khola (Dhapakhel) Bridge	Lalitpur		12234	7.10	1723.10
11	Karmanasha Khola Bridge (Nayabasti)	Lalitpur		20125	9.20	2187.50
12	Hanumante Khola Bridge (Madhyapur Thimi- Ananteshwor)	Bhaktapur		24756	20.60	1201.75
13	PokharekiKukreni Khola Box Culvert	Makwanpur		59854	96.75	618.65
				Average		**1391.99**

ANNEX V: Per Capita Investment

S. N	District	Name of bridge	Length	Cost (Length * per m cost) ('000) *A*	Mun/R. Mun	Population *B*	Per capita investment *[(A/B) *1000]*
1	Sindhuli	Chadaha Khola Bridge - 1(Belghari)	110.1	154140	Tinpatan	36420	4232.29
2	Sindhuli	Chadaha Khola Bridge-2 (Sakhamadi, Nakkaley)	72.6	101640	Tinpatan	36420	2790.77
3	Sindhuli	Waksu Khola Bridge	30.6	42840	Tinpatan	36420	1176.28
4	Ramechap	Bhatauli khola bridge (Bhatauli)	40.6	56840	Khadadevi	25786	2204.30
5	Ramechap	Bhatauli khola bridge-II (Thulo Khet)	40.6	56840	Khadadevi	25786	2204.30
6	Ramechap	Burke khola bridge	23.26	32564	Gokulganga	20074	1622.20
7	Ramechap	Chhaharekhola bridge	23.26	32564	Gokulganga	20074	1622.20
8	Ramechap	Darkhakhola bridge	28.19	39466	Gokulganga	20074	1966.03
9	Ramechap	Gumdel Khola Bridge	14.6	20440	Umakunda	17647	1158.27
10	Ramechap	Khaire Khola Bridge (Rajmantar)	13.6	19040	Doramba	22773	836.08
11	Ramechap	Khani khola bridge (Rajmanntar)	30.6	42840	Sunapati	18148	2360.59
12	Ramechap	Lorkhu Khola Bridge	16.6	23240	Likhu	23135	1004.54
13	Ramechap	Pharpu Khola Bridge	30.6	42840	Gokulganga	20074	2134.10
14	Ramechap	Sindurpakhola bridge	37.44	52416	Gokulganga	20074	2611.14
15	Ramechap	Thado Khola Bridge	18	25200	Umakunda	17647	1428.00
16	Dolakha	Andheri khola bridge	16.6	23240	Melung	20287	1145.56
17	Dolakha	Charnabatikhola bridge (Shera)	16.6	23240	Bhimeshwor	33324	697.40
18	Dolakha	Sorung Khola Bridge	35.6	49840	Bigu	18592	2680.72
19	Sindhupalchowk	Sipa Khola Bridge (RTIsWAP)	18.6	26040	Indrawati	28544	912.28
20	Sindhupalchowk	Dhade (Baramchi) Khola Bridge	25.6	35840	Balefi	19084	1878.01
21	Sindhupalchowk	Gohore Khola RCC Bridge	24.6	34440	Helambu	17964	1917.17
22	Sindhupalchowk	Hadi Khola Truss Bridge	71.6	100240	PanchpokhariThangpal	20986	4776.52
23	Sindhupalchowk	Jhyadi Khola Bridge	25.6	35840	Indrawati	28544	1255.61
24	Sindhupalchowk	Khahare Khola Bridge	24.6	34440	Barhabise	26960	1277.45
25	Sindhupalch	Mahadev Khola Steel Truss	30.6	42840	Panchpokh	20986	2041.36

S. N	District	Name of bridge	Length	Cost (Length * per m cost) ('000) *A*	Mun/R. Mun	Population *B*	Per capita investment *[(A/B) *1000]*
	owk	Bridge			ariThangpal		
26	Sindhupalchowk	Paakhar Khola Bridge	40.6	56840	Sunkoshi	17311	3283.46
27	Sindhupalchowk	Sindhu Khola Bridge	22.6	31640	Melamchi	45473	695.80
28	Kavre	Baasdol Khola Bridge	6.1	8540	Banepa	57722	147.95
29	Kavre	Cha Khola Motorable bridge	22.6	31640	Mandandeupur	32768	965.58
30	Kavre	Chauri Khola Bridge-1	50	70000	Sunapati	18148	3857.17
31	Kavre	Ladku Khola Bridge	20.6	28840	Panauti	47549	606.53
32	Kavre	Patne Khola Bridge	18.3	25620	Bethanchowk	15622	1639.99
33	Kavre	Punyamati Khola Bridge	6.9	9660	Banepa	57722	167.35
34	Kavre	Roshi Khola Bridge (Tribenighat)-Roshi and Punyamata	25	35000	Panauti	47549	736.08
35	Kavre	Roshi Khola Bridge (Dhand) Bridge	30	42000	Panauti	47549	883.30
36	Kavre	Roshi Khola Bridge (phalamesanghu)	40.6	56840	Namobuddha	29926	1899.35
37	Kavre	Sunkoshi River Bridge (Khahareghat)	101.87	142618	Chaurideurali	21130	6749.55
38	Lalitpur	Bagmati Khola Bridge (Khakana-Sokhal)	61.7	86380	Lalitpur	292848	294.97
39	Lalitpur	Ganggate Khola (Dhapakhel) Bridge	7.1	9940	Godawari	80376	123.67
40	Lalitpur	Karmanasha Khola Bridge (Nayabasti)	9.2	12880	Mahalaxmi	62624	205.67
41	Lalitpur	Khani Khola Bridge (Dalchoki-Ikudol)	25.6	35840	Bagmati	13049	2746.57
42	Lalitpur	Khani Khola Bridge (Kallon)	25.6	35840	Bagmati	13049	2746.57
43	Lalitpur	Khani Khola Bridge (Puytar)	35.6	49840	Bagmati	13049	3819.45
44	Lalitpur	Kodkhu Khola Bridge (Kharibot)	15.8	22120	Mahalaxmi	62624	353.22
45	Lalitpur	Kodku Khola Bridge (Thaiba)	16.6	23240	Godawari	80376	289.14
46	Lalitpur	Thosne Khola Bridge (Bhattedanda)	20.6	28840	Konjyosom	9709	2970.44
47	Lalitpur	Thosne Khola Bridge (Old)	35	49000	Konjyosom	9709	5046.86
48	Lalitpur	Tilpu Khola Bridge (Lubhu)	10.6	14840	Mahalaxmi	62624	236.97
49	Bhaktapur	Godavari Khola (Tikathali)	12	16800	Mahalaxmi	62624	268.27
50	Bhaktapur	Gosha Khola Bridge (Sudal)	10.6	14840	Bhaktapur	83658	177.39
51	Bhaktapur	Hanumante Khola Bridge (Madhyapur Thimi-	20.6	28840	Suryabinayak	78845	365.78

