Economic Importance of the Road Connectivity and Introduction of Master Plan Study of Road Slope Management in Bhutan

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ABSTRACT: Road are the irreplaceable means of travel and transportation in the Kingdom of Bhutan (hereinafter referred to be as "Bhutan"). The development of the efficient and safe road connectivity is vital for Bhutan's socio- economic growth especially in the regional mountainous areas where the movement of the tourists, merchants and farmers is supported by the road network. The framework for national development "Bhutan 2020", "Eleventh Five Year Pan (2013-2018)", "Road Sector Master Plan (2007-2027)" and "Bhutan Transport 2040 Integrated Strategic Vision" provide the basis for national development in the road sector. Under these policies the expansion of the road has been steady progressed in the arterial road as well as feeder roads. However the harsh topographical and geological conditions (Landslides and Rock fall etc.) constrain the safety and connectivity of the roads. The Department of the Roads (abbreviated as DOR) in Ministry of Works and Human Settlement has made an effort to maintain the slopes along the roads with simple reinforcing and vegetation works. But the frequent and worse slope disaster necessitated the introduction of the comprehensive and methodological approach in the road slope management with the aim of balancing the budget in the scope of the sustainability.

1 *BACKGROUND* AND CHALLENGIN ISSUE

1.1 *Economic Importance of Road in Bhutan*

Roads are major and vital means of travel and transportation in the Kingdom of Bhutan (hereinafter referred as Bhutan) which is the landlocked country on the Himalayan Mountain. The road development is essential for Bhutan's socio-economic growth by securing the efficient and safe movement of the people and goods in the scope of maintaining the inter-connectivity between rural areas and urban areas. The current years have seen the steady extension of the roads in the feeder roads to improve the people's accessibility in rural areas as well as the expansion (widening) of the main roads (The national highways) inter districts (Dzongkhag). The accessibility is the important development factor in all aspects of economic activities such as tourism, marketing, logistics and farming in the country.

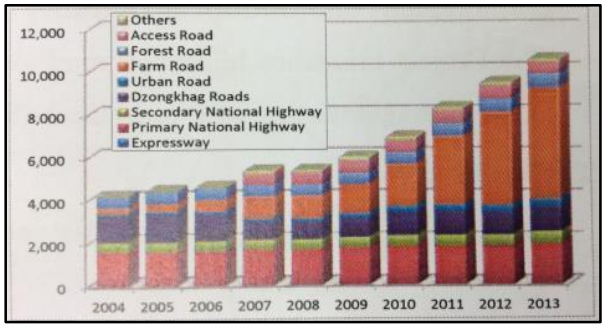

Fig. 1 Trend of Road Extension in Bhutan

The country's vehicle fleet has increased substantially from about 13,600 at the end of 1997 to well over 33,000 at the end of 2006 due to the sever moralization according from World Bank[1)].

Recognizing the importance of the roads, the current Eleventh Five Year Plan stated that the main thrust of the road sector will be aimed at the completion of the national highway grids between the urban and rural area by way of construction and upgrading the roads. The strategic framework for the construction, expansion and maintenance road infrastructure up to year 2027 is guided by the Road Sector Master Plan[2)].

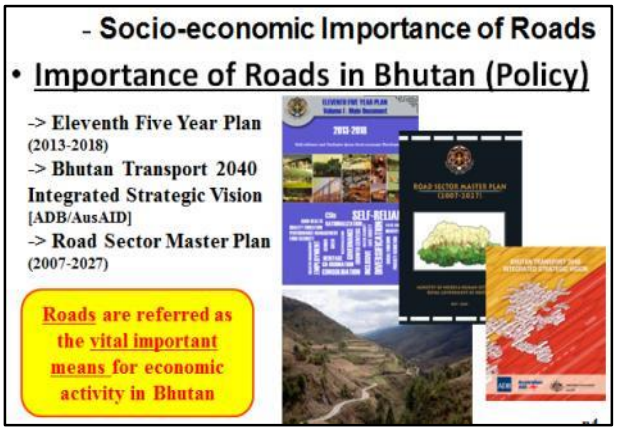

Fig.2 Socio-Economic Policy of Road in Bhutan

1.2 *Classification of the Road Networking in Bhutan*

The Bhutan's road transportation network is classified into five categories as follows according from the Eleventh Five Year Plan.

- National Highways – consisting of the Asian Highway/International Road,

Primary National Highway and Secondary National Highway.

