SUMMARY OF ESTIMATE OF INFRASTRUCTURE DEMAND ON SOCIAL and FLOOD CONTROL INFRASTRUCTURE

"Bridging the Infrastructure Gap in Asia" ADB-JICA Joint Side Event at the 50th Annual Meeting of the ADB Board of Governors

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Infrastructure demand uncovered by current estimate

The acceleration of economic growth in emerging countries has led to the rapid increase in demand for infrastructure in those countries. Asian countries are expected to continue to contribute more than 60% of global growth over the coming years, so that infrastructure demand in Asia will continue to be extremely strong. ADB (2017) shows that between 2016 and 2030, infrastructure demand will amount to 22.6 trillion USD for the 45 countries in Asia, or 26 trillion USD if climate change mitigation and adaptation is included. However, the financial resources needed to materialize the required infrastructure development are insufficient in many Asian countries.

Estimations of infrastructure demand have been conducted since early 2000. According to the current stylized model, which ADB (2017) is also applying, infrastructure demand depends on income growth, industrialization, and urbanization.[1] Therefore, the pace of the increase of

[1] The most frequently used model is developed by Fay and Yepes(2003), where the equation is as follows:

$$I_{i,t} = \alpha_0 + \alpha_1 I_{i,t-1} + \alpha_2 y_{i,t} + \alpha_3 A_{i,t} + \alpha_4 M_{i,t} + \alpha_5 D_i + \alpha_6 D_t + \epsilon_{i,t}$$

($I_{i,t}$ denotes infrastructure stock in Country i and Year t, y for per capita income. A for the share of agriculture in GDP, M for the share of manufacturing in GDP, D_i for country's fixed effect, D_t for time dummy, εfor error term)

Estimate is also made to include urbanization ratio and population density as explanatory variables. Apart from new construction demand, maintenance spending is added by multiplying infrastructure stock by certain percentage such as 2% for power, road and railway, 3% for water and 8% for telecommunication. There are other methods of infrastructure demand estimate, such as bottom-up

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demand is accelerating if a country experiences both high growth and a rapid transformation of economic structure. This is one of the important facts behind the increasing infrastructure demand in Asia, as rapid urbanization and industrialization is currently occurring.

Infrastructure demand estimates usually only cover economic infrastructure such as power, transportation, telecommunication, and water. However, the infrastructure demand in other sectors is also substantial. Other sectors include education and culture, disaster prevention, and agriculture and fisheries. According to Cabinet Office statistics from 2012, these sectors represent a more than 40% share of public capital stock[2] in Japan. In most cases when infrastructure issues are discussed, social infrastructure such as education and health facilities is not a part of the discussions. However, it cannot be ignored. Moreover the role of human capital is increasingly important for sustaining economic growth in emerging countries. Needless to say, human capital is the most important engine for long term growth and is integral to the attainment of the Sustainable Development Goals (SDGs). In Asia, where many countries have entered into the middle income stage, human resource development is considered as the key to overcoming the middle income trap.

Asian countries suffer the greatest amount of loss and damage due to natural disasters in the world. Once a disaster occurs, the loss and damages are huge not only because of the value of lost assets but also due to the decrease in production in some years as a result of loss in production capacity. The effects of this loss remain until production capacity returns to pre-disaster levels. Human loss as the result of these disasters also leads to a decrease in production. Moreover the loss of assets among the poor of the population, who usually have quite limited savings, may lead to decreased spending on education for their children; this drop in spending on education may then have a negative effect on potential growth. For this reason, preventive investment against disaster is essential for development. This research targets infrastructure for flood control as it is by far the largest of all disaster-related infrastructure.

Currently demand for infrastructure has only been estimated for the economic sectors, although there are some available estimates on social infrastructure in a number of countries. For instance, the Japanese Ministry of Education, Sports, Culture, Science, and Technology made public the financial demand estimates for schools for the next 30 years. However, this kind of estimate is

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individual sector analysis, or identifying the gap of infrastructure stock between the current level of target country and bench marking country such as OECD members.

[2] Public capital stock does not include most of power and railway sector, or hospitals out of social infrastructure as they are basically the investment by private sectors.

not usually available in emerging countries. Accordingly, budgetary and planning authorities in those countries are unaware of the integrated figures of infrastructure demand, combining economic, social, and disaster-related infrastructure.

In addition, as ADB (2017) did not include urban railway in their estimates, we conducted an estimate of the demand on urban and high speed railway, using a bottom-up approach. We consider the bottom-up approach to be effective for estimating the demand on new fields without existing stock, such as urban or high speed railway, in most Asian countries other than China, according to the current model equation. In other words, a top-down approach may underestimate the demand on the railway sector because of the relatively expensive construction costs of those new fields.[3]

JICA's Research Approach

Based on this background, JICA started its research by estimating: 1) social infrastructure demand, the composition of schools, hospitals, housing, and government facilities; 2) flood control infrastructure; and 3) urban and high speed railway.

We needed to begin with building the methodology for estimating social and disaster-related infrastructure. We therefore decided to begin by conducting a case country exercise that included the examination of what methodology would be appropriate to adopt to all of Asia at a later stage. For social infrastructure we have undertaken individual country studies for Japan, Thailand, and Indonesia. These cover both bottom-up and top-down approaches, including building a regression equation. Japan was selected as a case study due to the availability of long term data, which included both the era of population increase and that of population decrease, and due to the availability of other estimates for comparison.

Analysis was carried out by JICA staff members, Mr. Tsuyoshi HARA and Mr. Fumiaki ISHIZUKA, and Associate Professor Yu NAMBA from Toyo University, under the useful advices and inputs of Professor Yuji NEMOTO and Professor Kazuyasu KAWASAKI from Toyo University. Dr. Kitti Limskul of Saitama University and Dr. Nattapong Puttanapong of Thammasat University, Thailand also conducted independent analysis, including new model building for Thailand, while the Institute of Economic and Social Research, Faculty of Economics, University of Indonesia led by Dr. Teguh Dartanto also contributed independent

[3] The estimation of demand on the railway sector is based on the unit cost of traditional types of railway.

analysis for Indonesia[4]. In the future, we at JICA plan to expand the demand estimate for social infrastructure to include all Asian countries, by examining the results of the three independent case studies, including the ideas on regression proposed in each.

As we did with social infrastructure, we chose Japan and the Philippines as case study countries for looking at demand estimates of infrastructure for flood control. Unlike other infrastructure sectors, disaster-related infrastructure depends largely on the geographical and climate conditions within the country. It is therefore difficult to construct one single estimate model that is generally applicable to any other countries in the world. In our view, this is why future forecasts on disaster-related infrastructure spending would be substantially based on the examination of historical disaster events. This analysis is made by Dr. Mikio ISHIWATARI, Senior Advisor of JICA and Professor Kenichi TSUKAHARA from Kyusyu University.

The demand estimate for urban and high-speed railway is made by gathering any information on future investment by country that is available from official plans or media reporting. Although we intend to cover any plans up until 2030, most of the available information relates to the first half of the entire period. Therefore, the figure for demand on urban and high speed railway that we present here is considered as the lowest boundary of investment demand for the years 2016 to 2030. This analysis is made by Mr. Hiroshi TAKEUCHI, Senior Research Fellow of JICA Research Institute. Finally, all necessary coordination and arrangements have been made by Ms. Rinko JOGO, Research Program Division, JICA Research Institute.

Result of Case Country Study

In relation to social infrastructure, Table 1 provides a summary of demand estimates for social infrastructure in Japan, Thailand, and Indonesia.

Table 1 Summary of social infrastructure demand (per GDP[1)], 2016-30)

2), 3)	Education	Health Care	Public Housing
Japan	0.52-0.70%(macro) 0.63-0.89%(micro)	0.89-1.19%(macro) 1.03-1.36%(micro)	0.19-0.44(micro)
Thailand	0.21%(macro)	0.20%(macro-benchmark)	0.53%(macro)
Indonesia	0.13-0.17%(macro)	0.29%(macro)	24.52%(macro, including

[4] The Indonesian team is composed by Dr. Teguh Dartanto, Dr. Muhammad Halley Yudhistira, Ms. Chairina Hanum Siregar, Ms. Andhika Putra Pratama and Ms. Edith Zheng Wen Yuan.

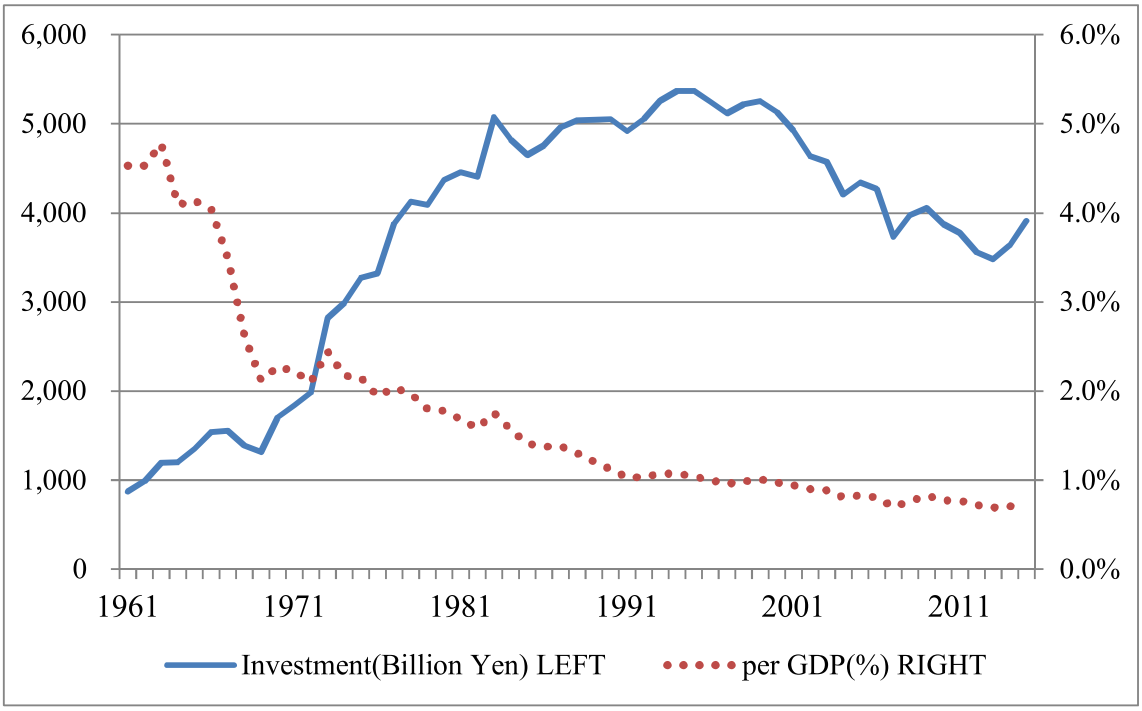
	0.02%(micro)	0.04%(micro)	private)

Note: 1) See detail in Executive Summary of case studies on how to calculate per GDP ratio, including the assumption.
2) Maintenance, rehabilitation and replacement for 3.67% of stock in Japan, 2% in Indonesia, but not included in Thailand.
3) Estimate of housing covers only pubic hosing for Japan. In case of Thailand it is a cooperation between public(NHA) and Community Organization Development Institute(CODI), while Indonesia's figure includes both public and private housing. Coverage of estimate for schools and hospitals are also different by case country. See the ANNEX.

The volume of social infrastructure investment in Japan is estimated as being as much as 0.52 to 0.89% for education, 0.89 to 1.36% for health, and 0.19 to 0.44% for social housing per GDP over the next 15 years - which is still significant. As Japan has achieved sufficient coverage of both education and health facilities and its population is expected to decrease, most of the financial demand is on maintenance, rehabilitation, and replacement. Despite this, we are unsure of the magnitude of spending on medical and educational equipment which is not a part of the estimates.

Figure 1 is the extension of the estimate model to the past. Here we see a clear trend of expenditure for schools in Japan. Financial demand on school facilities increased continuously until the early 1980s when the number of students reached its peak. Since then, as the enrollment ratio for every level of education remained unchanged, financial demand stayed at the same level until the early 2000s. It finally began to decrease as the number of students decreased. This expenditure pattern may be a useful reference for emerging countries.

Figure 1 Expenditure pattern for schools (Japan model)



Housings can be provided in several forms; public housing—rental housing for low-income household or residents with special needs; rental housing provided by corporations and residents' own housing to which government loan or subsidy may be applied. The number of public housing owned by local governments is currently 2.16 million throughout the country which is equivalent to 41.65% of households with extremely low income. As a result of the estimation with this ratio applied, Japan's public housing needs is estimated to be 31,545 billion JPY for 2016-2030 (an average expenditure per year: 2,103 billion JPY).

