APPROACH TO PRIORITIZING INTELLIGENT TRANSPORT SYSTEMS (ITS) SERVICES IN DEVELOPING COUNTRIES – THE MONGOLIA CASE

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ABSTRACT

This study proposes a systematic approach to prioritizing the selected ITS services, and applies it through a case study in Mongolia. While numerous ITS solutions have been deployed in various forms in many cities and countries, a specific set of ITS solutions must be inevitably selected due to budget constraints. In addition, the selected ITS services should be prioritized by taking their importance and the budget situation into account. This is more critical in developing countries in particular because the budget constraint in developing countries is more severe than that in developed countries. In addition, many developing countries have different situations by regions, and especially population is dense in the capital cities while it is very low in other regions. Thus, the prioritization should also take this regional imbalance into account. With this in mind, this study proposes a methodology for prioritizing ITS services, which is a core of the national ITS master plan. For prioritization, the following five criteria are suggested: i) existence in traffic policies and development plans of the target country, ii) problems and needs identified by the general public, iii) problems and needs identified by transport experts, iv) existing services currently in operation, and v) principal investigators' engineering judgment based on identified traffic problems and issues. Prioritization is made based on scores, and the total score of each ITS service is finally used to prioritize ITS services. As a result of case study in Mongolia, twenty ITS services were selected and prioritization was made in three stages for two regional separations, respectively. These systematic (i.e. criteria-based evaluation) and hierarchical (i.e. regional separation) features of the proposed methodology for prioritizing ITS services will also provide a useful reference for other developing countries in Asia.

Keywords: intelligent transport systems (ITS), ITS master plan, ITS service prioritization, public needs survey, and developing countries.

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I. INTRODUCTION

Intelligent Transport Systems (ITS) aim to mitigate severe traffic congestion and enhance safety in roadways by monitoring traffic states, providing relevant traffic information to drivers, and responding to any incidents. Conventional traffic solutions such as road construction, traffic calming, and fixed traffic signal timing plans either required abundant resources in the area of budget and labor or had marginal impacts in terms of mobility and safety. On the other hand, ITS has been an effective solution to resolve traffic issues with a relatively lower budget based on advanced sensor, communication, and information technologies. Considering ITS's efficiency and effectiveness, many countries have established an ITS master plan at the national and regional levels, and thus deployed ITS in their roadways (KICT, 2016).

The national ITS master plan is the first step to introducing ITS in one country, and should be established for an effective ITS deployment in terms of service benefits and budget. The ITS master plan generally provides ITS implementation plans by stage (i.e., short-term and long-terms plans), including selected ITS services and the following system designs, required finance, and any legal/regulatory issues to be resolved. Particularly, selecting and prioritizing the ITS services is a focal point of the ITS master plan because the subsequent tasks such as system design, finance, legal/regulatory amendment are supposed to be provided based on the prioritized ITS services deployment plan. In previous decades, national ITS master plans have mostly been established by developed countries, in recent years, many developing countries have also attempted to develop their own master plan (MOLIT, 2011). Developing an effective national ITS master plan is particularly important for developing countries because the budget constraint in the developing countries is generally more severe than in developed countries. That is, for developing countries the ITS services should be more thoroughly contemplated and selected when the national ITS master plan is being considered.

The conventional approaches of ITS services prioritization have not been standardized or articulately defined. In fact, ITS services prioritization has often been based on only the principal investigators' engineering judgment without enough explanation. The methodology proposed in this study aims to minimize the use of the principal investigator's engineering judgment, which might be subjective, so that the ITS services can be objectively and systematically prioritized considering many aspects such as the results of the needs survey, inclusion of the country's plans, and the investigators' understanding of the country's status and issues to be resolved.

With this in mind, this study aims to develop a methodology for selecting and prioritizing ITS services by stage considering the traffic issues and needs. To select and prioritize ITS services, the candidates need to be evaluated in terms of their significance including the regional traffic issues, and their urgency on the regional-social needs. Accordingly, the objective of this study is to develop a methodology for an evaluation of the significance and urgency of the candidates of ITS services, and ultimately to develop a methodology for selecting and prioritizing ITS services based on the regional traffic issues and needs.