S. N	District	Name of bridge	Length	Cost (Length * per m cost) ('000) *A*	Mun/R. Mun	Population *B*	Per capita investment *[(A/B) *1000]*
		Ananteshwor)					
52	Bhaktapur	Mahadev Khola Bridge (Budhi Gandaki)	9.1	12740	Suryabinayak	78845	161.58
53	Kathmandu	Balkhu Khola Bridge (Naikap- Kritipur)	25.6	35840	Chandragiri	87553	409.35
54	Kathmandu	Bishnumati River Bridge(Manamaiju)	20	28000	Tokha	100780	277.83
55	Kathmandu	Dhobi Khola Bridge(Nilopul)	14.1	19740	Budhanilakantha	112281	175.81
56	Kathmandu	Manahara Khola Bridge (Nare fat to Imadol connection Bridge)	35.6	49840	Mahalaxmi	62624	795.86
57	Kathmandu	Nikhileshwor Bridge	10.6	14840	Budhanilakantha	112281	132.17
58	Kathmandu	SaliNadi Bridge (Sankharpur Np.)	10.6	14840	Shankharapur	25558	580.64
59	Kathmandu	Sapantirtha Khola	40.6	56840	Tokha	100780	564.00
60	Nuwakot	Belkot Khola Bridge (Piplebesi)	25.6	35840	Belkotgadhi	40706	880.46
61	Nuwakot	Khahare Khola Bridge	20.6	28840	Likhu	16966	1699.87
62	Nuwakot	Khare Khola Bridge	25.6	35840	Suryagadhi	16800	2133.33
63	Nuwakot	Kolphu Khola Bridge(Chauthe-1, Dhulepul)	40.6	56840	Dhunibesi	31029	1831.83
64	Nuwakot	Kuthum Khola Bridge	25.6	35840	Dupcheshwar	22106	1621.28
65	Rasuwa	Dhobi Khola Bridge	18	25200	Kalika	9502	2652.07
66	Rasuwa	Sano Khola/Sano Bridge	16.6	23240	Suryagadhi	16800	1383.33
67	Dhading	Aashi Khola Bridge	16.6	23240	Nilakantha	58876	394.73
68	Dhading	Dhare Khola Bridge	14.6	20440	Thakre	32979	619.79
69	Dhading	Dundure Khola Bridge	50.6	70840	Khaniyabash	12749	5556.51
70	Dhading	Khahare Khola Bridge	18.6	26040	Tripura Sundari	22992	1132.57
71	Dhading	Kolphu Khola Bridge (Aanpghari)	25.6	35840	Dhunibesi	31029	1155.05
72	Dhading	Mahesh Khola Bridge	18.6	26040	Dhunibesi	31029	839.21
73	Dhading	Naubise Khola Bridge(Dharke)	20.6	28840	Dhunibesi	31029	929.45
74	Dhading	Palankhu Khola Bridge	18.6	26040	Nilakantha	58876	442.29
75	Dhading	Thopal Khola (Chhapepul)	40.6	56840	Nilakantha	58876	965.42
76	Dhading	Thopal Khola Bridge (Sunaulabazar)	35.6	49840	Nilakantha	58876	846.52
77	Makwanpur	AapKholsi Bridge (Raksiring)	18	25200	Raksirang	26192	962.13

S. N	District	Name of bridge	Length	Cost (Length * per m cost) ('000) *A*	Mun/R. Mun	Population *B*	Per capita investment *[(A/B) *1000]*
78	Makwanpur	Bagmati Khola Bridge (SikreDovan)	116.95	163730	Khanikhola	14398	11371.72
79	Makwanpur	Deujar Khola Bridge (kanteen-Raigaun-Panchpandab road)	16	22400	Bagmati	30587	732.34
80	Makwanpur	Hile Khola Bridge (Shikharpur)	26.3	36820	Bakaiya	39642	928.81
81	Makwanpur	Karra Khola Bridge (Hetauda)	43.9	61460	Hetauda	154660	397.39
82	Makwanpur	Manahari Khola Bridge (chuniya-namtar-bharta-khairang road)	41.95	58730	Kailash	23922	2455.06
83	Makwanpur	PokharekiKukreni Khola Box Culvert	96.75	135450	Hetauda	154660	875.79
84	Makwanpur	Rapti Khola Bridge (Pandrang- Lchung-Budichour Road)	49.95	69930	Manahari	39122	1787.49
85	Makwanpur	Samari Khola Bridge 1 (Kalikhola)	127.88	179032	Makawanpurgadhi	25379	7054.34
86	Chitwan	Bandar Mude Khola Bridge	25.6	35840	Madi	37764	949.05
87	Chitwan	Budi Rapti Khola Bridge	45.2	63280	Khairahani	56925	1111.64
88	Chitwan	Dhungre Khola Bridge (Gaindadhap)	41.2	57680	Rapti	59937	962.34
89	Chitwan	Dhungre Khola Bridge (Purbari)	41.2	57680	Rapti	59937	962.34
90	Chitwan	Karunaga Khola Bridge (Bharatpur- Kalika) Pathaini	43	60200	Bharatpur	285167	211.10
91	Chitwan	Kerunga Khola Bridge (Jagatpur)	66	92400	Bharatpur	285167	324.02
92	Chitwan	Kerunga Khola Bridge (Lamsal Chowk)Jagatpur II	43	60200	Bharatpur	285167	211.10
93	Chitwan	Khahare Khola Bridge	11.2	15680	Rapti	59937	261.61
94	Chitwan	Ladra Khola Bridge	45.2	63280	Khairahani	56925	1111.64
95	Chitwan	Rampur Jharana (Juwa Khola dovan) Bridge	16.2	22680	Rapti	59937	378.40
96	Chitwan	Rani Khola Bridge	32.4	45360	Bharatpur	285167	159.06
97	Chitwan	Shakti Khola Bridge	61.9	86660	Kalika	44898	1930.15