Thai's demand for social infrastructure investment is estimated as 0.21% for education, 0.20% for hospitals, and 0.53% for housing of the annual GDP for 2016 to 2030. The econometric estimates were applied for education and housing to build the future projection, which is a basis to estimate investment demand. The demand for hospitals was also estimated by top-down approach, however using a benchmark method where the necessary investment to reach the same "patient-bed population ratio" with South Korea is considered as the investment demand.

Indonesia's social infrastructure demand during 2016 to 2030 is estimated as 0.02 to 0.17% for education, 0.04 to 0.29% for health, and 24.52% for housing per GDP. Unlike the case in Japan, there are still large demand for new construction for education and health infrastructure in Indonesia, such as 40% and 74% respectively, according to the macro estimate, assuming that maintenance demand is equivalent with 2% of existing infrastructure stock. As housing demand estimate for the case of Indonesia includes both public and private houses, the demand scale is particularly large(24.52% of GDP), out of which 95% of the demand is for maintenance. As most of housing are the private owned, the demand for public housing would be 1.2% per GDP, assuming that public housing share is 5% of all housing. Large gaps between the the macro and micro approach such as 7 to 8 times differences are observed, which is subject to further study.

As a result of the comparative study, we found that budgetary spending on flood control is indeed on a country-by-country basis and is significantly related to the loss and damages from the worst disaster in each country's history. We therefore applied two approaches when estimating future demand, namely, 1) a simple extension of the current share of flood control investment per GDP and 2) the regression to include urbanization as an explanatory variable in addition to GDP growth and budget expenditure for flood control on previous year. Applying these ideas to the Philippines for the years 2016 to 2030, our estimate becomes 32.2 and 61.4 billion USD respectively. This scale is equivalent to between 0.45 and 0.85% of GDP through this period, where the latter is close to the highest level of spending in Japan and the Netherlands of 1% of the GDP.

In relation to the urban and high-speed railways, construction demand is estimated at 1.8 trillion USD for Asia, including China, which is a substantial amount. The scale of these investments between 2016 and 2020 - as most of the available project information relates to these years - is equivalent to 1.1% of the GDP of Thailand, 0.17% of Indonesia's GDP, and 0.26% of the GDP of the Philippines.

Findings on the key elements and methodologies, and next steps

We have produced a number of findings on the key elements as well as the research methodologies for demand estimates for social and flood control infrastructure.

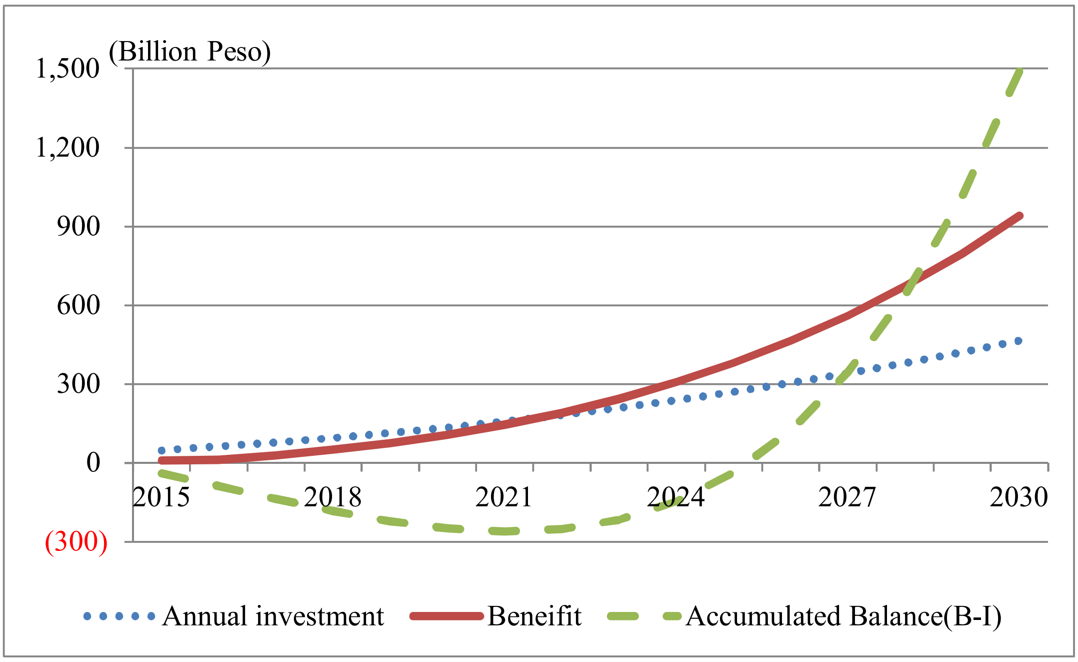
For social infrastructure three findings came to light through the case study in Japan. Firstly, the current stylized estimate model for economic infrastructure needs to be modified, as it was found to be unsuitable for social infrastructure demand estimates. Therefore, we need to adjust the equation according to the specific nature of the social infrastructure. Secondly, we found some key elements of demand estimates as a result of the bottom-up exercises. The number of beneficiaries is the most important explanatory valuable for both schools and hospitals. The enrollment ratio for higher education first increases according to economic development, then at a certain point levels off. On occasion Japan has changed its criteria for the allowable number of students in one classroom and the standard space for classroom accommodation. While the average floor area of current public housing exceeds 75 square meters, the demand for smaller public housing may be required with an increase in the ratio of single elderly households. Since it is not easy to change the size of housing during its lifetime, the planning of public housing should correspond to the increase of single-elderly households or private vacant dwellings can be used more actively instead of public housing. We need to consider the ways in which we reflect on these elements when we extend the estimate to all Asian countries. Finally, the impact of policy changes, such as the introduction of universal health coverage, has a significant effect on the demand estimate. We need to examine how we reflect on these factors when looking at future demand estimates for all of Asia.

Thai's case study is insightful for upper-middle income countries, experiencing the middle-income trap challenges and the rapid shift of demographics. The demand for social infrastructure is significant issue to raise the growth potential, such as raising skills human capital, while lowering the demand for unskilled labors. In this regard, Thai case study is particularly suggestive because the study applies the demand driven projection for enrollment ratios, in order to reflect the country's needs for human resources at different education level. Benchmark approach, which is applied for health, should be useful, particularly for upper-middle income countries such as Thailand, to estimate the necessary investment volume to reach the same standard of social services with advanced economies.

Indonesia's case must be most useful for many Asian countries where the population has been increasing, yet the absolute quantity of social infrastructure is still insufficient, particularly for health and housing. The stylized estimate model for economic infrastructure is applied in this analysis with provincial panel data, which is different from the case study for Japan where time series approach is applied. Study team for Indonesia built the panel data at provincial level, which is found useful as large regional differences, particularly for health sector, was observed in Indonesia. The differences of data sources in education such as domestic and international data did not create large differences of the result, which needs to be further examined when extending this study to all Asian countries.

Infrastructure is, in general, the physical facility or stock, benefitting the people over several decades. The nature of this is often underestimated if the benefit from the investment is invisible in the short term, in particular for disaster-related infrastructure. Figure 2 simulates the relationship between the benefits and costs of flood control investment in the Philippines. It is clear that the benefits of investment would exceed the costs in the long run; however, historically budget allocation was increased only after a large disaster hit the country. Therefore, the key consideration is how to establish the eco-system in a way that mainstreams disaster-related investment within a country's development planning and budgetary processes.

Figure 2 Benefits and costs of flood control (Philippines model)



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ANNEX: Summary of Coverage and Sources of Data on Social Infrastructure Demand Analysis

		Japan	Thailand	Indonesia
Coverage	Education	[Micro and Macro] Kindergarten Elementary Secondary University [Only for Micro] Nursery Special school for handicapped children (*Tokubetsu Shien Gakkou*) [Only for Macro] Junior college	Elementary Secondary University	Elementary Secondary
	Health	Hospital Clinic Heal Care Facility for Aged (*Kaigo Roujin Hoken Shisetsu*)	Primary Secondary Tertiary Excellent Center	Hospital PUSKESMAS1)
	Housing	Public for low income	Public(renting) Public(owning) Slam area development	Private Public
Facility Standard	Education	National	International	International
	Health	National average	National average	National average
Unit Cost of Supply	Education	[Micro] per m^2 [Macro] per facility	per facility	per facility
	Health	[Micro] per m^2 [Macro] Hospital: per m^2 Clinic: per facility	per facility	per facility
	Housing	per m^2	per facility	per facility
Operation & Maintenance (per construction cost)		3.67% 2)	Not included	2%

1) PUSKESMAS=regional community health center
2) This figure "3.67" includes replacement (depreciation rate: 1.67=100/60) and rehabilitation (60% of replacement).

Technical Note on the Estimation of Social Infrastructure Investment Needs
---*Case Study of Japan*---

"Bridging the Infrastructure Gap in Asia" ADB-JICA Joint Side Event at the 50th Annual Meeting of the ADB Board of Governors"

Tsuyoshi HARA and Fumiaki ISHIZUKA[1]

1. Introduction

Social infrastructure, such as schools and hospitals, is a key capital investment area for the maintenance of social services and securing the economic development of a region where population is expected to increase. The financial impact of this investment on public finance is also enormous. The Japan International Cooperation Agency (JICA) has agreed with the Asian Development Bank (ADB) to conduct research on Asia's social infrastructure needs estimates for the same period 2016-2030 as the ADB used to estimate economic infrastructure needs in its recently published report (ADB 2017).

The financial burden derived from infrastructure investment is not limited to the construction stage; new infrastructure requires subsequent expenditure to cover the costs of operation and maintenance, rehabilitation and replacement during and at the end of the facility's lifecycle. The problem of securing financial resources for infrastructure rehabilitation and replacement arises in a country such as Japan, where the population is aging and the financial deficit is expanding. Other Asian countries where a decline in birth rates in the future is projected will also follow the same path.

This paper therefore tries to build a methodology to estimate the demand for social infrastructure in Asia by holistically considering its lifecycle and applying it to the case of Japan. For this trial estimate, two specific social sectors in which urgent needs for investment are observed in the region were selected: education (schools) and health care (hospitals and other medical facilities). This case study is expected to contribute to the development of an estimation model for social infrastructure needs in the whole region.

[1] Tsuyoshi Hara is a Deputy Director at the Southeast Asia and Pacific Department of the Japan International Cooperation Agency (JICA). Fumiaki Ishizuka is an Assistant Director in the Operations Strategy Department of JICA.

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2. Methodology

The academic literature on social infrastructure investment needs estimate is however limited. In Japan, where the deterioration of existing infrastructure and its replacement has become social problem, Nemoto (2017) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (2013) have estimated replacement costs by identifying the social infrastructure stock which needs to be replaced on a yearly basis. On the other hand, a regression analysis using time series data, the methodology used in the above-mentioned ADB report on economic infrastructure, can also be extended to the analysis of social infrastructure.

Based on the above-mentioned studies and other inputs from academic experts[2], this paper proposes a new methodology for estimating social infrastructure investment needs covering the whole lifecycle of infrastructure: construction, operation and maintenance, rehabilitation and replacement. In this methodology, the following two approaches are applied to estimate each year's social infrastructure stock, and the pros and cons summarized as shown in Table 1:

1) A micro approach that builds a picture of each year's needs by multiplying the projected number of beneficiaries by official construction standards (square meter per beneficiary); and
2) A macro approach that estimates each year's demand using regression analysis to apply time series data of possible demographic/economic factors.

Table 1: The pros and cons of micro and macro approaches

Approach	Overview	Pros	Cons
1. Micro	Build up each year's needs by multiplying the projected number of beneficiaries (e.g. students for schools) by the official construction standard (e.g. square meter per student)	Needs can be estimated without considering constraints on the supply side (e.g. government budget ceilings, construction industry capacity)	Volume of data required for estimates would be relatively large (e.g. official construction standards), and may be difficult to apply to all countries in the region.
2. Macro	Estimate each year's demand (dependent variable) by regression analysis, applying time series data of possible demographic/economic factors (independent variables).	Relatively efficient in analyzing the chronological trends and differences among countries.	As the analysis is based on time-series data for past infrastructure stock (equilibrium of demand and supply), potential needs of the demand side cannot be incorporated.

[2] Technical inputs and advices to this research were provided by Professor Yuji Nemoto, Professor Kazuyasu Kawasaki and Assistant Professor Yu Namba of Toyo University.