To this end, this study uses a case study of Mongolia; thus, the preliminary analysis results of Mongolia are provided, and the ITS services prioritization results are also provided with regard to the ITS services selected for the Mongolian road and traffic networks. To consider the regional characteristics of the case study country (specifically, that 40 per cent of its total population lives in less than 1 per cent of the total land area), the analysis including a needs survey and service selection and prioritization are conducted separately for the capital city (Ulaanbaatar) and the other areas of Mongolia.

This hierarchical approach will provide a great reference for the other developing countries which have similar demographic characteristics. Furthermore, this study suggests a systematic approach in selecting and prioritizing ITS services using the scoring criteria and evaluations, ultimately so that other developing countries can readily apply this methodology when they develop their ITS master plan.

II. LITERATURE REVIEW

ITS master plans have been established by many countries and cities around the world because this is the first step of deploying ITS services and systems in a specific region. However, not many ITS master plan projects have utilized a systematic approach to prioritize ITS services, and a needs survey and a review on existing plans have been used as major approaches to prioritize the ITS services and systems. As a result of reviewing the existing ITS master plan practices, which are summarized in table 1, the following methods were used in these existing cases in order to prioritize ITS services: 1) analyzing traffic situations, 2) reviewing existing national/regional plans, and 3) a needs survey. Although these practices have attempted to introduce some procedures to identify the needs and problems of subject regions, the prioritization methods have not been applied with an articulated methodology or procedure, and rather the prioritization has been finally determined by the principle investigators' engineering judgement only in consideration of the understandings on subject regions. Therefore, there was no science involved in the prioritization of ITS services, and it was highly likely that decisions on ITS services prioritization involved subjective judgment by decision makers. Furthermore, there was no consideration of regional separation when selecting ITS services while this is important in developing countries where population densities are imbalanced by regions. Therefore, our review of existing ITS master plan practices identified a need to enhance the ITS services prioritization and develop a systematic method in prioritizing the ITS services. In addition, the methodology of the ITS services prioritization should flexibly take into account regional characteristics (e.g. the road and traffic characteristics are heterogeneous according to the region, a feature found in many developing countries).

Table 1. Summary of ITS service prioritization practices

Area/Country	Service prioritization criteria in consideration
Lima, Peru *(KICT, 2016)*	- Current traffic status and issues. - National policies on roads and traffic.
Czech Republic *(MOT, 2016)*	- Current traffic status and issues (roads, public transport, railway, and freight). - Existing national plans. - Standards and policies of European Union (EU).
Orlando, Florida *(MetroPlan Orlando, 2017)*	- ITS scoring methodology that includes 8 criteria was developed and adopted to prioritize the ITS projects related to the identified services. - 8 criteria chosen are as follows: Planned Priority; Existing Volume to Capacity; Stakeholder Survey Results; ITS Strategies; ITS Plan Goals and Objectives; Regional Connectivity; Safety; and Transit.
Orange County, California *(Orange County, 2013)*	- Inputs from a wide range of stakeholders in the county. - Existing conditions of ITS projects and programs and current state of technology. - Needs assessment and its results. - Three distinct time frames such as short-, medium- and long-term were proposed to describe deployment plan for strategy implementation.
Sejong, Korea *(Sejong City, 2014)*	- Current traffic status and issues. - Existing ITS services. - Survey from general public. - Existing national plans. - Each evaluation category was evaluated by Principle Investigators, and finally a 2-stage ITS service implementation plan was developed.
Seoul, Korea *(Gov. of Seoul, 2008)*	- Existing national ITS architecture. - Current traffic status and issues. - Overseas ITS services plans. - ITS services were categorized as 'extending from existing system' and 'new system', and the 'extending' services are implemented in the 1st stage, while the 'new' services are implemented in the 2nd stage.
Chungcheong Province, Korea *(Chungcheongnamdo, 2008)*	- Existing national plans. - Survey of the general public. - Survey of stakeholders. - Each evaluation category was evaluated by Principle Investigators, and finally a 3-stage ITS service implementation plan was developed.

METHODOLOGY

This study suggests a systematic approach to prioritizing ITS services using the scoring criteria and evaluations. The methodology aims to ensure that the ITS services are objectively and systematically prioritized considering many aspects such as the needs survey results, the country's plans, and the investigators' understanding of the country's status and issues to be resolved. Furthermore, this systematic approach is straightforward and can be readily transplanted to other countries, while there have been challenges in applying the conventional approach in other regions due to its complexity.