- Dzongkhak Road (currently feeder roads) – expanding within the prefecture/federal (Dzongkhag)
- Farm Road (currently Farm Road and Power Tiller Roads) – connecting the community to cultivation/grazing area.
- Thromde Roads (currently Urban Roads) – serves the transportation in Thimphu as Capital).
- Access Roads.

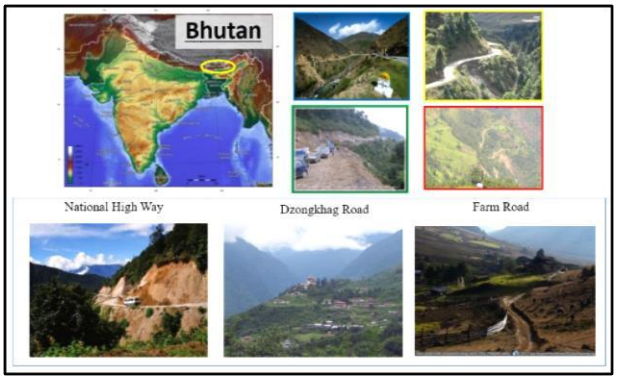

Fig.3 Road Type in Bhutan

1.3 *Challenging Issues*

The Eleventh Five Year Pan pointed out clearly that the following points as the Key Challenges to be overcome for the sustainable development in the road sector in Bhutan.

- Road Safety – The traffic volume has dramatically increased since the primary and secondary national highway constructed when the providing the connectivity was the primary objective. Although the Road Safety and Transport Act was enacted in 1999, the providing the road safety is still the main issue.
- Financial Sustainability – In terms of improving the specification of the existing road, maintenance cost and blacktopping cost of unpaved road is challenging to rural area when we will accomplish the target of providing the access in the rural areas whose road is still unpaved.

On top of above, the followings are the challenges stated by the World Bank.[1)]

- Limited Access to Regional and Global Markets – Due to its landlocked topographical character, Bhutan has an economic behind on the logistics and transport efficiency that reduces its competitiveness of the local products.

And due to the topographical constraint (Landlocked area on the Himalayan Mountains),

- Recurrence of the Landslides and Floods especially in the monsoon season – will disconnect the road network linkage that can't be replaced (not redundant) within the rural area.

1.4 *Landslides in Bhutan*

The slope stability is one of the main challenges to the road engineers in Bhutan. Since Bhutan lies within the young Himalayan Mountains, Bhutan's road network remains vulnerable to the many slopes failures, landslides, debris flows, and rock slope failures. There are many destabilized slopes in Bhutan, which pose great problems and serious impact on the safety and developmental activities, as shown in Figure 4. The current years have experienced the recurrence of the downpour due to the change in the precipitation pattern influenced by the climate change.

Fig.4 Destabilized Slope along National Highway (Southern Bhutan)

Geologically Bhutan situates itself on the Himalayan Orogenic Belt which is very fragile geology due to the ongoing collision of the continental plates. This phenomenon makes the road construction and maintenance activity technically and financially challenging issues. The landslides occur frequently in relatively in southern area whose geology is formed by the fractured zone with strongly weathered weak metamorphic rocks[3)] as shown Fig.5.

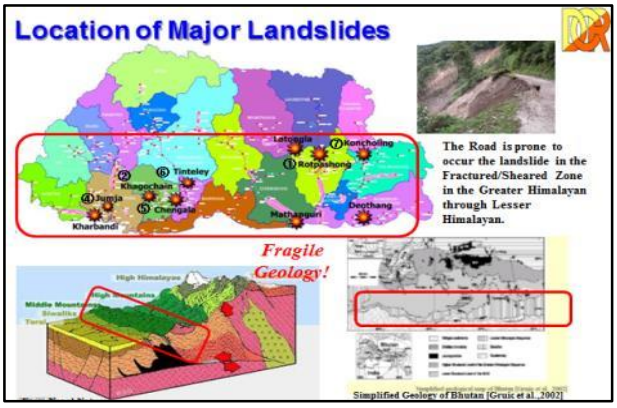

Fig.5 Location of Major Landslides in Bhutan

Informing the significance of the destabilized slopes in the meaning of road safety for the road users and developmental activities in the country, the government has set it a priority to leave the highway always open to the traffic by removing debris for the sake of road users and the settlement of the effected people. However, regarding the semi- permanent solution to the destabilized slopes, the mitigation methods that engineers choose will be influenced by many factors such as scale of the slope failures, type of soil, importance of the highway and materials locally available. Yet Bhutan being one of the under developed country, it goes for conventional ways and cheaper solutions by using the locally available materials. For those larger scale landslides and slope failures, engineers use the combination of retaining walls, check dam, RCC crib walls, different types of drainage and plantation. For the minor slides and failures, the commonly used mitigation are bio engineering with the combination of structures such as Boulder Wall, Barrel wall, Sand bags, Timber Crip wall and small drainage.