2-1. The Micro Approach

For the micro approach, each year's infrastructure stock measured as the area of facilities is estimated by multiplying the projected number of beneficiaries by the official construction standards. As long as the five specific data sets (a. construction unit price, b. projected number of beneficiaries, c. official facility standards, d. given O&M proportion, and e. official lifetime standard) can be obtained, each year's infrastructure needs in any country or locality can be estimated as the sum of: 1) new investment demand; 2) operation and maintenance demand; 3) replacement demand; and 4) rehabilitation demand; as shown in Table 2.

Table 2: Overview of the micro approach estimation method

Feature	Formula	Necessary Data
1) New Investment Demand	Construction unit price x Change in number of beneficiaries (e.g. student for school) x Official facility standard (square meter/person)	a. Construction unit price b. Projected number of beneficiaries c. Official facility standard (square meters/person)
2) Operation and Maintenance Demand	O&M unit price (Construction unit price x Given O&M proportion) x Infrastructure stock (Projected number of beneficiaries x official facility standards)	d. Given O&M proportion (the division of annual O&M cost by construction cost)
3) Replacement Demand	Construction unit price x Infrastructure stock/Official lifetime standard	e. Official building lifetime standard (the number of years for the use of facility).
4) Rehabilitation Demand	Construction unit price x 60%[3] x Infrastructure stock/Official lifetime standard	

2-1-1. Data used to study the Education Sector

For the education sector, most of the data necessary for the needs estimates can be obtained from the Japanese government's official statistics. The applied figures and sources for the estimation are summarized in Table 3.

Regarding b. Projected number of beneficiaries, the core of this estimation approach, the Japanese government's population projections by prefecture, age and sex (National Institute of Population and Social Security Research 2013) were used. As school enrollment rates have not radically changed in recent years, a fixed figure can be applied throughout the period from 2016 to 2030. A single exception is the school for handicapped children; its school enrollment rate

[3] The proportion of 60% is derived from the assumption that the construction cost of a building can be divided into four categories (30% for building frame, 30% for equipment such as electricity and ventilation, 30% for interior decoration and 10% for others), and that the replacement of equipment and interior decoration (only) is necessary for its rehabilitation at the middle of the life cycle. This is the standard applied in *Foundation for Regional Viltalization* (2016), and used by Japanese local governments for their social infrastructure management.

has been increasing, and this trend is assumed to continue until 2030.

Table 3: Data used for the education sector estimation

Data		Applied Figure	Source
a. Construction unit price		0.33	Japan Foundation for Regional Vitalization（2016）
b. Projected number of beneficiaries (multiplication of Japanese government's population projection[4] and school enrolment rates are shown in the right column)	Kindergarten & Nursery	0.93	Cabinet Bureau (2012)
	Elementary School	1.00	Assumed to be 100% (Obligatory education)
	Junior High School	1.00	Ditto
	High School	0.96	MEXT (2015a)
	University	0.56	Ditto
	Special School for Handicapped Children (*Tokubetsu Shien Gakkou*)	0.0083	Ditto Assumed to increase by 3.39% per year based on the past 15 years' trend
c. Official facility standard (square meter/person)	Kindergarten & Nursery	11.97	MEXT (2015b)
	Elementary School	15.48	Ditto
	Junior High School	17.36	Ditto
	High School	22.15	Ditto
	University	43.55	MEXT (2015c)
	Special School for Handicapped Children (*Tokubetsu Shien Gakkou*)	76.35	MEXT (2015b)
d. Given O&M proportion		0.01	Building Maintenance and Management Center (2005)
e. Official lifetime standard		60	Japan Foundation for Regional Vitalization（2016）

Regarding c. Official facility standards, the national government's standard for the disbursement of subsidy to local governments for construction of public schools was used. The total necessary area calculated using this standard for public schools is available from official statistics (MEXT 2015 b, c). The division of this figure by the number of public school students is applied to create the needs estimation.

4 National Institute of Population and Social Security Research (2013).

2-1-2. Data used for the Health Care Sector

For the health care sector analysis, the applied figures and sources for the estimations are summarized in Table 4.

Table 4: Data used for health care sector estimation

Data		Applied Figure	Source
a. Construction unit price		0.33	Japan Foundation for Regional Vitalization (2016)
b. Projected number of beneficiaries (the multiplication of Japanese government's population projection and medical treatment rates (proportion of persons under medical treatment) are shown in the right column)	Hospital (20 or more beds): Medical treatment rate (inpatient) (reference: average of all generation) Proportion of hospital inpatients	0.01038 0.97	Ministry of Health, Labor and Welfare (2014a) Ministry of Health, Labor and Welfare (2014a)
	Clinic (less than 20 beds): Medical treatment rate (outpatient) (reference: average of all generation) Proportion of clinic outpatients	0.05696 0.77	Ministry of Health, Labor and Welfare (2014a) Ministry of Health, Labor and Welfare (2014a)
	Health Care Facility for the Aged (*Kaigo Roujin Hoken Shisetsu*): Facility usage rate (reference: average of all generation)	0.00255	Ministry of Health, Labor and Welfare (2013)
c. Official facility standard (square meters/person)	Hospital: Area (Square meters)/Number of beds Number of beds/Number of beneficiaries	110.89 89.04 1.25	Japan Institute of Healthcare Architecture (2017) (Average of 651 hospitals constructed in the past 10 years) Ministry of Health, Labor and Welfare (2014 b)
	Clinic: Area (Square meters)/Number of beds Number of beds/Number of beneficiaries	53.88 2,207.12 0.02	Japan Institute of Healthcare Architecture (2017) (Average of 141 clinics constructed in the past 10 years) Ministry of Health, Labor and Welfare (2014 b)
	Health Care Facility for the Aged (*Kaigo Roujin Hoken Shisetsu*): Area (Square meters)/Number of beds Number of beds/Number of beneficiaries	97.94 89.04 1.10	No statistics. Assumed to be the same as for hospitals. Ministry of Health, Labor and Welfare (2013)
d. Given O&M proportion		0.01	Building Maintenance and Management Center (2005)
e. Official lifetime standard		60	Japan Foundation for Regional Vitalization (2016)

Regarding b. Projected number of beneficiaries, official population projections by prefecture, age and sex (National Institute of Population and Social Security Research 2013) were also used in the health care sector estimations. Medical treatment rates for hospitals and clinics, and facility usage rates for health care facilities for the aged are different according to generation (data by 10 years). The past trend of the change in medical treatment or facility usage rate is also assumed to continue until 2030.

Regarding c. Official facility standards, the data on the number of beds and facilities is available in official statistics. For the data on area (square meters) of facilities, the average provided in hospitals and clinics constructed in the past 10 years was calculated based on data provided by the Japan Institute of Healthcare Architecture, and applied to this needs estimation.

2-2. Macro Approach

For the macro approach, the number of facilities[5] in each facility was estimated from 2016 to 2030 by regression analysis, using time series data based on the past trend of infrastructure stock. Note that in our use of a regression formula for the projection from 2016 to 2030, our interest was to obtain the best fit possible and the highest explanatory power. Thus, we included the lagged value of the dependent variable in the regression to increase explanatory power. The lag length for each regression formula was selected by means of information criteria such as the Akaike Information Criterion (AIC) and the Bayes Information Criterion (BIC).

For the calculation of the infrastructure demand for each year, we regarded the increment from the previous year's infrastructure stock as "New Investment Demand," and adopted the methodology used in the micro approach to calculate for "Operation and Maintenance Demand," "Replacement Demand," and "Rehabilitation Demand."

2-2-1. Regression Equation on Education Sector

Since it was difficult to acquire long-term data on the area of educational facilities, this was estimated using the time series data from 1960 to 2015 of the number of each type of educational facility; classified into (a) preschool educational facilities (kindergartens), (b) early secondary educational facilities (elementary and junior high schools), (c) late secondary educational facilities (high schools), and (d) higher education facilities (universities and junior colleges).

Equation 1 was adopted for each type of educational facility:

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[5] In the case of demand estimation for hospitals, the number of beds was adopted as the dependent variable for the regression analysis.

$$I_t = \alpha_0 + \alpha_1(I_{t-i}) + \alpha_2 y_t + \alpha_3 Urban_t + \alpha_4 Pop_t + \epsilon_t \quad . . . \qquad 1$$

Where: all variables are in natural logs to linearize the model; I_t is demand for infrastructure stock at time t; (I_{t-i}) is the lagged value of the infrastructure stock; y_t is income per capita; $Urban_t$ is the urbanization rate; Pop_t is the population of target age [6]for each educational facility; and ϵ_t is an error term.

Income per capita, one of the independent variables, has led to an increase in the number of educational facilities, since enrollment rates increase with improvements in income. However, we excluded income per capita as an independent variable in the case of early secondary educational facilities, because this group's enrollment ratio has been 100% according to the constitution. The progress of urbanization, which is an independent variable in the estimation of economic infrastructure demand estimation by the ADB, is assumed to be related to increases and decreases in the number of necessary educational facilities.

2-2-2. Regression Equation on Health Care Sector

Demand estimates were made separately for hospitals and clinics using time series data from 1975 to 2014. The number of beds in hospitals and the number of facilities in clinics were adopted as dependent variables in the regression equation on hospitals and clinics respectively, in line with the method of demand estimation used in the micro approach.

Equation 2 was adopted for the demand estimates of hospitals and clinics:

$$I_t = \alpha_0 + \alpha_1(I_{t-i}) + \alpha_2 y_t + \alpha_3 Urban_t + \alpha_4 Pop05_t + \alpha_5 Pop65_t + \epsilon_t \quad . . . \qquad 2$$

Where: all variables are in natural logs to linearize the model; I_t is demand for infrastructure stock at time t; (I_{t-i}) is the lagged value of the infrastructure stock; y_t is income per capita; $Urban_t$ is the urbanization rate; $Pop05_t$ is the number of people from 0 to 5; $Pop65_t$ is the number people above 65; and ϵ_t is an error term.

Higher income per capita has led to an increase in the number of health facilities through improvements in the communities' ability to pay for medical expenses. In addition, the progress of urbanization affects the management of hospitals and clinics and encourages increases or decreases in the number of facilities. The number of beds in hospitals and of facilities in clinics is affected by the number of hospitalized patients and the size of the diseased population,

[6] (a) preschool educational facilities: age population from 3 to 5, (b) early secondary educational facilities: age population from 6 to 14, (c) late secondary educational facilities: age population from 15 to 17 and (d) higher education facilities: age population from 18 to 21.

therefore the age groups of the infants and elderly, who are more likely to be candidates for treatment, were adopted as independent variables.

2-2-3. Growth Projections relating to the Independent Variables

Estimates of infrastructure needs are based on projections of change in the independent variables as discussed in Sections 2-2-1 and 2-2-2 for the period 2016-2030. First, this paper used linearly interpolated data for each age group in the population up to 2030; based on the forecast data published by the National Institute of Population and Social Security Research of Japan. Second, projections of gross domestic product (GDP) were calculated from annual GDP growth rates published by the OECD. Finally, the annual increase rate of urbanization from 2014 to 2015, extrapolated to 2030, was used for projection purposes.

2-2-4. Infrastructure Unit Cost

For the education sector analysis, we put together data on the total area of educational facilities divided by the total number of facilities (square meter per facility), and multiplied this with the unit price (0.33 million JPY per square meter). For the health care sector, we used a pre-condition of the micro approach: 89.04 square meters per bed for hospitals; and 2,207.12 square meters per facility for clinics, and multiplied these data with the unit price (0.40 million JPY per square meter). The results of this estimation gave the following unit costs that could be used to calculate infrastructure investment requirements for each facility.