With these objectives in mind, five criteria are suggested and listed below. It should be noted that these five criteria were comprehensively determined based on reviews of past practices and several discussions with ITS specialists and researchers. Each ITS unit service is supposed to be scored according to these five criteria, and selected for implementation based on the total scores. The prioritization of the selected ITS unit services is also determined based on their total scores.

- **Criterion 1 (Inclusion in traffic policies and development plans of subject country) – 20 points**: If ITS services are included in transport policies and their upper-level plans of a subject country/region, a score of 20 points is given. If not, zero point will be granted.

- **Criterion 2 (Problems and needs identified by the general public) – 20 points**: Transport problems and needs are surveyed from general public through questionnaire surveys. The severity of the problems and needs is quantified in the range of zero to 20.

- **Criterion 3 (Problems and needs identified by transport experts) – 20 points**: Transport problems and needs are selected and prioritized by transport experts through questionnaire surveys. The severity of the problems and needs is quantified in the range of zero to 20.

- **Criterion 4 (Existing services currently in operation) – 10 points**: Depending on their current status of operation – operational or not – they are given a score of zero or 10 points.

- **Criterion 5 (Principal investigators' judgment considering the traffic problems and issues of a subject country/region) – 30 points**: Depending on the urgency and importance of the introduction of systems in close collaboration between the principal investigators and the stakeholders of a subject country/region, 10, 20 or 30 points will be given.

The fifth criterion is evaluated by the principal investigators (i.e., the authors of this study) in close collaboration and discussion with local stakeholders including scholars, public and police officers. If the stakeholders find specific ITS unit services that are expected to resolve traffic problems and issues of specific regions, then the specific services are scored based on the evaluations of principal investigators and the stakeholders. This is a qualitative approach among these proposed approaches, but this should be considered to reflect the decision-making process of stakeholders. Finally, these five criteria are evaluated and the ITS unit services can be selected and prioritized based on the total scores.

In addition, this ITS services prioritization is implemented in a hierarchical manner, based on the regional characteristics such as population, density, number of vehicles, and the following traffic problems and social issues. This study focuses on developing countries which frequently show different social and traffic conditions by regions. For example, many developing countries are composed of a mega capital having high density in a small area and the other regions having low density in a large area. Hence, national ITS projects should embrace all administrative regions and their various characteristics and should not be planned only for certain areas, this study proposes to apply the ITS services prioritization methodology by regional separations.

III. CASE STUDY

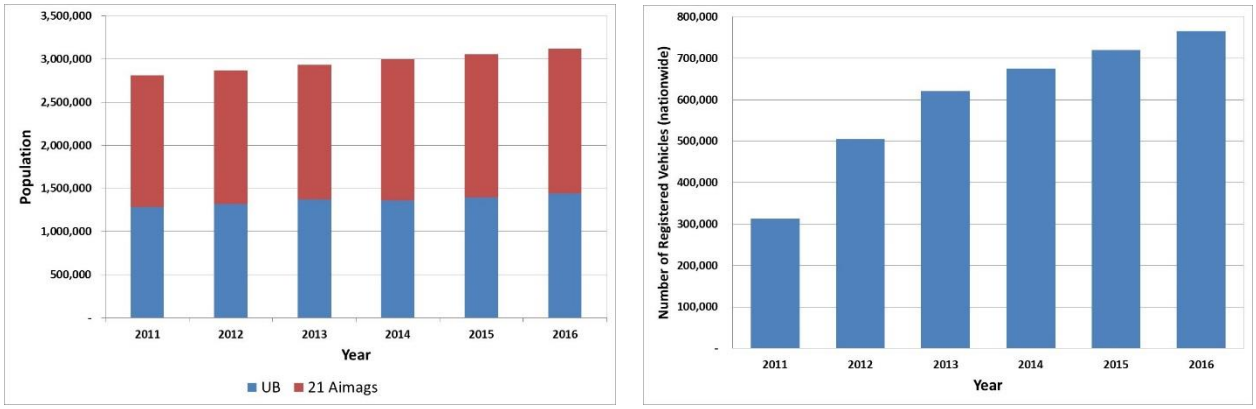
This study applied this methodology using a case study in Mongolia. To this end, a preliminary analysis was conducted to identify the regional characteristics of Mongolia. ITS services were determined based on the understanding of Mongolia; and the ITS services were finally selected and prioritized based on the methodology proposed in this study. For the preliminary analysis of this case study, the first section titled 'Demographics and vehicle statistics' describes the population and vehicle

characteristics of Mongolia in order to identify the traffic problems that should be addressed by ITS services. Also, implementation of the needs surveys including the survey method and results is explained as a basis of the ITS services prioritization.