Fig.6 Conventional Countermeasure in Bhutan

But there are few roads with sufficient road slope disaster management in place. The problem is to how to take a balance (manage) between the financially limited budget for the countermeasure and the economically appropriate decision making of which slope should be prioritized from the maintenance aspect. Besides, the institutional and human resource should be enhanced in the development strategy to strengthen the capacity of road sector from the technical aspect ranging from plan, design, controlling and management of construction work through maintenance of the roads[2].

2 ROAD SLOPE DISASTER MANAGEMENT METHOD EMPLOYED IN JAPAN

2.1 *Methodology (overview)*

The similar condition can be seen in the road slope management in Japan where the efficient budget allocation in the slope management should be needed under the harsh environmental condition such as topographical, meteorological and geological conditions. The road slope management in Japan is technically based on the comprehensive approach including planning, investigating, designing for countermeasure with the advantage from the statistical data analysis for appropriate decision making tool (Fig.7)[4].

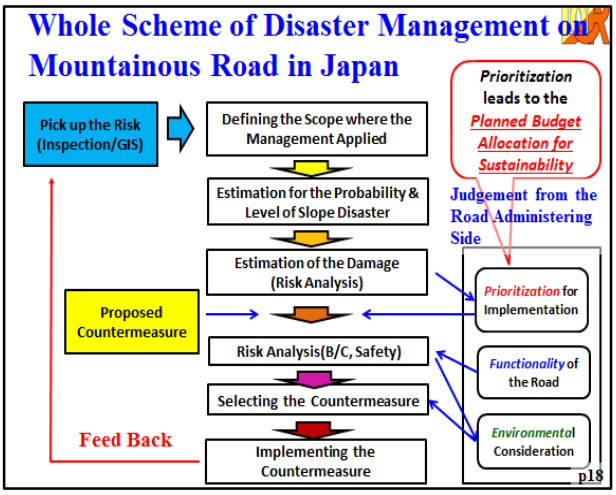

Fig.7 Whole scheme road slope management in Japan

2.2 *Project for Master Plan Study of Road Slope Management in Bhutan*

The project for Master Plan Study of Road Slope Management has been adopted and funded by JICA (Japan International Cooperation Agency) in Bhutan for the contribution to DOR (Department of Road in the Ministry of Works and Human settlement of Royal Government of Bhutan) in the expectation of the sustainable development in the road sector.

The characteristics of the project are as follows.

Purpose: To introduce the inspection techniques for the slope disaster management into Bhutan.

Contributor: To identify the high-risk roads by the inspection sheet and regular check sheets.

Project Duration:

From August 2014 to July 2016

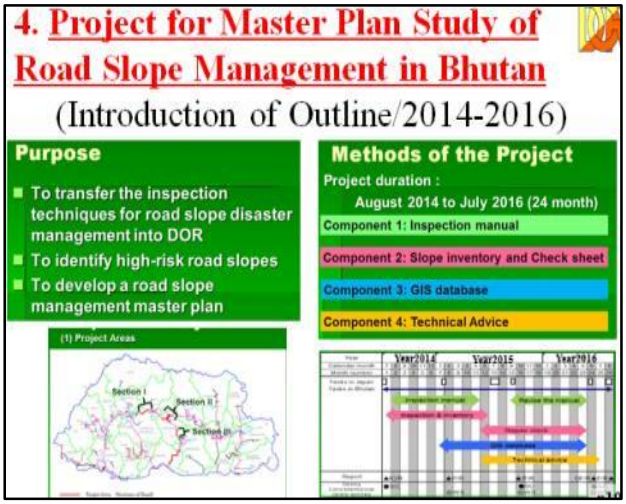

Fig.8 Outline of the Project

Target Area:

Target area for this project will be selected from many aspects ranging from socio-economic points to logistic points. The project area is designated along the national high way in Bhutan (Section1, 2 and 3). These areas are very important route for the inter-connectivity from the stand point of marketing, tourism and logistics (especially in hydropower development).