Table 5. Facility construction unit cost used for Macro approach

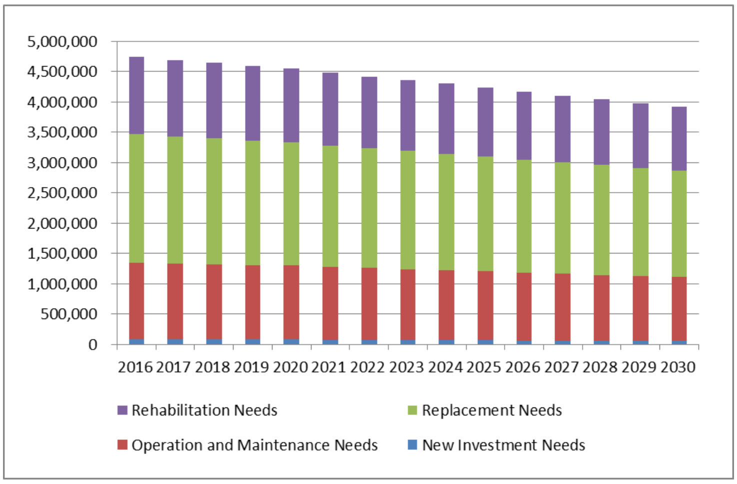
Type of Facility	Unit cost (million JPY, 2016 price level)	Unit
(a) Kindergarten	343.53	Facility
(b) Elementary and junior high school	1,761.54	Facility
(c) High school	4,345.11	Facility
(d) University and junior college	22,551.54	Facility
(e) Hospital	35.616	Bed
(f) Clinic	882.848	Facility

3. Estimation Results

3-1. The Micro Approach

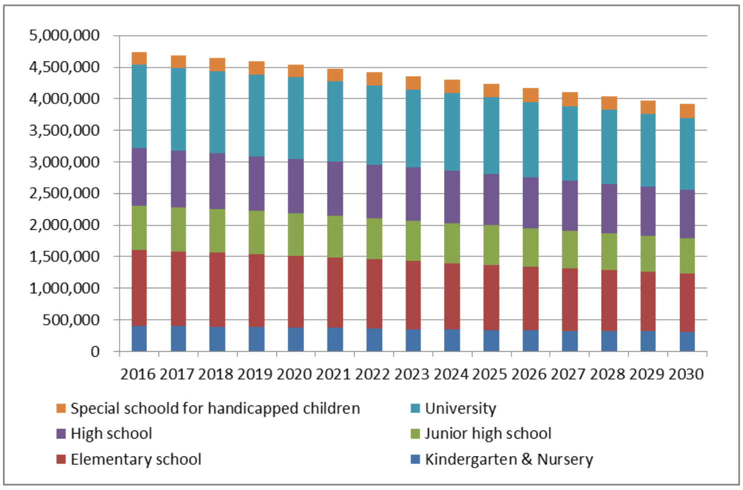
As a result of estimating each year's infrastructure needs based on the projected number of beneficiaries (the Micro approach), Japan's education infrastructure requires investments of **65,197,462 million JPY** in the period 2016-2030 (an average expenditure per year of 4,346,497 million JPY), and the country's health care infrastructure requires **102,947,978 million JPY** for the same period (an average expenditure per year of 6,863,199 million JPY). The detailed results by type of needs (new investment needs, operation and maintenance needs, replacement needs and rehabilitation needs), and by type of facility are shown in Figures 1 to 4.

Figure 1: Education sector estimation result (by type of needs, million JPY)



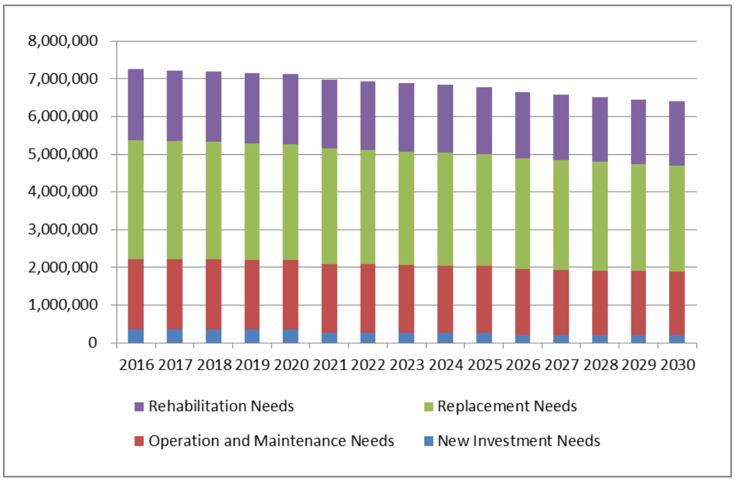
Type of needs	
as % of Total needs	
New investment	1.62%
Operation and maintenance	26.83%
Replacement	44.72%
Rehabilitation	26.83%

Figure 2: Education sector estimation result (by type of facility, million JPY)



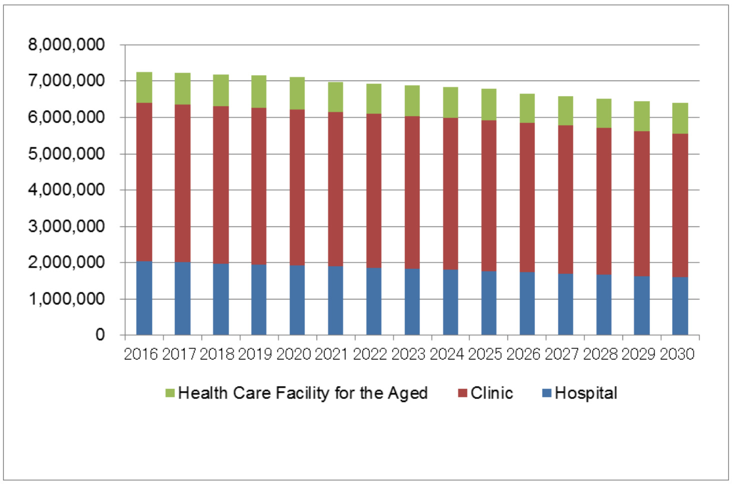
Type of facility	
as % of Total needs	
Kindergarten & Nursery	8.17%
Elementary school	24.61%
Junior high school	14.72%
High school	19.20%
University	28.42%
Special school for handicapped children	4.87%

Figure 3: Health care sector estimation result (by type of needs, million JPY)



Type of needs as % of Total needs	
New Investment	*3.86%*
Operation and maintenance	*26.22%*
Replacement	*43.70%*
Rehabilitation	*26.22%*

Figure 4: Health care sector estimation result (by type of facility, million JPY)

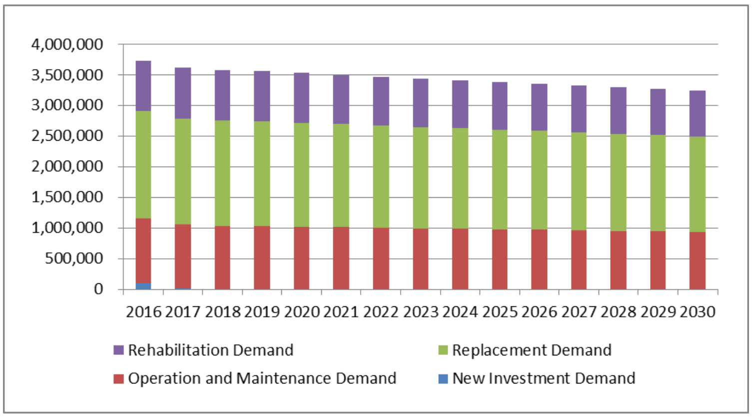


Type of facility as % of Total needs	
Hospital	*26.59%*
Clinic	*61.10%*
Health Care Facility for the Aged	*12.31%*

3-2. The Macro Approach

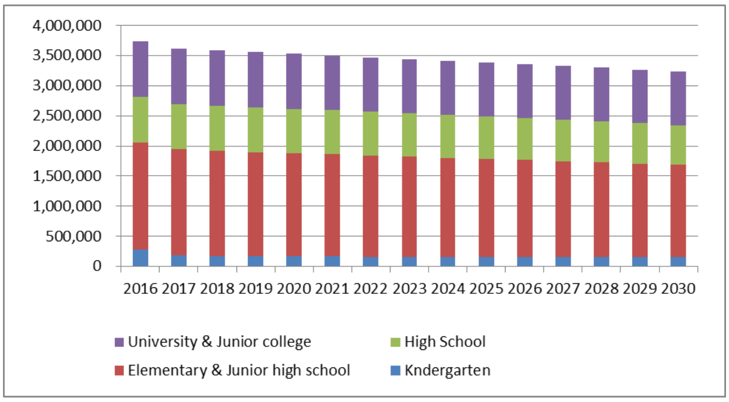
The regression analysis using time series data (the Macro approach), suggests that Japan's education infrastructure demand will be **51,719,073 million JPY** for the period 2016-2030 (average per year: 3,447,938 million JPY), and that the country's health care infrastructure demand will be **85,792,463 million JPY** for the same period (average per year: 5,719,498 million JPY). The detailed results by type of demand (new investment demand, operation and maintenance demand, replacement demand and rehabilitation demand) and by type of facility are shown in Figures 5 to 8. The results of estimated regression are also indicated in the Annex.

Figure 5: Education sector estimation result (by type of demand, million JPY)



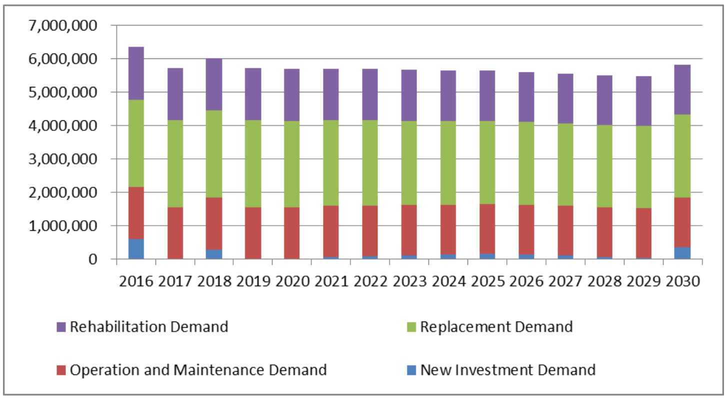
Type of demand as % of Total demand	
New investment	0.22%
Operation and maintenance	28.82%
Replacement	48.03%
Rehabilitation	22.93%

Figure 6: Education sector estimation result (by type of facility, million JPY)



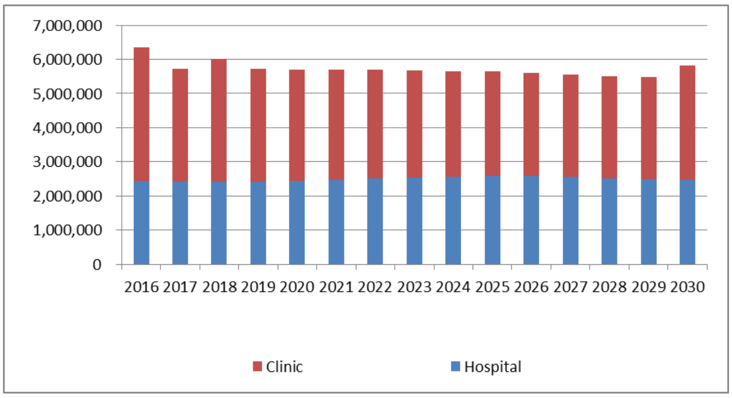
Type of facility as % of Total demand	
Kndergarten	4.93%
Elementary & Junior high sch	48.11%
High School	20.76%
University & Junior college	26.20%

Figure 7: Health care sector estimation result (by type of demand, million JPY)



Type of demand as % of Total demand	
New investment	2.48%
Operation and maintenance	26.60%
Replacement	44.33%
Rehabilitation	26.60%

Figure 8: Health care sector estimation result (by type of facility, million JPY)



Type of facility	
as % of Total demand	
Hospital	43.59%
Clinic	56.41%

4. Conclusions

The results of using the Micro and Macro approaches are summarized in Tables 6 and 7. The differences in the results between those two approaches may be understood from the differences in their nature. The micro approach does not consider constraints on supply side, while the macro approach is based on the past equilibrium of demand and supply of infrastructure. For the education sector, the estimated figures are nearly consistent with the past replacement needs estimation exercises conducted by Nemoto (2017), and the Ministry of Education, Culture, Sports, Science and Technology (2013)[7].