A. Demographics and vehicle statistics

The principal investigators need to understand the status (e.g. social and traffic issues) of the country in advance of selecting ITS services. Mongolia, the case study area of this study, is located in the southern part of the plateau in Central Asia, and the total area of the inland country is 1,567,000km², making it the world's 19th-largest country in terms of the area of territory (KOTRA, 2017). Mongolia is divided into 21 administrative districts called Aimags. These Aimags are subdivided into 315 Soms. Noting that Aimag and Som can be respectively compared to 'State' and 'County/City' by international standard. Ulaanbaatar (UB), the capital, is a separate municipal district with equivalent administrative status to an Aimag. As of 2011, as shown in Figure 1, Mongolia had a population of 2,811,666. By 2016, it had grown to 3,119,935. In the past five years, the population has increased by about 308,000 people. The average annual population growth rate during 2011-2016 was about 2.1 per cent. Over 45 per cent of the total population (1,440,447 persons as of 2016) is concentrated in its capital. UB and the population within the capital has been on the rise (MSIS, 2017). The remaining 21 Aimags (equivalent to provinces) show a very low average population density of 2 persons/km², and dispersed housing patterns. This kind of dense population in urban areas is clearly witnessed in the number of registered vehicles. Over 60 per cent of the total number of registered vehicles (766,019 vehicles as of 2016) are concentrated in UB, causing serious transport problems such as severe traffic congestion, a lack of parking spaces, and air pollution (UB was ranked the second worst city in the world for air pollution) (MSIS, 2017).

Figure 1. Population and vehicles statistics in Mongolia

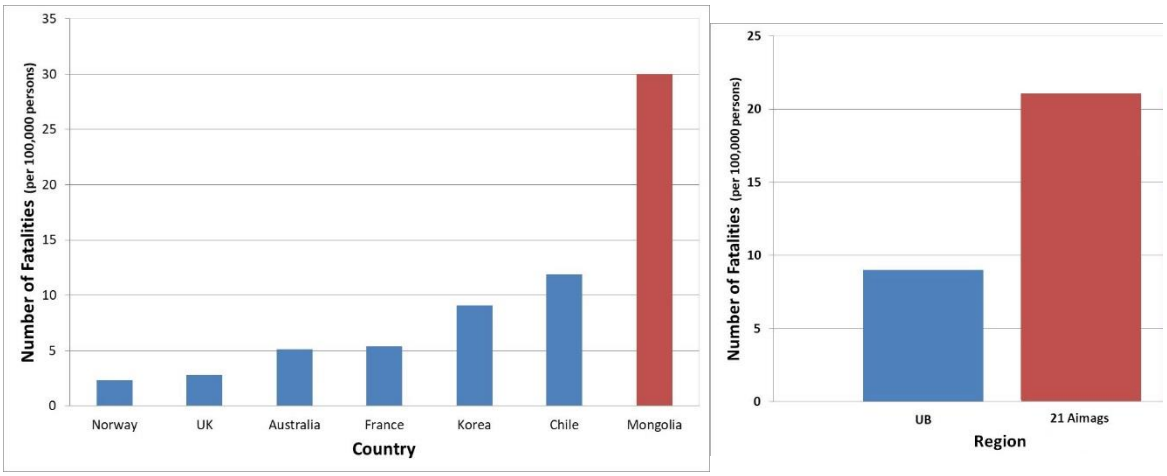


a) Population b) Registered Vehicles

Source: Mongolia Statistical Information Service. (http://www.1212.mn)

Approximately 45,000 traffic accidents occur in Mongolia each year, resulting in approximately 5,000 deaths (Mongolia National Police, 2016). Figure 2 shows the statistics on the accidents in Mongolia. Comparing the number of traffic deaths per 100,000 population with the average number of traffic deaths in Organisation for Economic Cooperation and Development (OECD) countries (OECD, 2017), Mongolia loses about 30 persons, 13 times higher than the figure for Norway (2.3 persons). In addition, of these 30 deaths (per 100,000 population), 21.1 deaths occur in the 21 Aimags other than UB, indicating the higher severity of traffic accidents in peripheral areas compared to the large city.