ANNEX VI: Road List with Routine Maintenance in Province 3

SN	District	Road Code	Road Name	Total Length (Km)	Routine Length (Km)
1	Dhading	30DR004	Hepinge-Khahara-Rigne-Satdobato-Chimchok-Ri Road	16.00	10.00
2		30DR006	Palpabhanjyang-Hulakbhanjyang-Chainpur-Rampur-Bangeraha	20.66	20.00
3		30DR007	Hulakbhanjyang-Sadhbhanjyang-Khari-Bhunkotghat-Rampur Road	16.00	16.00
4		30DR008	Sadhbhangyang-Dhola-Dudebhangyang-Samibhangyang-Satdobato-Thulichaur-Road	14.50	14.00
5		30DR010	Kalidaha-Archale-Pipalnalang-Thnatibhangyang-Khirre-Itpani-Kamalbari-Maidan-Road	16.56	16.00
6		30DR011	Majhimtar-Bharpang-Aibung-Gothibhangyang-Dumbang Road	6.02	8.00
7		30DR020	Simle-Lakmaldung-Bhumiechuli-Brumdi-Kandrang-Gadhi-Road	15.00	14.00
8		30DR022	Bhimdhunga-Lamidada-Galchhi-Road	40.44	20.00
10	Makwanpur	31DR001	Pulkomukh– Indrayanichaur - Phatbazar - Fedigaon – Chisapani- Chalti (Agrakhola Road)	25.00	25.00
11		31DR003	Daman-Dandabas-Baikuntha-Khairang-Kankada	31.79	9.33
12		31DR005	Gairigaon -Pakani - Dadakharka - Bharta - Chainpur- Manahari Road	20.00	20.00
13		31DR007	Chuniya- Namtar-Kalikatar-Bharta-Khairang	31.41	12.25
14		31DR009	Kulekhani-Phakhel-Humanebhanjyang road	15.60	15.60
15		31DR011	Pandrang - Ichung - Budhichaur Road	8.08	8.08
16		31DR015	Hattisude - Shikarpur - Phaparbari Road	22.76	22.76
17		31DR017	Phaparbari -Raigaon -Canteen Road	31.25	27.25
18		31DR016	Pangdure-Tinbhangale-Raigaon Road	20.00	12.00
20	Nuwakot	28DR003	Trishuli-Deurali-Meghang-Kimtang-Thambukhola	34.36	34.36
21		28DR017	Nuwakot-Bageshwori-Urleni	24.00	24.00
22		28DR026	Patle-Duipipal-Kolputar	43.00	15.00
23		28DR023	Ranipauwa-Chaturale-Belkot-Tadipul	24.00	24.00
24		28DR020	Ganesthan-Narjamandap-Dadakopato	9.49	9.49
25		28DR029	Satbise-Bagmara-Deurali-Malabhanjyang	13.00	10.00
26		VRCN	Labdhu-Halde	6.00	6.00
28	Rasuwa	29DR003	Bahundada-Goljung-Thambuchet Road	6.00	6.00

SN	District	Road Code	Road Name	Total Length (Km)	Routine Length (Km)
29		29DR004	Syafru-Gatlang-Somdang Road	37.50	22.00
30		29DR005	Satdobato-Haku-Gre-Gatlang Road	10.00	10.00
31		29DR007	Sole-Bhimali-Hakubesi Road	6.00	6.00
32		29DR008	Kalikasthan-Dhunge-Karmidada-Banuwa Road	10.00	10.00
33		29DR012	Syaubari-Lokil-Doklang-Yarsa Road	22.00	22.00
34		29DR013	Kalikasthan-Jipjive-Sarsyuu Road	6.00	
35		29DR014	Jipjive-Rupsepani-Bhadaure-Dharapani Road	8.80	8.80
36		29DR015	Dasmure-Seti Devi-Dhuseni-Tallorupsepani Road	4.80	4.80
37		29DR016	Koldada-Aapchour-Bhadaure-Chiti-Khalchet Road	7.20	7.20
38		29DR017	Bogatitar-Simle-Bhorle-Parchyang Road	6.00	6.00
39		29DR018	Lachyang-Saramthali-Partikharka Road	8.80	8.80
40		29DR019	Lachyang-Nirkubhanjyang-Yarsa Road	8.00	8.00
41		29VR017	Jyanglang-Aldanda-Lokil Road	7.50	7.50
42		29VR008	Pairibesi-Kuwapani-Bhalayadada-Manigaun	6.00	6.00
43		29VR011	Simle-Salimebhitta-Pairigaun-Thulogaun	6.00	6.00
44		29DR010	Lingling-Pelko-Briddhim-Khamjing	6.00	6.00
45		29VR018	Dharmaxxa-Wangdel-Briddhim	6.00	6.00
47	Sindhupalchock	23DR002	F30-Kiul-Bagar-Nigale-Sermathang	8.76	8.76
48		23DR004	Dauchet-Keureni-Banskharka-Jatan-Baruwa	18.35	18.35
49		23DR006	Majhirumtitar-Lekhkharka-Gunsa-Raithane	11.00	11.00
50		23DR007	Tipeni-Bhotenamlang-Gunsakot	6.00	6.00
51		23DR008	Khaldekhola-Lagarche-Okhreni	5.90	5.90
52		23DR013	Naubise Chautara Melamchi	43.00	43.00
53		23DR016/17	Okhreni-Toribari-Selang-Mandanda	11.85	11.85
54		23DR034	Sunkoshi-Dhuskun-Piskar-Tauthali-Kharidhunga-F32	14.75	14.75
55		23DR036	Pyukharka-Thuldhading-Dasedhovan	10.13	10.13
56		23DR040	F31-Melchaur-Bhaise-H03	12.00	12.00
57		23DR003	Timbu-Doring-Nakote	8.78	8.78
58		23DR001	Chanaute-Ichowk-Kutumsang	8.00	8.00

ANNEX VII: AHP Questionnaire Format Used Sample for Federal Level

Personal Details:

Name: Date:

Organization:

Position:

Following criteria along with sub-criteria's were finalized for prioritizing new motorable bridge for its implementation on federal level based on literature review, study of policy documents and consultation with related experts for purpose of Thesis work "Developing priority tool (Priority Matrix) for identifying bridges in federal Nepal using multi-criteria analysis" in Master of TransportationEngineering.

Each criterion identified need to be provided weights for which analytic hierarchy process will be used. Pairwise comparisons are need to be made for each pair of criteria's for deriving weights for each criteria's in AHP process and for the same I would like to request for your input and would like to thank you in advance for your support.

Brief description of each criteria's along with sub criteria were made before proceeding to filling up comparison form.