Table 6. Summary of estimation results for education sector (million JPY)

Educational Sector	Micro Approach	Macro Approach
Kindergarten	5,326,058	2,551,519
Nursery		—
Elementary school	16,047,109	24,883,437
Junior high school	9,598,572	
High school	12,520,545	10,735,345
University	18,532,116	13,548,772
Junior college	—	
Special school for handicapped children (*Tokubetsu Shien Gakkou*)	3,173,062	—
Total (2016-2030)	65,197,462	51,719,073
Annual Average	4,346,497	3,447,938

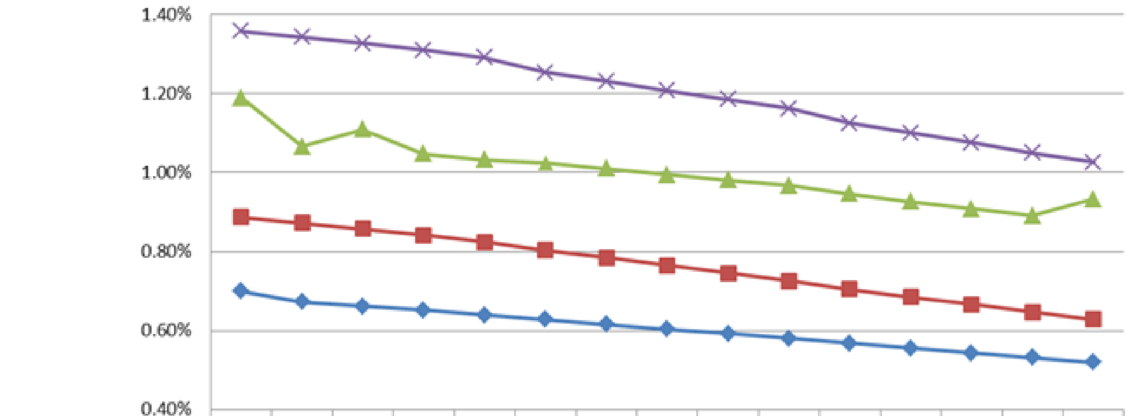
Table 7. Summary of estimation results for health care sector (million JPY)

[7] Nemoto (2017) estimated the annual replacement needs of public school (mostly elementary school and junior high school) to be 1.5 trillion JPY. The Ministry of Education, Culture, Sports, Science and Technology (2013) estimated the annual replacement needs of public elementary schools and junior high schools to be 1.3 trillion JPY.

	Micro Approach	Macro Approach
Hospital	27,371,627	37,397,807
Health care facility for the aged (*Kaigo Roujin Hoken Shisetu*)	12,671,759	
Clinic	62,904,592	48,394,655
Total (2016-2030)	102,947,978	85,792,463
Annual Average	6,863,199	5,719,498

According to these estimations, the volume of social infrastructure investment required is significant; investment as much as 0.52-0.89% of GDP for education, and 0.89-1.36% of the annual GDP of the country is required to meet social infrastructure needs in the coming 15 years, as shown in Figure 9. As noted though, those figures are only for education and health care facilities, and would become larger if other social infrastructure such as public housing and government buildings is included.

Figure 9: Japan's social infrastructure investment needs per GDP (%)



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Education (Macro)	0.70%	0.67%	0.66%	0.65%	0.64%	0.63%	0.62%	0.60%	0.59%	0.58%	0.57%	0.56%	0.54%	0.53%	0.52%
Education (Micro)	0.89%	0.87%	0.86%	0.84%	0.82%	0.80%	0.78%	0.76%	0.75%	0.73%	0.70%	0.69%	0.67%	0.65%	0.63%
Health (Macro)	1.19%	1.07%	1.11%	1.05%	1.03%	1.02%	1.01%	0.99%	0.98%	0.97%	0.95%	0.93%	0.91%	0.89%	0.93%
Health (Micro)	1.36%	1.34%	1.33%	1.31%	1.29%	1.25%	1.23%	1.21%	1.18%	1.16%	1.13%	1.10%	1.08%	1.05%	1.03%

From this estimation for Japan, three findings may be observed. Firstly, the current stylized estimate model for economic infrastructure (ADB 2017) was found to be unsuitable for social infrastructure demand estimates. It is important to note that we need to adjust the equation according to the specific nature of social infrastructure. Secondly, it was observed in bottom-up exercises that the number of beneficiaries is the most important explanatory valuable for both schools and hospitals. Japan has sometimes changed its criteria on the allowable number of students in one classroom, and the standard space for classroom accommodation. Also, enrollment ratios in higher education increase according to economic development, and then levels off at a certain point. We need to consider how we reflect such elements when we extend the estimates to all Asian countries. Finally, the impact from policy changes such as the introduction of universal health coverage, which occurred in 1961 in Japan, affects the demand estimate, so we need to examine how we reflect these factors in future demand estimates for Asia.

From this trial estimation for Japan's education and health care facilities, it is acknowledged that the estimation of holistic infrastructure investment needs including new investment, operation and maintenance, replacement and rehabilitation, is possible if the specified five data (the Micro approach), or the time series data for dependent and independent variables (the Macro approach) can be obtained. In the next stage of this research project, the authors plan to estimate investment needs for other Asian countries, and to propose policy recommendations to fill the gap between the estimated needs and current modes of infrastructure investment.

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Annex

RESULTS FROM EMPIRICAL ESTIMATION

	Kindergarten	Elementary & Junior high school	High school	University & Junior college	Hospital	Clinic
Lagged Dependent Variable (-1)	-1.452358	1.339647	1.065244	1.7188	1.368956	0.7763015
	7.06(*)	9.96(*)	24.67(*)	12.84(*)	7.87(*)	5.88(*)
Lagged Dependent Variable (-2)	-0.5494045	-0.3441017		-1.113371	-0.476102	-0.1112965
	-3.08(*)	-2.48(*)		-4.08(*)	-2.62(*)	-0.62(*)
Lagged Dependent Variable (-3)				0.1568996		0.6806142
				0.58		3.85(*)
Lagged Dependent Variable (-4)				0.1343689		-0.8014549
				*1.13		-7.47(*)
Urbanization Rate	0.1257699	0.033735	0.2753223	-0.1832494	-0.3803307	-0.2634689
	1.19	3.01(*)	3.56(*)	-1.48	-1	-1.45
GDP per capita	0.0144013		-0.081674	0.0687548	0.0668318	0.0494384
	0.36		-3.92(*)	2.7(*)	1.09	2.14(*)
Population of target age 3-5	0.0655057					
	1.64					
Population of target age 7-14		0.024242				
		4.23(*)				
Population of target age 15-17			0.0152094			
			1.15			
Population of target age 18-21				0.0183971		
				1.46		
Infant Population age 0-5					-0.0707302	0.1521145
					-0.52	2.99(*)
Elderly Population age above 65					0.0026239	0.1984968
					0.12	3.55(*)
Constant	-0.8139091	-0.4927546	-0.7135891	0.1691475	3.198522	-0.1963375
	-1.28	-1.98	-3.22(*)	0.58	0.74	-0.13
Observations	65	65	65	65	49	49
R-aquared	0.9974	0.9957	0.9845	0.9974	0.9981	0.9994

t>2.0(*)

All relevant variables in logarithms.

SUMMARY ON ASIA'S SOCIAL INFRASTRUCTURE DEMAND ESTIMATE: THE CASE STUDY OF THAILAND

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Population change was driven population policy since 1970 which applied a 'Family Planning Program' as main policy instrument. The family planning measure has been effective to reduce TFR (Total Fertility Rate)[1] has reduced from 6.3 in 1965 before introduced a family planning measure to be 1.6 person in 2010 respectively. Thai National population projection is quite stable at 64-66.4 million persons in the next 30 years, the population with age 65 year, approximately 9 percent of total population in 2553 will increase to 14 percent in 2021, and 20 percent in 2031 respectively. In addition, it is clear also that within the next 30 years most of population will reside in the urban area.

The changing population trend has called in a policy to increase population quality rather than numbers by a family planning program. In order to shift economic structure away from labor-intensive towards an improvement of labor quality and productivity[2], immigration of unskilled-skilled labor policy. More importantly, population policy has turned to human security, equitable income distribution[3] as well as gender gap, and raising quality of life for aged population.

ADB estimated the demand of Asia's economic infrastructure (power, water and sanitation, transport and telecommunication) from 2010 to 2020, which costs 8 trillion USD approximately, in a report "Infrastructure for a Seamless Asia" in 2009. JICA has agreed with ADB to conduct a research on an estimate for Asia's social infrastructure demand for the same period from 2016 to 2030 to complement ADB's demand estimate for economic infrastructure. Social infrastructure, such as schools and hospitals, is key capital investment to maintain social services and secure economic development of the region where the population is expected increase. The financial impact of the investment to public finance of each country would be also enormous.

The purpose of this research is 1) to estimate the investment demand of Asia's social infrastructure up to 2030 by two estimate methodologies namely a 'Micro' and 'Macro' approach. The research team has developed model for social infrastructure needs.

The demand for schooling, low cost housing, and health care services, and government buildings are designed as follows:

1 Number of average children at birth per a fertile mother

2 Measured by Total Factor Productivity (TFP)

3 Measured by 'Gini's Coefficients.

1) Under the trend of population change in Thailand, household demand for education given 'enrollment ratios assumption', the NESDB (2013)[4]has projected number of students from the *supply-side*. As Thailand is trying to escape from a Middle Income Trap syndrome, key determinants would be both physical as well as human capital development. The equilibrium 'enrollment ratios' is simulated to project the demand for labor by skills (occupation-education) by sector of production. The demand for labor by education was later translated into the demand for schooling by disciplines investment.

2) The demand for health care services and hospital facilities and physicians and other human resources depends on the aging structure of population. The model would predict the number of patient of non-communicable (NCD) and other patients. The translations of demand for health services into physical infrastructure and cost effective investment will be done by our designed model.

3) The housing need and affordability of low-middle income in Thailand has been main government policy. It is officially serviced by the National Housing Authority of Thailand. Middle-high income housing demand has been taken care by private housing market at large. In our study, we applied SES data base to estimate the demand for housing by income class. Some income class will be able to afford only 'rent-a-house' rather than mortgage.

The demand for housing for aged citizen may need new vision how to apply new technology for the amenity of aged people and how to design community for senior-new breed family living nearby in the same community.

4) The soft infrastructure demand for government building will be estimated by applying data base on how the social capital stock (the case of government building) is estimated by NESDB. We will apply a model starting from population resettlement under dimension of 'Urban-Rural'.

A. Social Infrastructure Needs Assessment

In our study, we have applied an econometric model to forecast the growth scenario of Thailand 2016-2030. The model has taken into account the policy inclusion of demand driven human capital development in Thailand. The rising demand for skills labor is key determinant to our growth on the coming decades.

Table 1 Base Line Scenario Forecast for Thailand 2016-2030.

Year	*Population (Thousand person)*	*GDP in current price Million USD*	*GDP per capita USD*	*GDP Growth in constant price %*
2016	67,454.69	407,960.00	6,047.91	2.99

4 Single year age population is applied.

2020	68,127.78	493,902.92	7,249.65	3.09
2025	68,502.23	639,170.02	9,330.65	3.58
2030 2016-2030	68,305.84 Average growth rate 0.084 % p.a.	848,921.12 Average growth rate 7.20 % p.a.	12,428.24 Average growth rate 7.03 % p.a.	4.15 Average growth rate 3.43%

Over the forecasting horizon 2016-2030, Thailand would be able to pick up depressed economic growth potential with average GDP growth rate of 3.43 percent p.a. Here, the per capita GDP will increase from 6,047.91 USD per person to 12,428.24 USD per person in 2030, given the population growth of 0.084 percent per year. The demand for social infrastructure would be significant issue in Thailand to reach the assumed growth target.

Social Infrastructure Demand for Schooling

1) The growth potential of Thailand in next decades would need to raise skills human capital by 1-1.5 percent during 2015-2030 while lowering the demand for unskilled labor respectively. The increase of human capital intensity is consistent with the GDP growth rates and GDP per capita. The assumption of enrollment ratios in this study is demand driven projection and consistent with the projection of human capital needs of skills labor over the horizon. The projected number of students signifying the social infrastructure needs of education and human capital investment as follows.

Table 2 Demand driven projection of Social Infrastructure Need: Education

year	GDP growth rates, % p.a.	GDP per capita (USD)	Enrollment Ratios, %			No. of Students (million persons)		
			Prim.	Second.	Tertiary	Primary	Secondary	Tertiary
2016	2.9	6,047	99.74	89.10	80.13	4.64	2.92	4.62
2020	3.0	7,249	99.80	89.52	81.77	4.45	2.86	4.32
2025	3.5	9,330	99.89	90.11	84.14	4.29.	2.69.	4.04
2030	4.1	12,428.	99.99	90.78	86.92	4.01.	2.57.	3.93.
2035	3.8	11,061	100.10	91.54	90.18	3.70	2.59.	3.72.
2040	4.1	13,758	100.23	92.40	93.98	3.36.	2.52.	3.47.

Social Infrastructure Demand for Low-Income Housing

Econometric estimates have found the following results:

1) The increase size of household would lead to lower tendency to rent a house for entire country, municipal area, and Bangkok area and vicinities.

2) The wealthier a household becomes they would likely to shift to purchase houses instead of

renting houses especially for who lives in Bangkok and cities area.When age of household head increases, person will have higher tendency to own a house. As people are gaining in age they accumulate assets and becoming wealthier. Thus, afford higher house price.