Figure 2. Traffic accidents



a) Fatalities of each country (OECD) b) Fatalities in Mongolia

Sources: Mongolia Statistical Information Service and OECD Statistics

An excessive population concentration in urban areas is often observed in developing countries, and social problems caused by this high density such as those associated with traffic congestion and traffic safety have become more severe in recent years. If such traffic problems are not addressed, the overall social development of developing countries will be undermined. Therefore, the ITS master plan and the selection of ITS services should be done with understanding of the country status and their needs in the areas of mobility, safety, and the environment.

B. Needs analysis by regional separation

There are clear differences in the regional characteristics of the large cities and provincial cities in Mongolia due to the concentration of the population in cities. 40 per cent of the total population of Mongolia live in less than 1 per cent of its total areas, indicating that the situations of UB and the other areas (21 Aimags) are totally different and should be separately considered in the national ITS master plan. The differences between UB and the Aimags were clearly revealed through questionnaire surveys of the general public and transport experts. It should be noted that here, “general public” refers to the residents of the subject areas, while “transport experts” includes professor, researchers, public officers, police officers, and contractors who are engaged in transport. Table 2 shows the number of samples surveyed for this study.

This survey was conducted from July to August 2017 across the nation at major transport sites including terminals and bus stops in UB and other 21 Aimags. As a survey method, ‘face-to-face (1:1) and online survey’ was applied for the general public and ‘paper-based survey using an official template document’ was used for the experts. The following table describes the number of samples (public users and experts) for this survey.

Table 2. Survey samples

Respondents	Area	Number of Samples	Total
General public	UB	300 copies * 1 city = 300 copies	930 copies
	21 Aimags	30 copies * 21 Aimags = 630 copies	
Experts	UB	27 copies * 1 city = 27 copies	69 copies
	21 Aimags	2 copies * 21 Aimags = 42 copies	

An expert needs survey was conducted on the demand of and preference related to ITS services by surveying Mongolian traffic officers and professionals in universities. 52 per cent of the respondents worked in areas related to transport affairs. Of these, 32 per cent of respondents had 5-10-year work experience. Respondents to the survey for the general public were 63 per cent male and 37 per cent female. In terms of age distribution, the largest group was in 20s (57 per cent) while 29 per cent in 30s. More than 40 per cent responded that they commuted by driving.

For the results, in the survey of the general public in Mongolia, those living in UB highly recognized the severity of transport problems such as lack of parking spaces, traffic congestion, and lack and inaccuracy of public transport information, while those living in the 21 Aimags surveyed in this study highly recognized problems such as a lack of parking information and parking facilities, low quality of safety, and a lack of information on public transport information and waiting areas. It is noted that in this context, public transport refers to buses. In the survey, the transport experts responded that advanced traffic operations and management were needed in UB in priority, and the safety issue was the most serious problem in Aimags, as shown in table 2. In addition, the transport experts identified the application of automated traffic enforcement systems and fare collection systems in Mongolia in priority.

There are clear differences in the characteristics of transport in densely populated areas and non-densely populated areas in Mongolia. In this regard, it is likely to be necessary to differentiate ITS services for different regions. As such, in establishing future ITS master plans, different services need to be applied to different regions in consideration of their regional characteristics.

C. ITS unit services selection results

While the ITS service selection and prioritization methodology proposed in this study was implemented using a case study in Mongolia, a list of ITS services was initially introduced from the Korea's ITS architecture (MOLIT, 2010). This is because Mongolia has deployed many ITS services (e.g. speed enforcement and bus information systems) based on the Korea's ITS architecture during the past decades. Table 3 shows the entire list of ITS unit services used for the following selection and prioritization process.