Targeted Outcome:

1) Inspection and diagnosis manual will be created.
2) Field Survey will be performed in selected sections.
3) Database will be developed including the results from the field survey results.
4) Japanese Experts Team gives a technical advice to the DOR in two pilot sites where the road slope management system will be applied for the sake of the DOR's capacity enhancement.
5) The project results will be included and reflected in the summarized guidelines technically and operationally for the DOR's independent enhancement.

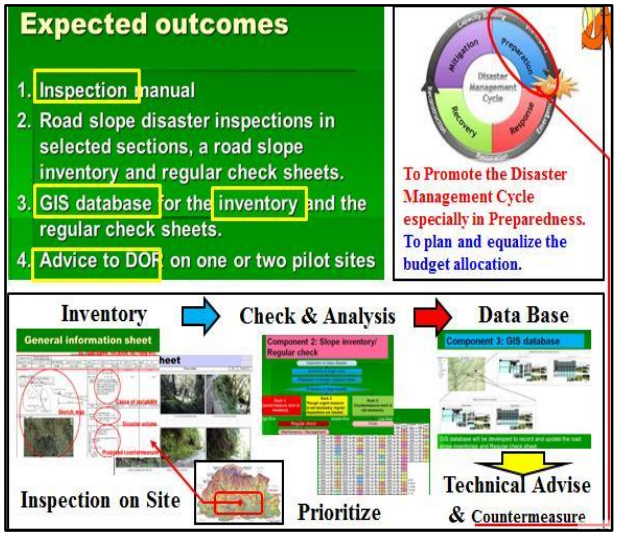

Fig.9 Outcome from the Project

Current status as of November 2015:

After gathering and finalizing the inspection sheets by filling the inspection sheets on respective site as the Japanese experts took the leading role of disseminating the technical know-how in slope maintenance scene with the local engineers. The observed and examined information will be organized into the platform of GIS data base (The GIS data base is being constructed as of November 2015 and will be completed and be integrated into DOR's data-base platform until next April 2016). On the course of organizing the inspection sheets, we categorized each slope into four levels of judgements ranked as "Rank 1A", "Rank 1B" , "Rank 2" and "Rank3" according as the necessity and urgency generated from the risk assessment implemented on each slope site (Inspection activity/ Screening). The categorization has been referred to the technical guidebook of road slope inspection in Japan[7)] and has been customized into the Bhutanese geotechnical condition that has been affected by environmental features in each slope. The consultation has been made with the local engineers in DOR for mutual understanding. The categorization means that "Rank 1A" defined as to be advisable to introduce the Japanese technology to stabilize the slope due to availability of technology, "Rank 1B" defined as to be advisable to introduce the local technology such as Gabion, Retaining wall or the kinds, "Rank 2" defined as to be advisable to be monitored using the regular check sheets, and "Rank 3" defined as to be unnecessary to be monitored because the stability of slope is maintained.

On parallel with input the database of Inspection sheet, the first regular check activity has been implemented from October 2015 through March 2016 so that we could catch the change or abnormality in the geological aspects generated in the slope after the timing of Inspection caused from environmental condition. The categorization has the possibility to be changed on course of regular checking implemented periodically on site because the unforeseeable phenomena will occur to destabilize the slope such as harsh downpour or unexpected earthquake. In the end the accumulated data and categorization will contribute the decision maker (Civil Engineers in DOR) to decide which slope should be prioritized to be treated with consideration of social importance so as to maintain the road without the diverting route when the connectivity will be disrupted.

The above matter has been shared with DOR local engineers so that they will handle the technical matters by themselves after the project outcome will be handed over to them. The technical seminars have been held in many times

for mutual understandings not only in Thimphu but also in regional cities.

Fig.10 Outcome from the Project activity has been shared in the seminar.

Fig.11 Results from the field survey and its feedback into GIS database for slope management cycle

For the safety traffic and appropriate choice of the countermeasure

The Japanese expert team is taking the initiative and giving the technical advice to DOR's engineers on what kind of countermeasure would be effective technically and economically in the designated slope on site with the consideration of the Bhutan's condition into account.

The results from the consultation will be summarized into the countermeasure catalogue book of the Japanese slope stability standardized works as a product from the project[6].