Er. Suraj HariAdhikari

1.Strategic importance of road/ Government priority policy

Sub-criteria	Score	Remarks
1.Bridges in national Highways/in links connecting east west highways to state capital's & federal capital/north south highways connecting international borders	10.0	As per "Standards for classification& allocation of development program and projects falling under jurisdiction of federation, state and local levels, 2076.(संघ, प्रदेश, रस्थानीयतहकोकार्यजिम्बेवारिमापर्नेबिकासकार्यक्रमतथायोजनाकोबर्गिकरणरबाडफाडसम्बन्धिमापदण्ड, २०७६" published by office of prime minister & council of minister: For physical infrastructure and transport sector, under the responsibility of federation comes: 1. included in schedule 5 of constitution of nepal 2. short & rapid link connecting east west highways to state capital's & federal capital. 3. north-south highways connecting international borders. 4. commercial links connecting federal/state capital from east-west highway to north south highways. 5. links connecting federal/state capital & Pushpalal highway. 6. Links connecting national highway to projects of national pride. 7. bridges in national highway. 8. tunnel roads 9. roads which are handed over to federation upon state request. 10. link connecting national road network to district headquarters.
2. Bridges in link connecting federal/state capital to Pushpalal highway & Links connecting national highway to projects of national pride/link connection national road network to district headquarters.	7.5	
3.commercial links connecting federal/state capital from east-west highway to north south highways.	5.0	
4. Bridges on roads handed over on state request	2.5	
5. Bridges on other roads	0	

2.Present Traffic Volume (AADT)

Sub-criteria	Score	Remarks
1. less than 150	0	AADT data referred of 160 traffic count stations from road diary DOR 2075/76 excluding stations inside Kathmandu valley. Average of max 5 AADT values is assigned score 4 and average of min. 5 AADT values is assigned score 0. The same is plotted on a chart to generate values for score 1,2 &3 Merit over previous: ➢ AADT data from DOR traffic count station can be made available for prioritization purpose. ➢ Priority tool itself can be updated based on maximum &
2. 150-4500	2.5	
3. 4500-9000	5.0	
4. 9000-12500	7.5	
5. more than 12500	10.0	

Sub-criteria	Score	Remarks
		minimum AADT in fixed time interval for suiting the then current scenario.

3.Readiness of project

Sub-criteria	Score	Remarks
Detailed survey/design/IEE on-going or completed.	10	Bridge projects are evaluated on eight criteria among which one criterion was "Local request, support and readiness" *Cambria County Long Range Transportation Plan*, 2015 2040". *Report "Preparatory Survey for Public-Private Partnership (PPP) Infrastructure Development Projects in the Republic of the Philippines" has outlined project readiness as evaluation item, current status of project as evaluation indicator & evaluation details were detail design* On-going/Completed = score 8.0, feasibility study Completed/On-going/Committed = 7.0Pre-feasibility study Completed/On-going/Committed = 5.0 and Conceptual Stage = 2.0 for project prioritization. "आर्थिकबर्ष२०७६/७७कोबजेटतथाबार्षिकबिकासकार्यक्रमरत्रिबर्शीयमध्यमकालिनखर्चसंरचनातर्जुमासम्बन्धिमार्गदर्शन २०७५" published by NPC has identified "Projects previous work progress, time of completion, readiness for further work" as one of the basic criteria among 6 criteria's and provided weights 20% for nationwide project prioritization purpose.
Detailed Feasibility Study completed / ongoing committed.	7.5	
Prefeasibility Study ongoing/committted	5	
Conceptual stage	0	

Please make pairwise comparisons of each of the following criteria. Preference (between criteria A & criteria B) & score (1 to 9) provided will be used to derive weights for each of the criteria using analytic hierarchy process.

Comparison form

S.no.	Criteria		More important (A or B)	Score (1 to 9)
	A	B		
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)		
२.	Strategic importance of road/ Government priority policy	Readiness of project		
३.	Present Traffic Volume (AADT)	Readiness of project		

Direction to fill comparison form.

Please fill either A or B as per your judgement in "more important (A or B)" column and score 1 to 9 as per your judgement in " Score (1 to 9) " column with help of table below.

Intensity	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience & Judgement slightly favor one criterion over another.
5	Strong importance	Experience & Judgement strongly favor one criterion over another.
7	Very strong importance	One criterion is favored very strongly over another. Its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one criterion over another is of the highest possible order of affirmation.
2,4,6,8 can be used to express intermediate values		

ANNEX VIII: AHP Questionnaire Format Used Sample for Province Level

Personal Details:

Name: Date:

Organization:

Position:

Following criteria along with sub-criteria's were finalized for prioritizing new motorable bridge for its implementation on province level based on literature review, study of policy documents and consultation with related experts for purpose of Thesis work "Developing priority tool (Priority Matrix) for identifying bridges in federal Nepal using multi-criteria analysis" in Master of TransportationEngineering.

Each criterion identified need to be provided weights for which analytic hierarchy process will be used. Pairwise comparisons are need to be made for each pair of criteria's for deriving weights for each criteria's in AHP process and for the same I would like to sincerely request for your input and would like to thank you in advance for your support.

Er. Suraj Hari Adhikari

1.Strategic importance of road/ Government priority policy

Sub-criteria	Score	Remarks
1.Road link connecting National Highway/Feeder road/State highway to local level HQ.	4	(संघ, प्रदेश, स्थानीयतहकोकार्यजिम्बेवारिमापर्नेबिकासकार्यक्रमतथायोजनाकोबर्गिकरणरबाडफाडसम्बन्धिमापदण्ड, २०७६" published by office of prime minister & council of minister: For physical infrastructure and transport sector, under the responsibility of province comes: 1. as per schedule 6 of constitution 2. projects previously handled by DOLIDAR 3. major links connecting state capital with main administrative
2. Road link connecting district HQ & local level HQ	3	
3.Road link connecting two or more than 2 local level HQ	2	

4. Road excluded from above 3 sub-criteria & implemented by DOLIDAR previously.	1	centre of local levels. 4. links connecting two or more than 2 local level headquarters. 5. Bridges on state highways 6. trail bridge
5.Other roads	0	

2.Per capita Investment

Sub-criteria	Score	Remarks
1.Per capita Investment less than Rs 50.	4	The underlying concept for this criterion is 'Government should give more priority to short bridges serving higher population rather than long bridges serving smaller population.' Standard cost of 14 lakh per meter of bridge is assumed based on different type of bridge being constructed by LRBP in province no. 3 (13 nos) .Total estimate cost is divided by total length of the bridge to get the average per metre cost. Bridge carriageway width less than 6m are not considered for analysis. Maximum & minimum population of local level in province 3: KathmanduMahanagarpalika: 1003285 (Maximum),Rasuwa ParbatikundaGaunpalika: 5533 (Minimum). Longest & shortest bridges taken for analysis:Bagmati Khola Bridge (SikreDovan),prestress bridge with pile 2 span*55=110mShortest: 25 m (many). So, cost/person minimum: (min bridge length serving max population) 25*1400000/1003285=35 Rs/person Also, cost/person maximum (max bridge length serving min population) =110*1400000/5533=27833 Rs/person.
2. Per capita Investment between Rs 50 to Rs 7000.	3	
3. Per capita Investment between Rs 7000 to Rs 14000.	2	
4.Per capita Investment between Rs 14000 to Rs 21000.	1	
5.Per capita Investment more than Rs 21000.	0	