3) The low income household is those belong to the percentile 25. In order to assist the low-income household to purchase houses with 22-30 square meters, government may need to assist or subsidies such as reducing interest rates for home loan, and assisting construction costs. The affordable house price is THB 650,000 baht. A mortgage payment of 4,500 baht per month with 7% interest charge for 30 years payment is big burden for household with a monthly income of 15,000 baht.

4) The low income housing 10 years (2016-2026) development plan by NHA in cooperation with related organization in private sector and government sector for 1,707,437 household with budget for implement of 716,599.54 million baths or 21.391 billion USD (at current exchange rate of 33.5 baht per USD) or 2.139 billion USD per year. The investment plan consists of 4 categories:

(1) Quality of life improvement plan (rental) of 3-5 floors residential area, one bedroom with 28-32 square meters 91,657 units in Bangkok and perimeter area 45,359 units and in rural area 46,298 units. The ground floor of the building is 'Universal' design for the elder and handicapped.

(2) Strengthening the housing security plan (hire purchase) in amount of 421,034 units in the Bangkok and perimeter (condominium with 4-35 floors) 161,248 units and rural area (single house double house townhouse and condominium) 259,786 units.

(3) Government officer housing project in amount of 55,000 units in format of house for government officer in amount of 30,000 units and official residence in amount of 25,000 units.

(4) CODI in cooperation with the local government for the low income in amount of 1,044,510 units consists of Housing for the slum dwellers and urban low income in amount of 692,725.84 household.

Social Infrastructure Demand for Health Services

The study has found that 'patient bed- population ratio' in Thailand was still far from the OECD's level. Hospital in Thailand is equipped with 122,470 beds (1.9:1,000 populations) in public hospital. If the number of bed is added with private hospital of 34,602 beds, it is equivalent to 2.4:1,000 populations. This is much lower than developed countries such as Japan is 7.9:1,000 populations and South Korea of 6.4:1,000 populations respectively. Given the population projection 2016-2040 we have estimated the cost of investment of health services in terms of beds equivalent. In order to catch up with South Korea in 2040, Thailand has to invest 10,399 and 15,392 beds in 2030 and 2040 respectively. The investment cost is projected to be 51,993 and 76,962 million baht. It is equivalent to

Table 3 Social Infrastructure Needs: Health Services

year	No. beds (stock)	Ratio of bed per 10,000 population	New investment (beds)	Estimated cost of investment (million baht)	Valuation at current exchange rate of 33.5 baht per USD (in billion USD)
2016	156,128	23.90	6,005	30,025	0.900
2020	182,648	27.68	7,025	35,125	1.053
2025	222,219	33.48	8,547	42,734	1.232
2030	270,363	40.86	10,399	51,993	1.552
2035	328,938	50.33	12,651	63,257	1.896
2040	400,203	62.66	15,392	76,962	2.307

Note: 1) assuming constant cost investment over the horizon of 5 million baht per bed.

B. Cost of Social Infrastructure Investment

In order to surpass the "Middle Income Trap" Syndrome, productivity upgrading and human capital development would play significant role in the coming 15 years. Thailand needs intensive and continuous investment in social infrastructure in both of quantity and quality aspects. The total cost of social infrastructure investment in Thailand for 2016-2030 is estimated to be 84.083 billion USD or equivalently 0.94 percent of GDP. It is 82.11 USD per person on average during the forecasting horizon.

Investment in low-income housing comprising for ownership, rental house or provision a living in slump area of urban city shares quite a large proportion of social infrastructure need. The estimated investment requirement is as much as 47.25 billion USD or 0.53% of average GDP in current price.

The demand driven of gross enrollment is consistent with the human capital investment of skills labor over the horizon. Thus, the rates would be declined overtime as result of decrease population growth. The structural change has however changed over the period. That is to say, enrollment of primary students would likely to decrease rapidly. On the contrary, students in secondary and tertiary or university level would need to be increased. Especially, the social investment in skills formation education of Science and Technology would need to be increased substantially. The estimated cost of investment in changing education structure is estimated 18.88 billion USD or 0.21 percent of GDP. This is inclusive of only new buildings alone. If we include the demand for facilities, learning-teaching materials this could be further scaled up.

For public health in Thailand, under an "Aging Scenario", even though Thailand is well known for medical-services under the universal health care system, but there are still large gap for rural and urban services provision in the aging scenarios. Thailand is still lacking of advance facilities for non-communicable (NCD) in urban cities while rural household has still face needs accessibility and sufficient medical quality.

The estimation here did not taken into account the need for human resources such as medical doctors, nurses in rural area, and helper for elderly persons in coming decades. The cost of social infrastructure investment is estimated at least 17.94 billion USD or 0.20 percent of annual GDP.

Table 4 Estimated Social Infrastructure Needs for Thailand 2016-2030.

Year	***Schools (Million USD, %)***		***Hospitals (Million USD, %)***		***Housing (Million USD, %)***		***Government bldg. (Million USD, %)***		***Total Cost (Million USD, %)***		*Per Capita (USD/person)*
	Amount	***% of GDP***	***Amount***	***% of GDP***	***Amount***	***% of GDP***	***Amount***	***% of GDP***	***Amount***	***% of GDP***	
2016	660.02	0.16	896.26	0.22	2,138.29	0.52	14.36	0.0035	3,694.56	0.91	54.77
2020	971.55	0.20	1,048.49	0.21	2,578.05	0.52	11.44	0.0023	4,598.10	1.00	67.49
2021	1,045.27	0.20	1,090.43	0.21	2,713.34	0.52	10.72	0.0021	4,849.04	1.02	71.05
2022	1,122.57	0.21	1,134.05	0.21	2,860.48	0.52	9.73	0.0018	5,117.10	1.05	74.87
2023	1,204.90	0.21	1,179.41	0.21	3,020.29	0.53	8.74	0.0015	5,404.60	1.07	78.99
2024	1,293.48	0.21	1,226.59	0.20	3,193.70	0.53	7.76	0.0013	5,713.77	1.09	83.45
2025	1,389.42	0.22	1,275.65	0.20	3,381.78	0.53	6.76	0.0011	6,046.86	1.12	88.27
2030	2,019.87	0.24	1,552.03	0.18	4,590.55	0.54	1.53	0.0002	8,162.44	1.24	119.50
2016-2030	**18,884.80**	**0.21**	**17,946.27**	**0.20**	**47,252.39**	**0.53**	**126.54**	**0.001**	**84,083.47**	**0.94**	82.11

Institute for Economic and Social Research
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Executive Summary of Interim Report

Estimating the Demand for Social Infrastructure Investment in Indonesia[1]

Investments on transport, power, telecommunication, and water infrastructure remains crucial for a national development; however, these infrastructures are necessary condition but not sufficient to promote a future inclusive growth. Social infrastructure as sufficient condition will improve the quality of nation's human resource in form of quality level of education, health, and housing. Complementing a study of ADB (2017), this study aims at estimating the demand of social infrastructures (education, health and housing) in Indonesia up to 2030 and providing insightful policy recommendations to filling the gap. This study utilizes two approaches: 1) macro econometric approaches using both panel data of Asian countries and panel data of provincial level in Indonesia to estimate the demand of new infrastructure; 2) micro approach estimating a minimum standard of service that calculates the number of population and the unit cost. The new infrastructure investment demand is calculated by multiplying the estimated infrastructure stock by the standard unit price, while the maintenance cost is assumed based on the previous experience.

Following the framework of Fay and Yepes in 2003 and Ruiz-Nunez and Wei (2015) and using dynamic panel data of provincial level, this study found that over 15 years, Indonesia needs $2.6 billion annually or 0.29% of GDP for expanding of health infrastructure. Hospital requires most of this number, $34.5 billion (over 15 years), while health center only requires the other $4.8 billion. On the education sector, the investment reaches $21.9 billion, mostly for elementary school investment, or amounting only 0.16% of GDP. In addition, housing (including both public and private housing) requires $216.4 billion per year, and a total of $3,245.5 billion in 15 years, or 23.86% of projected GDP. Moreover, estimations using panel data of 40 Asian countries shows within 15 years, Indonesia will need $17.4 billion (or $1.2 billion annually). This accounts for 0.13% of projected GDP.

In order to complementing estimations of macro model, this study multiplies the national official minimum standard and the population projection from 2016-2030 to calculate the minimum standard services. Our study estimated that over the 15 years, Indonesia needs a total of $2.58 billion or $0.172 billion a year to fulfil social infrastructure demand. Most of this amount falls in health sector, which requires $0.01 billion per year, and a total of $1.46 billion in 15 years. It happened since Indonesia tries to fulfil the health facilities to support the national health insurance program. Furthermore, Education sector is at the second place and needs $0.074 billion annually. On the education sector, the investment reaches $1.11 billion. The challenges are then how to fulfil this social infrastructure gap in the term of financing and priority. This study will continuously elaborate on estimations as well as discussions with several stakeholders to provide an appropriate policy recommendation.

[1] Prepared by Teguh Dartanto, M. H. Yudhistira, Chairina Hanum, Andhika Pratama, Edith Z. W. Y., M. Sowwan

This paper is presented to the ADB-JICA joint seminar in Yokohama on May 5, 2017 on the occasion of ADB's Annual Meeting. The views expressed in this paper are those of the author(s) and do not necessarily represent the official positions of JICA.

Social Infrastructure Demand in Indonesia

The **purposes** of this research are:
1) to estimate the investment demand of Indonesia's social infrastructure up to 2030,
2) to estimate the investment demand of Indonesia's social infrastructure at regional level,
3) to provide policy recommendations to Indonesia to fill the projected gap of social infrastructure investment.

Social Infrastructure

- Education → Primary | Junior Secondary | Senior Secondary
- Health → Hospital | Community Health Center
- Housing → House ownership
- Government Building

Our Approach

- Province Data
- ASIA Data

Macro Approach ← Our Approach → Micro Approach

Population Projection

The Unit Costs of Each Social Infrastructure

	in Rp.	in USD
Education	2 billion	0.15 million
Community Health Center	7.5 billion	0.57 million
Public Hospital	35 billion	2.69 million

Projected Infrastructure Needs by Sector using WDI 2016-2030

Sector	Investment needs(USD Billion)	Annual average (USD Billion)	% of projected GDP
Education	17.9	1.2	0.13%
Primary	11.9	0.8	0.09%
Secondary	6.0	0.4	0.04%
Total	17.9	1.2	0.13%

Projected Infrastructure Needs by Sector using Population Projection Data, 2016-2030

Sector	Investment needs(USD Billion)	Annual average (USD Billion)	% of projected GDP
Education	8.53	0.57	0.63%
Health	4.54	0.30	0.33%
Total	13.07	Total	13.07

Projected Infrastructure Needs by Sector using Provincial Data, 2016-2030

Sector	Investment needs (USD bilion)	Annual average (USD bilion)	% of projected GDP
Education	22.5	1.5	0.17%
Elementary	14.0	0.9	0.10%
Junior high	7.4	0.5	0.05%
Senior high	1.1	0.1	0.01%
Health	40.5	2.7	0.29%
Hospital	35.6	2.4	0.25%
Health Center	4.9	0.3	0.04%
Housing	3335.6	222.4	24.52%
Government building			
Total	3398.6	226.6	24.98%

" *Estimating the Demand for Social Infrastructure Investment in Indonesia* "

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Appendix. Social Infrastructure Demand in Indonesia

01 Estimation Result for Each Social Infrastructure Stocks

Makro-approach

		Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Indonesia	Education	New	0.2	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.7	0.7	0.7	0.7	9.0
		Maintenance	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	13.5
	Health	New	0.6	1.1	1.3	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	3.1	29.8
		Maintenance	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	10.7
	Housing	New	20.6	18.5	14.8	13.9	13.6	11.9	12.0	12.0	11.9	11.7	8.1	7.9	7.8	7.7	7.6	180.0
		Maintenance	35.8	207.6	210.5	213.0	215.4	217.8	220.0	222.2	224.4	226.6	228.9	230.7	232.4	234.2	236.0	3155.6
	Sub-total	New	21.3	20.1	16.7	16.0	15.8	14.2	14.5	14.6	14.6	14.7	11.2	11.2	11.2	11.3	11.4	218.9
		Maintenance	37.1	208.9	211.8	214.4	216.8	219.3	221.5	223.8	226.1	228.3	230.6	232.5	234.4	236.2	238.1	3179.8

Mikro-approach

		Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Indonesia	Education	New	0.14	0.12	0.12	0.12	0.11	0.09	0.07	0.08	0.07	0.07	0.05	0.04	0.03	0.02	-	1.11
		Maintenance	0.48	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.49	7.42
	Health	New	0.12	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.08	1.47
		Maintenance	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.22	3.07
	Housing	New	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	2.6
		Maintenance	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	10.5

TECHNICAL NOTE ON THE ESTIMATION OF INFRASTRUCTURE DEMAND FOR FLOOD CONTROL

"Bridging the Infrastructure Gap in Asia," ADB-JICA Joint Side Event at the 50th Annual Meeting of the ADB Board of Governors

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1. Introduction

Each country decides the scale of its investment in flood control based on various factors, such as the scale and frequency of flood disasters, the assets accumulated in areas at risk, and the level of community concern about potential disasters. The experience of selected countries shows that governments allocate budgets for flood control according to historical records of the impact of the most severe disaster on the national economy. Countries can turn a flood disaster from a crisis into an opportunity to expand investment in flood control. The Japanese experience over the last one and half centuries shows that the country has increased flood control budgets every time it has suffered from a major disaster. Experience also shows that budgets for flood control have a positive correlation with urbanization and gross domestic product (GDP) per capita. Based on this experience, investment for flood control in the Philippines is estimated at USD 33-61 billion until 2030. These analyses are useful for estimating the requirements for infrastructure investment for flood control in Asian countries.