Table 3. Selected ITS unit services

Service Domains	Service Groups	Unit Services
Traffic Management	Traffic administration support	**Traffic demand management support**
		Road maintenance support
		Pollution management support
	Basic traveller information	**Basic traveller information**
	Automated traffic enforcement	**Speed limit violation enforcement**
		Traffic signal violation enforcement
		Bus exclusive lane violation enforcement
		Overloaded vehicles enforcement
		Illegal parking enforcement
	Cautious roadway management	**Roadside speed warning**
		Poor vision segment management
		Poor pavement segment management
		Obstacle management
	Traffic control	**(Real-time) Traffic signal control**
		Traffic signal priority control
		Railway crossing signal control
		Freeway traffic management
	Incident management	Incident management
Traffic Information	Traffic information integration and management	**Traffic information integration and management**
	Integrated traffic information provision	Integrated traffic information provision

Service Domains	Service Groups	Unit Services
Public Transport	Transit operations	**Bus operation management**
	Transit information	**Bus information provision**
	Transit reservation	Transit reservation
	Para-transit operations support	Para-transit operations support
Electronic Payment	Electronic payment for public transport	**Electronic payment for public transport**
	Electronic payment for roadways	**Electronic toll collection**
		Congestion charging
	Electronic payment for transport facilities	**Electronic payment for parking**
Commercial Vehicle	Hazardous materials vehicle safety management	**Hazardous materials vehicle safety management**
	Heavy vehicle operations support	Heavy vehicle route guidance
Traveller information	Pre-trip travel information	Pre-trip travel information provision
	En route travel information	Driver travel information provision
		Transit traveller information provision
		Pedestrians and cyclists travel information provision
Newly added	Environment	**Limit decrepit diesel vehicles**
	Bicycle	**Public bicycle support**
	Parking	**Parking information provision**

Note: The shaded cells are the selected ITS unit services to be further prioritized.

These ITS unit services, which are the candidate ITS unit services to be prioritized for UB and the other regions of Mongolia, were evaluated through the five-stage evaluation process. It should be noted that the intelligent vehicle road service group was excluded from the service selection process because self-driving-based services are far beyond Mongolia's road and traffic situation, and some of the ITS unit services given zero points in Criteria 1, 4, and 5 were preemptively excluded prior to the prioritization process because these services were assumed to be unnecessary or far beyond the Mongolia's traffic situation. In addition, the ITS unit services having zero points from the surveys of experts and general public were also excluded. Based on that the Mongolia's transport experts and normal people believe that these services are unnecessary in the near future in Mongolia. As a result, twenty ITS unit services (shaded areas in table 3) were selected, as shown in table 3. Of the twenty ITS unit services to be further prioritized, seventeen were extracted from the Korean ITS architecture, and three additional were proposed by the principal investigators (i.e. the authors of this study) and the stakeholders in Mongolia.

D. ITS unit services prioritization results

The score of each ITS unit service was calculated based on the criteria and scoring scheme. Threshold values are set to establish short-term, mid-term and long-term plans based on the calculated priorities. Items for which the final score is 70 or higher are set as the first priority. Items with a final score that is 40 or higher but lower than 70 are set as the second priority. Lastly, items with a final score lower than 40 are set as the third priority. For non-densely populated areas, items with a final score of 60 or higher are set as the first priority, while items with a final score of 30 or higher but lower than 60 are set as the second priority. Items with a final score lower than 30 are set as the third priority. It is noted that as none of the ITS services are in operation in the Aimags of Mongolia, the criterion for the ITS service existence (i.e. 10 points) was not considered for the Aimags. Thus, the rated evaluation points (total 90 points) were normalized to 100 points. Based on these evaluation schemes, the priorities of ITS services were differentiated in consideration of their regional characteristics, and the evaluation and prioritization were conducted as shown in table 4.

For the UB case, bus information provision, bus operation management, basic traveller information, illegal parking enforcement, real-time traffic signal control, and parking information provision services were selected to be provided in priority. Importantly, public transport and parking are the critical issues in UB, thus it turned out that the bus information and management services and the

illegal parking enforcement and parking information services were considered as the most fundamental services in priority. For the Aimags case, speed limit violation enforcement, bus information provision, bus operation management, basic traveller information, and electronic payment for public transport services were selected to be provided in priority. While the bus services were selected as the same with the UB case, the speed limit violation enforcement service was top-ranked in Aimags. This is because traffic safety is a more important issue in Aimags, compared to the UB's situation that traffic congestion is the most critical issue.