3.Present Traffic Volume (VPD)

Sub-criteria	Score	Remarks
1. None	0	VPD in 59 road links (with bridge structure in it) identified in DTMP report of 13 districts in province 3 are taken for analysis. For analysis purpose, maximum (39) & minimum VPD (0) are taken and assigned score 0 & 4. Max VPD =39 (DRCN 31DR008), Minimum VPD =0 (many). Assuming linear relation of value functions, range for score1,2 & 3 are set.
2. 1-10	1	
3. 11-20	2	
4.21-30	3	
5. more than 30	4	

4.All weathered road length

Sub-criteria	Score	Remarks
1. less than 3 km	0	All weathered road section made by means of 54 bridge constructed in

2. 3-10 Km	1	province no. 3 by DOLIDAR/LRBP is considered for analysis.
3. 10--17 Km	2	Maximum length all weathered :30 Km (Pharfu Khola Bridge,
4. 17-24 Km	3	Ramechhap) (Score 4)
5. More than 24 Km	4	Minimum Length all weathered: 3 Km (Chadaha-1 Box Culvert, Sindhuli) (Score 0) Assuming linear relation of value functions, range for score1,2 & 3 are set.

5. Access to socio-economic activities:

Sub-criteria	Score	Remarks
1. Access to significant tourism/cultural/hydropower sites or access to at least 3 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	4	The contribution to economy society can be a vast subject and complete analysis is beyond the scope of the study. However, an attempt to address this to some extent is done. For that, the presence of any economic, commercial, social activities (agro, manufacturing industry, health centres, education centres etc.) in road link/section which is becoming all weathered by means of bridge constructed is considered. Report "Preparatory Survey for Public-Private Partnership (PPP) Infrastructure Development Projects in the Republic of the Philippines" has outlined project Contribution to National/Regional Economic Development as an evaluation item and Major Existing and Potential industries along the corridor as an indicator with sub criteria's; Agro-fishery Industry = 1.0, Manufacturing Industry = 1.0, Business/Commercial Industry = 1.0, Tourism Industry = 1.0,(Two or more industries = add weights, Max = 2.0points)
2. Access to 2 cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres.	3	
3. Access to single cottage industry (agriculture, livestock, manufacturing related)/ health centres/education centre.	2	
५ .No kind of cottage industries (agriculture, livestock, manufacturing related)/ health centres/education centres in all weathered road section.	0	

Please make pairwise comparisons of each of the following criteria. Preference & score provided will be used to derive weights for each of the criteria using analytic hierarchy process.

Comparison Form

S.no.	Criteria		More important (A or B)	Score (1 to 9)
	A	B		
1.	Strategic importance of road/ Government priority policy	Cost per person	.....	.....
२.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	.....	.....
3.	Strategic importance of road/ Government priority policy	All weathered road length	.....	.....
4 .	Strategic importance of road/ Government priority policy	Contribution to economy/society	.....	.....
5.	Cost per person	Present Traffic Volume (VPD)	.....	.....
6.	Cost per person	All weathered road length	.....	.....
7.	Cost per person	Contribution to economy/society	.....	.....
8.	Present Traffic Volume (VPD)	All weathered road length	.....	.....
9.	Present Traffic Volume (VPD)	Contribution to economy/society	.....	.....
10.	All weathered road length	Contribution to economy/society	.....	.....

Direction to fill comparison form.

Please fill either A or B as per your judgement in "more important (A or B)" column and score 1 to 9 as per your judgement in " Score (1 to 9) " column with help of table below.

Intensity	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience & Judgement slightly favor one criterion over another.
5	Strong importance	Experience & Judgement strongly favor one criterion over another.
7	Very strong importance	One criterion is favored very strongly over another. Its dominance is demonstrated in

		practice.
9	Extreme importance	The evidence favoring one criterion over another is of the highest possible order of affirmation.
2,4,6,8 can be used to express intermediate values		

ANNEX IX: AHP Questionnaire Format Used Sample for Local Level

Personal Details:

Name: Date:

Organization:

Position:

Following criteria along with sub-criteria's were finalized for prioritizing new motorable bridge for its implementation on local level based on literature review, study of policy documents and consultation with related experts for purpose of Thesis work "Developing priority tool (Priority Matrix) for identifying bridges in federal Nepal using multi-criteria analysis" in Master of Transportation Engineering.

Each criterion identified need to be provided weights for which analytic hierarchy process will be used. Pairwise comparisons are need to be made for each pair of criteria's for deriving weights for each criteria's in AHP process and for the same I would like to request for your input and would like to thank you in advance for your support.

Brief description of each criteria's along with sub criteria were made before proceeding to filling up comparison form.

Er. Suraj Hari Adhikari

1.Strategic importance of road/ Government priority policy

Sub-criteria	Score	Remarks
1. Road Link connecting local level HQ/major settlements with National Highway/Feeder road/State highway.	4	(संघ, प्रदेश, रस्थानीयतहकोकार्यजिम्बेवारिमापर्नेबिकासकार्यक्रमतथायोजनाकोबर्गिकरणरबाडफा डसम्बन्धिमापदण्ड, २०७६" published by office of prime minister & council of minister: For physical infrastructure and transport sector, under the responsibility of local level comes:
2. Road link connecting local level HQ and major settlements/cultural/economic/tourism destinations.	3	

Sub-criteria	Score	Remarks
3.Road link connecting two or more major settlements.	2	as per schedule 8 local roads, rural roads & agro roads.
5.Other roads	0	rural roads & community infrastructure development.

2.Present Traffic Volume (VPD)

Sub-criteria	Score	Remarks
1. None	0	VPD in 59 road links (with bridge structure in it) identified in DTMP report of 13 districts in province 3 are taken for analysis. For analysis purpose, maximum (39) & minimum VPD (0) are taken and assigned score 0 & 4. Max VPD =39 (DRCN 31DR008), Minimum VPD =0 (many). Assuming linear relation of value functions, range for score1,2 & 3 are set.
2. 1-10	1	
3. 11-20	2	
4.21-30	3	
5. more than 30	4	

3. All weathered Road length operable by concerned local level.

Sub-criteria	Score	Remarks
All of the length	4	The underlying concept is "Bridges on roads where longer length of all weathered road sections is manageable by local level for vehicular movement throughout the year should be preferred." This criterion is previously used by LRBP Bridge Screening and prioritization criteria for local level screening at DDC/DTO level.
Most of the length	3	
about half	2	
less than half	1	
only some	0	

4. Road Closure Duration due to absence of bridge:

Sub-criteria	Score	Remarks
more than 3 months in a year	4	The underlying concept is "This criterion address the public concerns in a grass hood level regarding the behest of public to stay isolated and difficult access & mobility." This criterion is currently being used in DOR and seems to be more reasonable for local level screening of bridge projects.
2 to 3 months in a year	3	
1 to 2 months in a year	2	
10 days to 1 months in a year	0	

Please make pairwise comparisons of each of the following criteria. Preference (between A or B) & score (1 to 9) provided will be used to derive weights for each of the criteria using analytic hierarchy process.