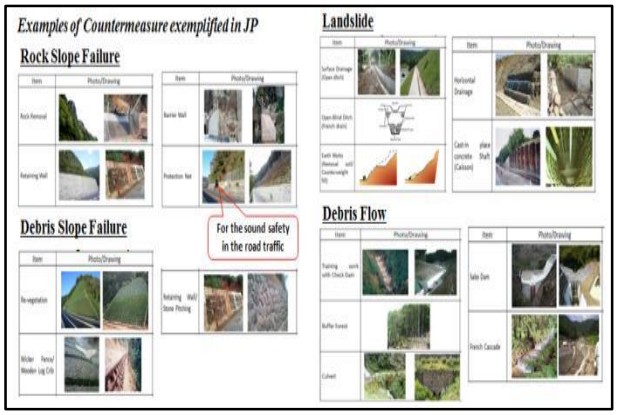

Fig.12 One example of Advisable countermeasures

3 THE ISUEES ARISING ON COURSE OF THE PROJECT AND WAY FORWARD

The following issues have been recognized on course of the project.

1) How well should we construct the slope disaster management cycle for appropriate decision making including the site inspection analysis?

2) How much should we maintain the close involvement from the counterparts (the DOR's engineers) in their usual engineering works?

For the above issues, data base (the inventory) will be developed based on the easy-to-use free GIS software. The inventory will be constructed by the module layers including the inspection results, regular check sheets and meteorological data that are easy to browse through Internet. The data base will contribute the DOR's accurate decision making when they will take a certain activity.

The Workshops and public relations will be held at many times for the technology transfer and better understanding of the management skills. Besides, the seminars will facilitate the DOR's engineers to acquire the technical knowledge and know-how. And the Training in Japan was accomplished in July 2015 and taken place in highway /national/prefectural road maintenance facility to learn the road maintenance practices and the disaster management skills employed practically on site.

Finally we hope the project outcome will lead to the resilience in the slope disaster management along the road in Bhutan through the continual

investment from the normal times according from the DR²AD MODEL[7].

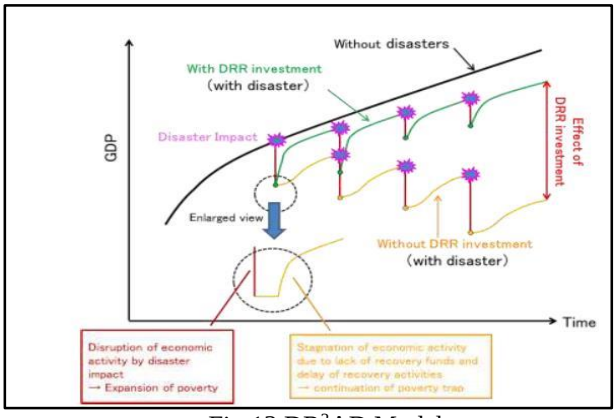

Fig.13 DR²AD Model

4 THE ACKNOWLEGEMENTS

The author wishes to highly acknowledge the cooperation of JICA and relating partners who are involved and participated in this project (DOR in the kingdom of Bhutan) and express great appreciation for inviting this report in NBRO symposium 2015 on the National Building Research Organization in Sri Lanka where the culture of resilience especially in the road sector I hope will be promoted from the aspect of well disaster management.

Finally I hope to remember the grievous loss of 104 people in the touring buses that fell suddenly into the deep valley due to unexpected slope failure under the harsh downpour in Japan on 18th August 1968[5]. The judicial judgement after this incident initiated the road slope management in Japan and the administrative decision was made that the responsibility for the safety and maintenance along the road will be assumed in the management cycle by the road administrator[5),8]. We might well learn from the past experience and lesson in the past.

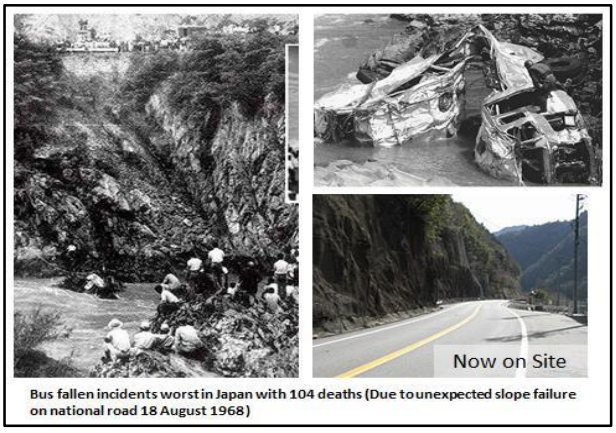

Fig.14 Worst Incidents due to the landslide involving the touring buses housing 104 victims

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