2. Relationship between flood control investment and flood damage

Each country decides the scale of its investment in flood control according to the impact of the most severe disaster on the national economy in the past, rather than on the average level of flood damage experienced over time (Table 1). Mega-disasters often become triggers to expand investment in flood control. Japan has repeatedly experienced enormous flood disasters caused by typhoons and heavy rainfall since the Second World War. The economic damage caused accounted for over 10% of national income in 1947 and 1953 for example, and as a result, the Japanese government invested

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0.6-1% of GDP for flood control until the mid-1960s to mitigate flood damage. The Netherlands spent 1% of GDP on flood control in 1960 following the catastrophic North Sea flood of 1953. This disaster caused 1,853 casualties and economic damage of some 0.7 billion Euros. Currently, flood damage in the Netherlands and Japan has decreased to 0.02% and 0.06% of GDP, respectively. Yet, these two countries are continuing to make high level of investments of some 0.2% of GDP for flood control. The Netherlands is also increasing its budget for flood control to prepare for potential disasters caused by climate change.

The Philippines, China, UK, and Indonesia have increased their flood control budgets in the past several years as a reaction to the enormous damage from recent disasters. The scale of their investments is also dependent on the magnitude of these disasters. The Philippines and China allocate some 0.4% of GDP, and the maximum economic damage experienced has been 1.3% and 3.5% of GDP, respectively. The UK and Indonesia allocate 0.2 % and 0.06 % of GDP respectively, and the maximum damage experienced has been some 0.2% of GDP. The flood control budget of US Army of Corp Engineers accounts for some 0.01% of GDP. This may seem a low level of investment considering the economic damage of 1% of GDP from Hurricane Katrina in 2005, but it is because only the US federal government budget figures are available; state government budgets are not included.

Table 1: Flood control investment and flood damage in selected countries

Country	Investment % of GDP		Damage % of GDP		Event causing maximum damage	Budget data period
	maxi-mum	mini-mum	maxi-mum	average*		
Netherlands	1.0	0.06	10.6	0.02	1953 High Tide	1960 & 2006-2013
Japan	0.99	0.18	10.2**	0.06	1947 Typhoon	1955-2015
Philippines	0.44	0.06	1.3	0.63	1993 Typhoons	1990-2016
China	0.37	0.15	3.5	0.31	1998 Flood	2000-2015
UK	0.2	0.08	0.2	0.08	2013 Flood	2000-2015
Indonesia	0.06	0.04	0.2	0.1	2007 Flood	2006-2012
USA	0.01	0.01	1.0	0.3	2005 Hurricane	2007-2017

* average annual damage from 1996 to 2015, ** % of National Income.
Sources: Cabinet Office (2015); Darwanto (2012); Department of Budget Management of the Philippines; IMF's World Economic Outlook Database; Japan Institute of Country-ology and Engineering (2011); Kok et. al (2012); Kreft et. al (2015); Ministry of Water Resources of People's Republic of China (yearly); Ministry of Finance of Japan; Office of Civil Defense of the Philippines; Priestley and Allen (2016); Research Center for National Land Development (2006); Statistics Netherlands; U.S. Army Corps of Engineers (yearly); Zhong (2016).

Table 2: Japanese flood control budget by decades from the 1880s to the 1930s		
Decade	**Total budget for flood control and rehabilitation (Billion JPY, 1995 prices)**	**Events**
1880s	179.3	1885 major flood in Osaka
1890s	374.3	1896 Major floods throughout the country 1896 Enacted River Law
1900s	518.7	
1910s	831.1	1910 largest flood in Meiji Era 1911 First long-term plan for flood control
1920s	820.4	1921 Second long-term plan for flood control 1923 Great Kanto Earthquake
1930s	1,400.7	Takahashi expansionary financing following the Great Depression 1933 third long-term plan for flood control Increasing military budget
Source: Research Center of National Land Development (2006), modified by the authors.		

3. Trends in Japanese investment for flood control from the late 19th Century

The Japanese experience shows that the country has increased investment in flood control by taking the opportunity to do so after major disasters. Japan has increased flood control budgets through developing legislation, long-term investment plans, and special accounts following major flood disasters during the modernization process from the late 19th century until the mid-20th century. The budget for flood control for each decade increased by eight times from the 1880s to 1930s (Table 2). However, these budgets were less than the economic damage from floods for most of the period before the Second World War (Figure 1).

The national government started projects for flood control in 1885 on the Yodogawa River in Osaka and Kyoto prefectures, following a flood disaster. This flood submerged most of Osaka City, and affected some 270,000 people, resulting in economic damage estimated at 4.4% of the then National Income. Before this disaster local governments had conducted flood control projects, but flood control works in major rivers required high-technology inputs and enormous budgets that local governments could not meet.

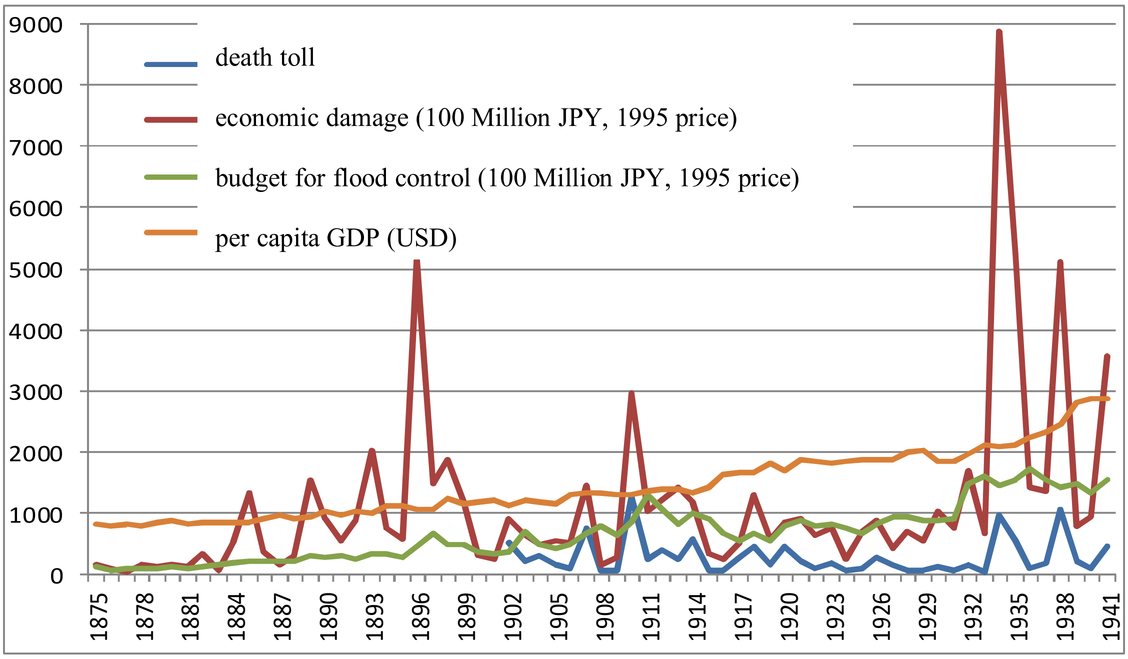

Figure 1: Investment for flood control before the Second World War

Source: Research Center of National Land Development (2006), The Maddison-Project, http://www.ggdc.net/maddison/maddison-project/home.htm, 2013 version.

A River Law was enacted to mitigate flood damage in 1896 when flood disasters impacted on communities throughout the country. This law stipulated that the national government could conduct flood control works covering multiple prefectures, while prefectural governments were in principle responsible for flood disaster management.

The government formulated the first long-term plan for flood control in 1911, recognizing the necessity for long-term commitment to flood control. Flood disasters in 1911 left some 2500 people dead or missing, and economic damage accounted for 3.6% of National Income. The long-term plan covered works in 50 major river basins for 18 years. Also, the government created a special account to manage financing that included shares by local government, and loan programs from postal savings.

However, the government could not always secure budgets for flood control because of inflation in the 1910s, rehabilitation efforts following the Great Kanto Earthquake in 1923, and the impact of the Great Depression in 1929. Furthermore, in the 1930s, the government allocated the major portion of the national budget for military expansion instead of public works. Because of limited investment in flood control the country suffered from serious floods following the Second World War. Annual economic damage from the floods was between 1 and 10 % of National Income from 1946 until 1959 (Figure 2).

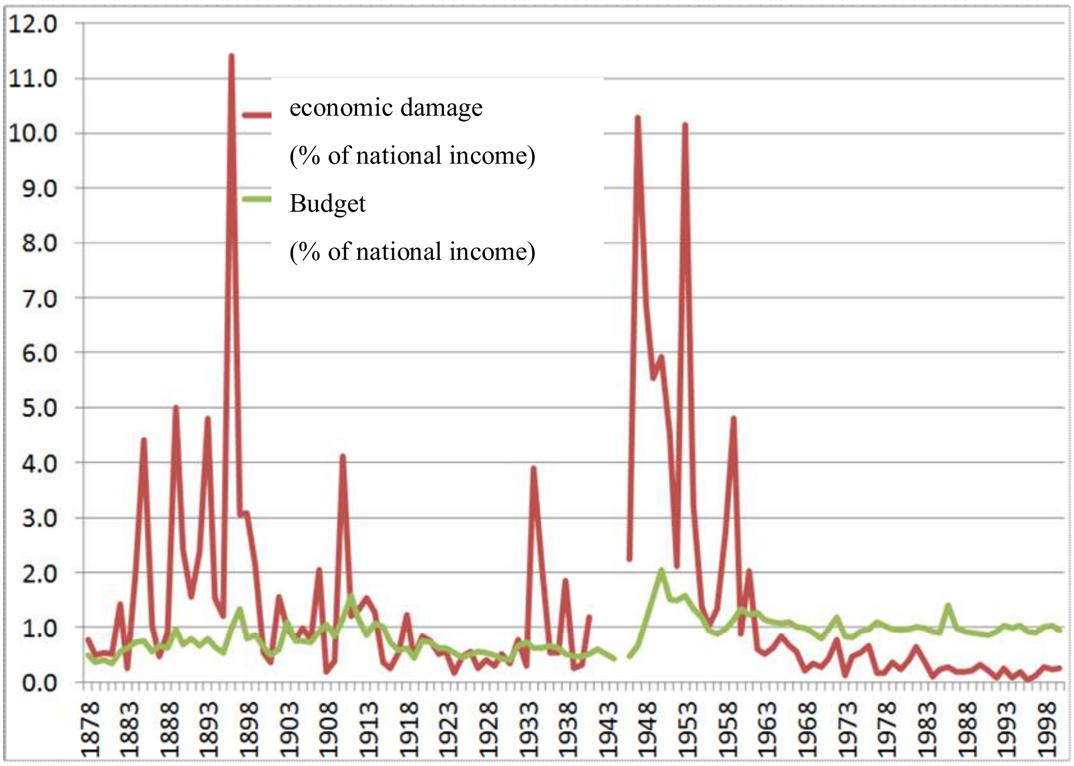

Figure 2: Trend of flood damage and flood control budget (1878-2000)

Source: Research Center or National Land Development (2006).

Because of the intensive budget allocation, economic damage substantially decreased to 0.1% of National Income. Following a serious of serious flooding in the 1940s and 1950s the government increased the flood control budget accordingly, to about 1% of National Income (more than the cost of flood damage in most years), until now to protect the assets increasingly accumulating in risk areas. This budget level shows a positive correlation with urbanization and GDP per capita (Figure 3). Tsukahara and Kachi (2016) estimated the annual benefit from flood control investment at over 6 trillion JPY, or 55 billion USD, in the mid-1990s. This was almost double the budget for flood control.