Comparison Form

S. N.	Criteria		More important (A or B)	Score (1 to 9)
	A	B		
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	.....	.....
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	.....	.....
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	.....	.....
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	.....	.....
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	.....	.....
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	.....	……

Direction to fill comparison form.

Please fill either A or B as per your judgement in "more important (A or B)" column and score 1 to 9 as per your judgement in " Score (1 to 9) " column with help of table below.

Intensity	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience & Judgement slightly favor one criterion over another.
5	Strong importance	Experience & Judgement strongly favor one criterion over another.
7	Very strong importance	One criterion is favored very strongly over another. Its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one criterion over another is of the highest possible order of affirmation.
2,4,6,8 can be used to express intermediate values		

ANNEX X: List of Personnel Consulted During Criteria Fixation/AHP:

S.no	Name	Position	Contact/Email
1.	Naresh man Shakya	SDE, Bridge Branch	9841428386, naresh.shakya@yahoo.com
2.	Krishna Raj Adhikari	previously SDE at DOR Bridge branch at present, Division Chief, Bharatpur	9841255926, adhikarirajkrishna@gmail.com
3.	Ashok Kumar Byanju	Mayor, Dhulikhel Municipality, President, Municipal Association of Nepal (Muan)	9851073175
4.	Dr. Jagat Kumar Shrestha	Professor, Pulchok Campus	9851161350
5.	Dr. Bharat Mandal	Head of Civil Department, Pulchok Campus.	9851168252
6.	Saroj Bhattarai	Former SDE at DOR/Bridge Branch	9851043390
7.	Madhav Bhattarai	SDE, Chief local bridge section, DOLI	9841374231
8.	Mahesh Chandra Neupane	SDE, Planning section DOLI, Former TID chief of Province 3	9851219555
9	Gauree Shrestha	Former SDE at TID, Province 3 Hetauda	9841356106
10.	Shakil Manadhar	Deputy Team leader, LRBSU	9851066991
11.	Dr. Sahadev Bhandari	TID Chief Province 3	9841380634
12.	Jagat Ranabhat	CEO, RIDC consultant	9851132180
13.	Kuber Nepali	SDE, DOR	9841653325

ANNEX XI: Filled AHP Questionnaire's (Federal Level)

Participant1: Saroj Bhattarai

CR:2%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	B	4
2.	Strategic importance of road/Government Priority Policy	Project readiness level	B	3
3.	Present Traffic Volume	Project readiness level	A	2

Participant 2: Gauree Kumar Shrestha

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	8
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	7
3.	Present Traffic Volume	Project readiness level	A	2

Participant 3: Ashok Byanju

CR:1%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	9
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	7
3.	Present Traffic Volume	Project readiness level	A	1

Participant 4: Shakil Manandhar

CR:10%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	5
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	8
3.	Present Traffic Volume	Project readiness level	A	4

Participant 5: Madhav Bhattarai

CR:6%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	9
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	9
3.	Present Traffic Volume	Project readiness level	B	2

Participant 6: Bharat Mandal

CR:6%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	2
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	9
3.	Present Traffic Volume	Project readiness level	B	9

Participant 7: Dr. Jagat Kumar Shrestha

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government	Present Traffic Volume	A	4

	Priority Policy			
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	5
3.	Present Traffic Volume	Project readiness level	B	3

Participant 8: Mahesh Chandra Neupane

CR:1%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	B	2
2.	Strategic importance of road/Government Priority Policy	Project readiness level	B	3
3.	Present Traffic Volume	Project readiness level	B	2

Participant 9: Jagat Ranabhat

CR:0%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	B	1
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	3
3.	Present Traffic Volume	Project readiness level	A	3

Participant 10: Krishna Raj Adhikari

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of	Present Traffic	A	3

	road/Government Priority Policy	Volume		
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	5
3.	Present Traffic Volume	Project readiness level	B	4

Participant 11: Dr. Sahadev Bahadur Bhandari

CR:1%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/Government Priority Policy	Present Traffic Volume	A	5
2.	Strategic importance of road/Government Priority Policy	Project readiness level	A	7
3.	Present Traffic Volume	Project readiness level	A	2

ANNEX XII:Filled AHP Questionnaire's (Province Level)

Participant 1: Saroj Bhattarai

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	4
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	4
3.	Strategic importance of road/ Government priority policy	All weathered road length	A	6
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	B	3
5.	Per capita investment	Present Traffic Volume (VPD)	A	2
6.	Per capita investment	All weathered road length	A	5
7.	Per capita investment	Access to socio-economic activities.	B	6
8.	Present Traffic Volume (VPD)	All weathered road length	A	3
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	B	5
10.	All weathered road length	Access to socio-economic activities	B	6

Participant 2: Gauree Kumar Shrestha

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	9
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	7
3.	Strategic importance of road/ Government priority policy	All weathered road length	A	6
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	6

5.	Per capita investment	Present Traffic Volume (VPD)	B	2
6.	Per capita investment	All weathered road length	B	5
7.	Per capita investment	Access to socio-economic activities.	B	2
8.	Present Traffic Volume (VPD)	All weathered road length	A	2
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	4
10.	All weathered road length	Access to socio-economic activities	A	3

Participant 3: Ashok Byanju

CR:10%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	9
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	6
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	B	2
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	9
5.	Per capita investment	Present Traffic Volume (VPD)	B	1
6.	Per capita investment	All weathered roadlength	B	5
7.	Per capita investment	Access to socio-economic activities.	B	1
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	3
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	4
10.	All weathered roadlength	Access to socio-economic activities		5

Participant 4: Shakil Manandhar

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	6
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	4
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	3
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	5
5.	Per capita investment	Present Traffic Volume (VPD)	A	3
6.	Per capita investment	All weathered roadlength	B	5
7.	Per capita investment	Access to socio-economic activities.	B	3
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	4
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	B	4
10.	All weathered roadlength	Access to socio-economic activities	A	2

Participant 5: Madhav Bhattarai

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	7
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	8
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	6
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	4
5.	Per capita investment	Present Traffic Volume (VPD)	A	3
6.	Per capita investment	All weathered roadlength	B	4