Table 4. Prioritized ITS services in Mongolia (Ulaanbaatar / Aimags)

Unit Service	Existence in plans	Needs identified by general public	Needs identified by experts	Existing ITS services	Judgment by stakeholders	Total Score	Priority
Bus information provision	20 / 20	20 / 20	9 / 1	10 / -	30 / 30	**89 / 79(71)**	**1 / 1**
Bus operation management	20 / 20	19 / 20	1 / 2	10 / -	30 / 30	**80 / 73(66)**	**1 / 1**
Basic traveller information	20 / 20	14 / 8	4 / 4	10 / -	30 / 30	**78 / 69(62)**	**1 / 1**
Illegal parking enforcement	20 / 20	12 / 12	10 / 11	0 / -	30 / 10	**72 / 59(53)**	**1 / 2**
Real-time traffic signal control	0 / 0	12 / 5	20 / 6	10 / -	30 / 10	**72 / 23(21)**	**1 / 3**
Parking information provision	20 / 20	20 / 20	0 / 0	0 / -	30 / 10	**70 / 56(50)**	**1 / 2**
Speed limit violation enforcement	20 / 20	5 / 10	10 / 11	10 / -	20 / 30	**65 / 79(71)**	**2 / 1**
Freeway traffic management	0 / 0	14 / 8	20 / 6	0 / -	30 / 20	**64 / 38(34)**	**2 / 2**
Electronic payment for public transport	20 / 20	0 / 0	2 / 10	10 / -	30 / 30	**62 / 67(60)**	**2 / 1**
Traffic demand management support	20 / 20	14 / 8	4 / 5	0 / -	20 /10	**58 / 48(43)**	**2 / 2**
Traffic information integration and management	0 / 0	12 / 5	3 / 0	10 / -	30 / 10	**55 / 17(15)**	**2 / 3**
Congestion charging	20 / 0	14 / 8	6 / 1	0 / -	10 / 10	**50 / 21(19)**	**2 / 3**
Electronic payment for parking	20 / 20	12 / 12	6 / 1	0 / -	10 / 10	**48 / 48(43)**	**2 / 2**
Traffic signal violation enforcement	0 / 0	5 / 6	10 / 11	10 / -	20 / 10	**45 / 29(27)**	**2 / 3**
Overloaded vehicles enforcement	0 / 0	6 / 13	10 / 11	0 / -	20 / 20	**36 / 49(44)**	**3 / 2**
Hazardous materials vehicle safety management	20 / 20	1 / 4	1 / 2	0 / -	10 / 10	**32 / 40(36)**	**3 / 2**
Electronic toll collection	0 / 0	6 / 4	6 / 1	0 / -	20 / 10	**32 / 17(15)**	**3 / 3**
Public bicycle support	20 / 0	0 / 0	0 / 0	0 / -	10 / 10	**30 / 11(10)**	**3 / 3**
Limit decrepit diesel vehicles	0 / 0	0 / 0	0 / 0	0 / -	20 / 10	**20 / 11(10)**	**3 / 3**
Roadside speed monitoring	0 / 0	5 / 6	3 / 20	0 / -	10 / 20	**18 / 51(46)**	**3 / 2**

Notes: a. The left and right-values indicate Ulaanbaatar and 21 Aimags, respectively)
b. The total scores of Aimags' cases were normalized to 100 points, and the parenthesized numbers are original values.

CONCLUSION

This study proposed a methodology for selecting and prioritizing ITS services by stage, which was tested through a case study in Mongolia. The major contribution of this study is that a systematic prioritization methodology was developed based on a scoring scheme. The remarkable features of this proposed methodology include the following: five evaluation criteria were proposed to score ITS services and ultimately to prioritize the selected ITS services, and the prioritization was conducted for two separate regions, which are UB and the other regions of Mongolia.