7.	Per capita investment	Access to socio-economic activities.	A	5
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	3
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	3
10.	All weathered roadlength	Access to socio-economic activities	A	5

Participant 6: Bharat Mandal

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	B	1
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	8
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	6
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	B	6
5.	Per capita investment	Present Traffic Volume (VPD)	A	5
6.	Per capita investment	All weathered roadlength	A	5
7.	Per capita investment	Access to socio-economic activities.	B	4
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	1
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	B	9
10.	All weathered roadlength	Access to socio-economic activities	B	9

Participant 7: Dr. Jagat Kumar Shrestha

CR:9%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	2
2.	Strategic importance of road/	Present Traffic Volume	A	3

	Government priority policy	(VPD)		
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	B	3
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	3
5.	Per capita investment	Present Traffic Volume (VPD)	A	3
6.	Per capita investment	All weathered roadlength	B	4
7.	Per capita investment	Access to socio-economic activities.	A	5
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	3
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	3
10.	All weathered roadlength	Access to socio-economic activities	A	5

Participant 8: Mahesh Chandra Neupane

CR:10%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	B	4
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	5
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	B	3
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	B	4
5.	Per capita investment	Present Traffic Volume (VPD)	A	2
6.	Per capita investment	All weathered roadlength	B	1
7.	Per capita investment	Access to socio-economic activities.	B	4
8.	Present Traffic Volume (VPD)	All weathered roadlength	A	2
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	B	5
10.	All weathered roadlength	Access to socio-economic activities	B	5

Participant 9: Jagat Ranabhat

CR:6%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	5
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	1
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	1
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	B	3
5.	Per capita investment	Present Traffic Volume (VPD)	B	5
6.	Per capita investment	All weathered roadlength	A	1
7.	Per capita investment	Access to socio-economic activities.	B	5
8.	Present Traffic Volume (VPD)	All weathered roadlength	A	3
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	B	3
10.	All weathered roadlength	Access to socio-economic activities	B	3

Participant 10: Krishna Raj Adhikari

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	5
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	3
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	7
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	3
5.	Per capita investment	Present Traffic Volume (VPD)	B	2
6.	Per capita investment	All weathered	B	3

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
		roadlength		
7.	Per capita investment	Access to socio-economic activities.	A	1
8.	Present Traffic Volume (VPD)	All weathered roadlength	A	5
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	3
10.	All weathered roadlength	Access to socio-economic activities	B	3

Participant 11: Dr. Sahadev Bahadur Bhandari

CR:2%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Per capita investment	A	6
2.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	5
3.	Strategic importance of road/ Government priority policy	All weathered roadlength	A	3
4.	Strategic importance of road/ Government priority policy	Access to socio-economic activities	A	7
5.	Per capita investment	Present Traffic Volume (VPD)	A	2
6.	Per capita investment	All weathered roadlength	B	3
7.	Per capita investment	Access to socio-economic activities.	A	1
8.	Present Traffic Volume (VPD)	All weathered roadlength	B	2
9.	Present Traffic Volume (VPD)	Access to socio-economic activities	A	2
10.	All weathered roadlength	Access to socio-economic activities	A	3

ANNEX XIII:Filled AHP Questionnaire's (Local Level)

Participant 1: Saroj Bhattarai

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	8
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	B	5
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	7
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	6
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	A	2
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	6

Participant 2: Gauree Shrestha

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	4
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	3
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	A	3
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	B	3
5.	Present Traffic Volume	Road Closure Duration due	A	2

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
	(VPD)	to absence of bridge		
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	A	1

Participant 3: Ashok Byanju

CR:10%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	5
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	4
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	2
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	2
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	3
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	3

Participant 4: Shakil Manandhar

CR:10%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	6
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	2
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	4
4.	Present Traffic Volume (VPD)	All weathered Road length	B	3

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
		operable by concerned local level.		
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	6
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	8

Participant 5: Madhav Bhattarai

CR:6%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	3
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	B	4
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	6
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	2
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	3
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	6

Participant 6: Bharat Mandal

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	9

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	5
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	A	2
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	B	5
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	5
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	3

Participant 7: Dr. Jagat Kumar Shrestha

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	5
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	B	3
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	5
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	B	5
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	5
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	2

Participant 8: Mahesh Chandra Neupane

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	4
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	3
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	A	3
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	5
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	A	4
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	A	2

Participant 9: Jagat Ranabhat

CR:7%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	B	3
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	B	1
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	B	3
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	3
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	A	3
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	3

Participant 10: Krishna Raj Adhikari

CR:8%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	5
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	7
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	A	3
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	6
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	B	2
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	B	5

Participant 11: Dr. Sahadev Bahadur Bhandari

CR:1%

SN	CRITERIA A	CRITERIA B	MORE IMPORTANT	INTENSITY (1-9)
1.	Strategic importance of road/ Government priority policy	Present Traffic Volume (VPD)	A	3
2.	Strategic importance of road/ Government priority policy	All weathered Road length operable by concerned local level.	A	4
3.	Strategic importance of road/ Government priority policy	Road Closure Duration due to absence of bridge	A	9
4.	Present Traffic Volume (VPD)	All weathered Road length operable by concerned local level.	A	2
5.	Present Traffic Volume (VPD)	Road Closure Duration due to absence of bridge	A	5
6.	All weathered Road length operable by concerned local level.	Road Closure Duration due to absence of bridge	A	2

ANNEX XIV: Budget Allocated Bridge for Fiscal Year 2076/77 By DoR (Bridge Taken for Analysis of Federal Level Matrix)

SN	Bridge Name	Road name
1	Sansare bridge	MRM Ch.392+280
2	Mamti Khola Bridge	BP Highway
3	Trisuli River Bridge	Pasang lamhu Road
4	Khani Khola Bridge	Tamakoshi Manthali Khurkot Bridge
5	Karmanasa Bridge	Thimi-Lokanthali-Tikathali-Manohara-Mahalakshmi na.pa. 18, Imadol
6	Ghatte River Bridge	Sallaghari-Katunje-Lubhu
7	Sankheshwari Bridge, Kavre	Gwarko-Panauti road
8	Hanumante Khola Bridge	Kaushaltar-Balkot-Sirutar-Biruwa road, su.na.pa. 3, Balkot
9	Budhigandaki River bridge	Trolley bus Arniko highway Suryabinayak Chamelidanda road
10	Mahadev River Bridge	Trolley bus Arniko Highway
11	Mahadev River Bridge	Sallaghari-Katunje-Sumlingtar Su. na. Pa. 5 & 7
12	Martal River Bridge	Dumre Khadi Chepang Marga
13	Gongar River bridge	Thakaltar Chepang marga
14	Tudi River Bridge	Chepang Marga
15	Reti RIver Bridge	Chepang Marga
16	Jhirti River Bridge	Chepang Marga
17	Malekhu RIver Bridge	Chepang Marga

ANNEX XV: Budget Allocated Bridge for Fiscal Year 2076/77 By Province 3

SN	District	Bridge Name
1	Sindhuli	Dhobi River Bridge, Mulkot Amare Road
2	Sindhuli	Kyan Khola Bridge, Kyansar quarter
3	Sindhuli	Dudhauli Khola Bridge, Dudhauli 7 khatri tol
4	Sindhuli	Waksu River bridge, Dakaha-Chakmake-bahun tilpung-Nawalpur Road
5	Ramechhap	Gumdel Khola bridge, Kyama & Gumdel connecting
6	Ramechhap	Bhatauli River bridge, Sitkha-Goganpani-Dhulebesi road
7	Ramechhap	Ranajor River bridge Manathali-Raltar-Salu Road
8	Dolakha	Andheri Bridge, Pawati Doramba Road
9	Dolakha	Sorung Khola Bridge, SIngti-Sangba Road
10	Dolakha	Yarsa Khola Mulgauda Bridge, mainapokhari Bagar Mirje Majuwa Road
11	Dolakha	Charnawati River Bridge
12	Bhaktapur	Srungmati River Su. Na. Pa. 1-4 Gamcha tarkhgal Biruwa Road
13	Bhaktapur	Mahadev Khola Su. Na. Pa. 4-7 Kiwachok Gundu Road
14	Bhaktapur	Majuwa Khola, Thapatol-Sallaghari Road Su.Na.Pa. 10
15	Bhaktapur	Hanumante RIver Bridge, Anatalingeshwar Na.Pa. ward 5
16	Bhaktapur	Salnakhola, Sangammarga Suryabinayak Na. Pa.
17	Dhading	ThopalKhola Sunaulo Bazaar, Dhading
18	Dhading	Dundure Khola Bridge, Sokosh Tipling Road
19	Kathmandu	Bishnumati, Sapantirtha Bhatkeko Pul
20	Kathmandu	Narefat-Imadol-Lalitpur Sahak Bridge
21	Kathmandu	Manohara River Bridge
22	Kavrepalanchok	Jibau River Bridge
23	Kavrepalanchok	Majhikhola Bridge, Bhullu-Mandan deupur Na.Pa. 10
24	Kavrepalanchok	Betini Khola Bridge, Mandan Deupur na.pa. 12
25	Kavrepalanchok	Todke River Bridge, Mandan deupur na. pa.9,10
26	Kavrepalanchok	Mahadev Khola Bridge, Nala-Kashibhanjhyang Banepa Na.Pa.
27	Kavrepalanchok	Rosi Khola Bridge,Mamti, CAIP कोCarry Over
28	Kavrepalanchok	Rosi Khola Bridge,Katunje,CAIP कोCarry Over
29	Kavrepalanchok	Roai RIver & Punyamati RIver Confluence, Panauti-Khopasi Road
30	Kavrepalanchok	Kavre Basthali 13,Panauti-Basthali Road, Rosi River Bridge

SN	District	Bridge Name
31	Kavrepalanchok	Namobuddha Panauti Sunthan Road, Sankheshwari River Bridge
32	Lalitpur	Thosne Khola Bridge, Chapeli-Bhattedanda Road
33	Lalitpur	Nakkhu Khola Bridge, Karyabinayak-13, Chunikhel
34	Lalitpur	Siddhipur Lubhu Godawari Bridge, Lalitpur
35	Lalitpur	Nakkhu Khola Bridge, Sanoghatta, Thecho, Bungmati
36	Lalitpur	Tungan Khola Bridge, lele-Chandanpur Road
37	Lalitpur	Khani Khola Bridge, Kalwan-Bhattedanda-Ikudol-Chapeli-Majkhanda Road
38	Lalitpur	Tinkune-Pokhara-Jharuwarasi Road, Gongate RIver Bridge
39	Lalitpur	Mahalakshmi Na.Pa. 16, Nayabasti Karmanasa Khola Dhobhighat PakkipulNirman
40	Nuwakot	Kolpu River bridge, Dhulepul-Kumari-9-Dihi Road
41	Nuwakot	Tadi River Bridge, Chaukhuda-Khanigau-Kastutar Road
42	Nuwakot	KuthumKhola Bridge, Sikhar-Ghyang-Fedi Road
43	Nuwakot	Lapkalung Ghatte Khola Bridge, Shivapuri ga.Pa.2
44	Nuwakot	Jyamire Khola bridge, Shivapuri Ga.Pa. 1
45	Nuwakot	Langur khola Bridge, Tinpane Ga.Pa. 1
47	Sindhupalchok	Sipakhola Bridge
48	Sindhupalchok	Tripange Khola Bridge, Chautara-Chyat Dada-Simpani-balefi Road
49	Sindhupalchok	Sipakhola Bridge Archale-Budhichaur-Indrawati Ga.Pa. 8
50	Sindhupalchok	Pakhar Khola
51	Sindhupalchok	Khahare Khola Bridge, Budepa-bagar-ghorthaliRoad
52	Sindhupalchok	Hadi Khola Steel Truss bridge, CAIP Carry Over
53	Sindhupalchok	Mahadev Khola Bridge,CAIP Carry Over
54	Sindhupalchok	Dhade Khola Bridge, baramchi, Sindhupalchok
55	Chitwan	Badarmudhe Khola Bridge, Kalyanpur-Shivarajpur Road
56	Chitwan	Kerunga Khola Bridge, lamsalChok
57	Chitwan	Karunga Khola bridge, Bharatpur Na.pa. -KAlika Na.pa. Connecting
58	Chitwan	Kayar Khola Bridge, Jalantar-Pithuwapur road
59	Chitwan	Bagmara-DobhanRatnagar 7,8
60	Makwanpur	Bagmati Bridge, SikreDobhanTaldhunga Kavre Raigaun
61	Makwanpur	PokhreniKukhreni Khola Bridge, Hetauda Na.Pa.
62	Makwanpur	Simalitar Bridge, Aambhanjhyang Ga.bi.sa.3-Gadhi Ga.bi.sa.7 connecting

SN	District	Bridge Name
63	Makwanpur	Hetauda Na.Pa. ward 20 & 22 connecting
64	Makwanpur	Bhungdal Khola Bridge, Daman-Dhadebas Road
65	Makwanpur	Kalikhola Bridge, Kalikatar-Chuniya-namtar Road
66	Makwanpur	Jyamire Khola bridge, SimaltarGadhi Ga.pa.5
67	Makwanpur	Aapkholsi Bridge, Makwanpur