First of all, this study proposed a systematic approach in selecting and prioritizing ITS services using the scoring criteria and evaluations. While conventional approaches to ITS services prioritization have not been articulately defined and the principal investigators' engineering judgment is a major factor in many cases, this study aims to minimize this subjective factor and develop a reasonable and fair methodology that can also consider comprehensive aspects such as needs, country's status and existing plans, and expert knowledge. The ultimate goal of this systematic approach is to resolve traffic issues and improve quality of life in the target country by selecting the most effective and necessary ITS services. As this proposed systematic approach is straightforward and based on criteria and an evaluation methodology, it is expected that this methodology can be readily transplanted to other developing countries having similar characteristics in terms of demographic and social problems.

Importantly, this study proposed a hierarchical approach based on population density, suggesting the development of separate national ITS master plans for a capital city (i.e. high density in a small area) and the other low-populated regions; this is significant, as these density characteristics are frequently shown in many developing countries. National ITS projects, unlike metropolitan ITS projects, should embrace all the characteristics of large cities and provincial cities, and should not be planned for certain areas. In Mongolia, approximately 40 per cent of total population is concentrated in Ulaanbaatar, while approximately 60 per cent of population lives in the other 99 per cent of Mongolian territory. This imbalance in density should be considered in the national ITS master plan in order to suggest relevant ITS services to all regions of the country and for the effective operations in the future.

Furthermore, for the successful introduction of ITS in developing countries, it is most important to understand not only the status of transport in these countries, but also their overall conditions such as environment, culture, economic structure and infrastructure. With this view in mind, the evaluation criteria include the ITS services in the Mongolian government's existing plans and the identified problems and needs answered by the general public and transport experts in Mongolia.

However, to ensure the reliability of the proposed methodology, the evaluation criteria and the assigned points (i.e. share) need to be further discussed and verified through many practices and studies. In addition, the ITS service selection methodology should be enhanced by taking emerging ITS services, which have not yet been introduced, into account, while the ITS services were selected from an existing Korean ITS standard and architecture in this study.

In conclusion, these systematic (i.e. criteria-based evaluation) and hierarchical (i.e. regional separation) features of the proposed methodology and approach in prioritizing ITS services would also provide a great reference for the other developing countries in Asia when developing their national ITS master plan. Although there are many different countries with different demographic and infrastructure situations and the proposed methodology needs to be validated with the different situations, this knowledge dissemination about ITS services prioritization based on a case study of Mongolia will be of help for countries that have similar characteristics to Mongolia.

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REFERENCES

Chungcheongnam-do (2008). *Intelligent Transport Systems (ITS) Master Plan*.

Korea Institute of Construction Technology (KICT) (2016). *Korean Intelligent Transport Systems(ITS) Export to Latin America.*

Korea Trade-Investment Promotion Agency (2017). National information. Available at http://news.kotra.or.kr/user/nationInfo/kotranews/14/userNationBasicView.do?nationIdx=65

MetroPlan Orlando (2017), *Intelligent Transportation Systems (ITS) Master Plan*.

Ministry of Land, Infrastructure and Transport (MOLIT) (2011). *Intelligent Transport System Master Plan 2020.*

Ministry of Land, Transport and Maritime Affairs (MOLIT) (2010). *Korea's National ITS Architecture for Vehicles and Road Traffic*.

Ministry of Land, Transport and Maritime Affairs (MOLIT) (2010). *Korea's National ITS Architecture for Vehicles and Road Traffic* (ver 2.0).

Ministry of Land, Transport and Maritime Affairs (MOLIT) (2013). *Korea ITS Standardization Annual Report (2012~2013)*.

Ministry of Foreign Affairs (2016). 2016 Mongolia.

Ministry of Transport of the Czech Republic (MOT) (2016). *Action plan for the Deployment of Intelligent Transport Systems (ITS) in the Czech Republic until 2020*.

Mongolia National Police (2016). *Crash data recorded in Mongolia National Police*. Unpublished report.

Mongolia Statistical Information Service (2017). Available at http://www.1212.mn/stat.aspx?LIST_ID=976_L03

Orange County (2013). *Intelligent Transportation Systems (ITS) Strategic Deployment plan*.

Organisation for Economic Co-operation and Development (2017). OECD Statistics: Road injury accidents statistics. Available at http://stats.oecd.org

Sejong city (2014). *Intelligent Transport Systems (ITS) Master plan*.

The Government of Seoul (2008). *Seoul's Master Plan for the ITS*.