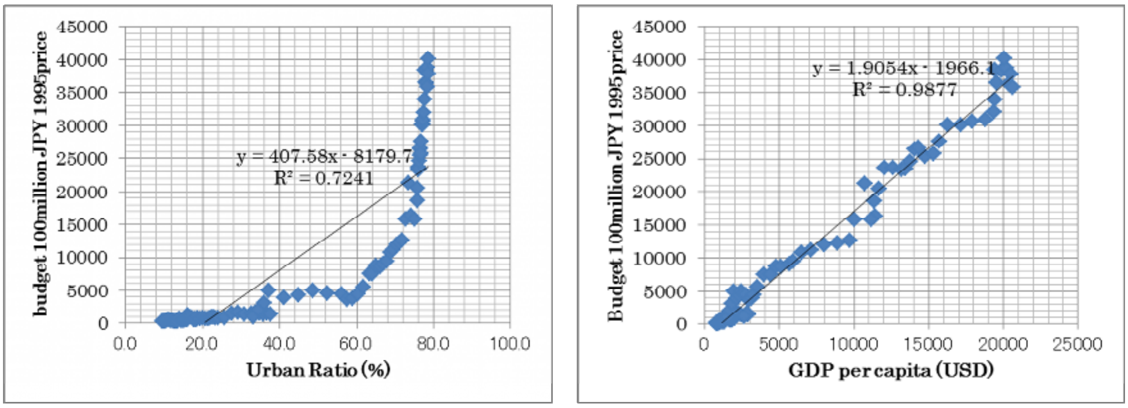

Figure 3: Relationship between budget for flood control and (a) urban ratio (1893-2000) and (b) per capita GDP (1875-2000)

Source: Research Center of National Land Development (2006), The Maddison-Project, http://www.ggdc.net/maddison/maddison-project/home.htm, 2013 version, Statistical Bureau of Japan.

4. The Philippines is increasing investment on flood control.

The Philippines is rapidly increasing its national budget for flood control following a serious of typhoon disasters in recent years. The government increased the budget by 10 times from 2008 to 2016 (Figure 4). Typhoons Ondoy and Pepeng caused serious floods and landslides in Metro Manila and Luzon Island in September and October 2009. The total economic damage was estimated at PhP38 billion, or 0.5% of GDP. Following 2009, several typhoons continuously caused serious damage. In particular, Typhoon Yolanda caused a high tide disaster in the Leyte Islands, resulting in economic damage of PhP95 billion, or 0.8% of GDP.

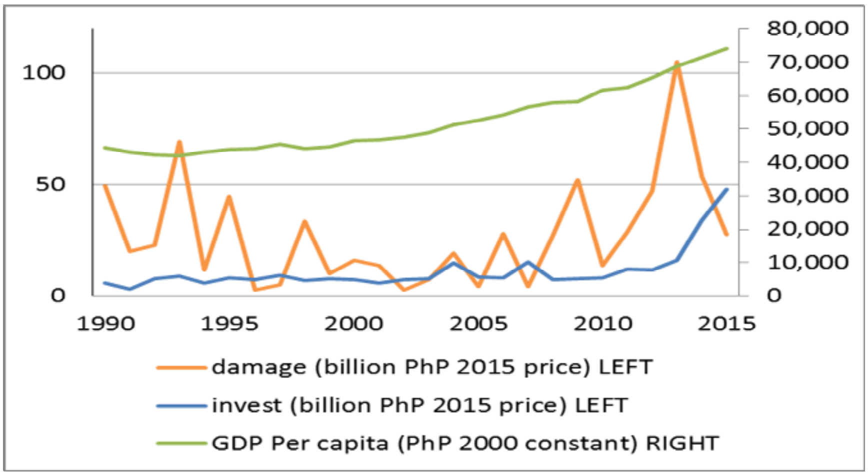

Figure 4: Trends of flood damage, flood control budget, and GDP per capita in the Philippines

Source: Department of Budget Management of the Philippines and ADB.

The demand for flood control investment was estimated at USD 33-61 billion, or PhP1.5-2.8 trillion from 2016 until 2030 by applying two methods: (a) increasing budgets at the same pace as GDP growth as a lower estimation, and (b) using the results of a multiple regression model as an upper estimation (Figure 5). This investment scale is equivalent with 0.45 to 1.08% of GDP in 2030. The upper estimation of 61 billion USD is almost double of the lower estimation of 32 billion USD because it is based on the recent rapid growth in the actual budgets.

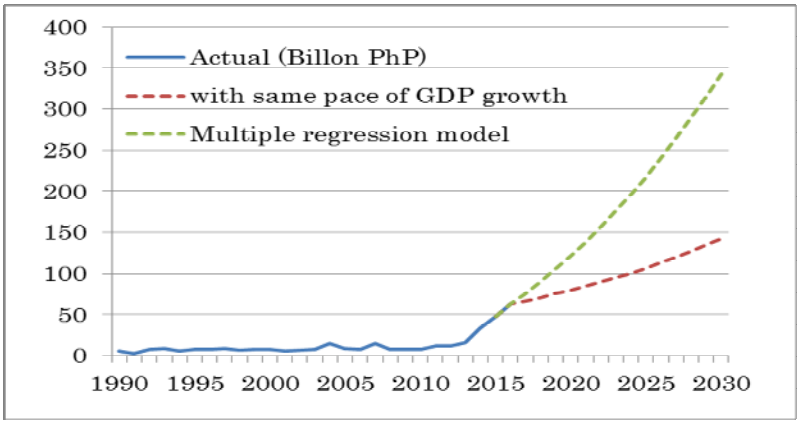

Figure 5: Estimate of infrastructure investment for flood control in the Philippines
Source: Department of Budget Management of Philippines, and the authors.

Urbanization, growth of GDP per capita, and budget of previous year are used as explanatory variables for the regression model. The ADB uses several variables, including lagged values of the infrastructure stock, GDP per capita, shares of agriculture and industrial value-added in GDP, the urbanization rate, and population density, to estimate infrastructure investment. Among these variables, the budgeted amounts for flood control are correlated with changes in urbanization, GDP per capita, and previous year's budget. Urbanization increases the potential for flood damage. For example, while the built-up area increased by 50% from 2008 to 2015 in Davao city, the area at risk increased by more than 200% (Figure 6). The R^2 value for the regression model used here is 0.909, and the adjusted R^2 value is 0.896.

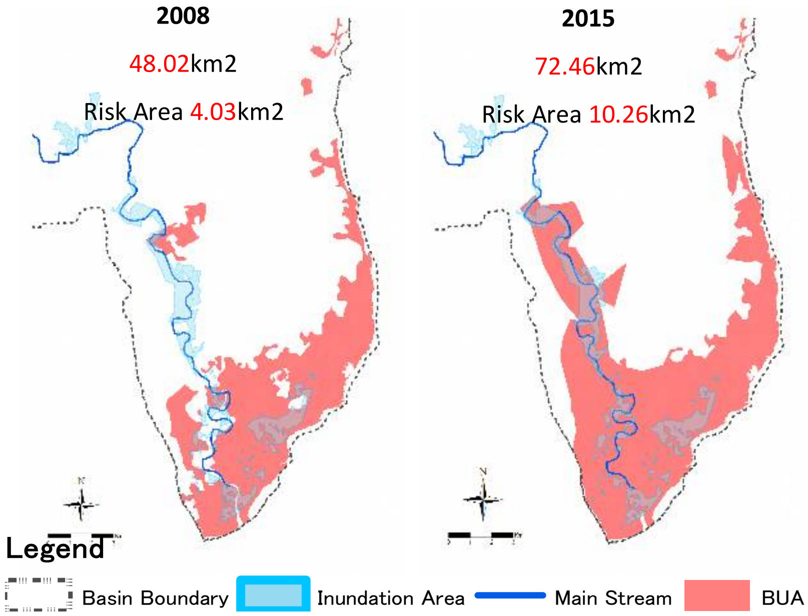

Figure 6: Change of risk area in Davao

Source: JICA (2008), Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

The investment will pay off. Figure 7 shows the results of the economic analysis of investment using the upper estimation model. At the early stage of investment, the cost exceeds the benefit. However, as per capita GDP grows, the benefit exceeds the cost because the asset density of the protected area increases. The balance (benefit minus cost) accumulation becomes positive in 2025. The ratio of benefit per cost until 2030 is estimated at 1.92. Total benefit is assumed from the average benefit of the flood control projects recently planned in the Philippines.

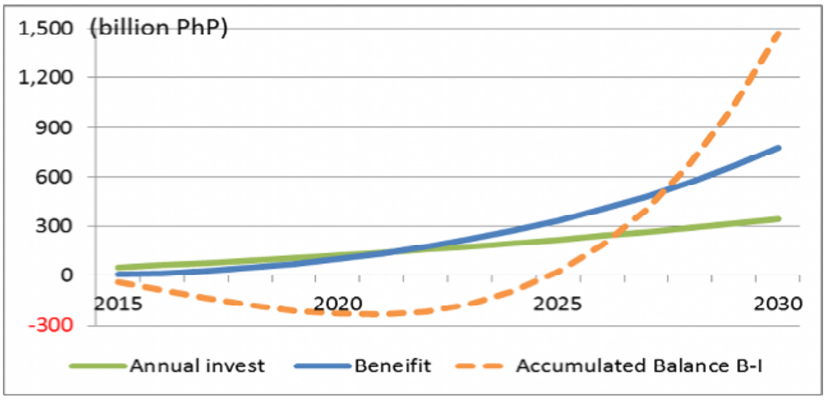

Figure 7: Benefit of investment

Source: The Authors.

5. Conclusion

The relationship between flood control budgets and the level of flood damage was examined in Japan and selected countries in this note. These countries decide on the scale of their flood control investment based on the disaster that had most impact on the national economy in the past. Japan and some other countries have turned these disasters from crises into opportunities for expanding this type of investment. Demand for flood control infrastructure in the Philippines is estimated at 32-61 billion USD using multiple regression analysis and the growth of GDP. The investment will pay off, since the asset value in risk areas will increase because of urbanization and economic growth. This estimation shows a continuous rapid increase of the budget. Financing arrangements and strengthening the implementation capacity for flood control are challenges.

As the next step, the level of the investment in the infrastructure required for flood control will be estimated for other Asian countries. Policy recommendations on how to secure the enormous financial resources for flood control infrastructure in these countries will be examined.

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Technical Note on Micro Estimation of Urban Railways and High-Speed Railways Investment Needs

"Bridging the Infrastructure Gap in Asia" ADB-JICA Joint Side Event at the 50th Annual Meeting of the ADB Board of Governors"

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1. Introduction

Recent economic development and population growth in Asia has caused traffic congestion and corresponding air pollution, negatively impacting the urban environment.

One effective method for dealing with traffic problems in cities is to improve public transportation systems such as urban railways. Urban railway networks such as MRT (Mass Rapid Transit) are both started and expanded in countries such as India, Malaysia, Thailand, and the Philippines. Furthermore, MRT operation in countries such as Vietnam, Indonesia and Bangladesh will begin in near future, and in Cambodia, an urban railway plan has been proposed by a JICA survey. Recently, the development of railway systems in Asian is increasing.

High-speed railways, responsible for high-speed mass transport between cities, are also being developed. Currently, some countries like India, Thailand, Malaysia-Singapore, Vietnam, and Indonesia are planning their high-speed railway projects and are proceeding to the implementation stage.

Developing countries have few previous experiences introducing urban and high-speed railways. It is difficult to assess the current demand through macro estimations. For this reason, this research study estimates the overview of the plans in Asian countries. I believe that the results of this survey will help to estimate the future demand for railway systems in Asia.

2. The growth of Asian countries and the trend of railway needs

Before estimating urban railway and high-speed railway investment needs, I explain in this chapter recent growth and railway demand in Asia. I also highlight points to be considered when assessing long-term demand in the future.

2-1 The growth of Asian cities and the trend of railway needs

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The growth and development of Asian cities is remarkable.

As one example, I show the increase of traffic in the city of Phnom Penh in Cambodia in Figure-1.

In Phnom Penh, Japan International Cooperation Agency (JICA) conducted a Person Trip Survey (a household survey focusing on traffic conditions) in 2000 and 2012.

The traffic volume in Phnom Penh city has increased by 2.5 times from 2000 to 2012. In particular, the rapid growth in the volume of motorcycle traffic in 2012 far exceeds former study's prediction.

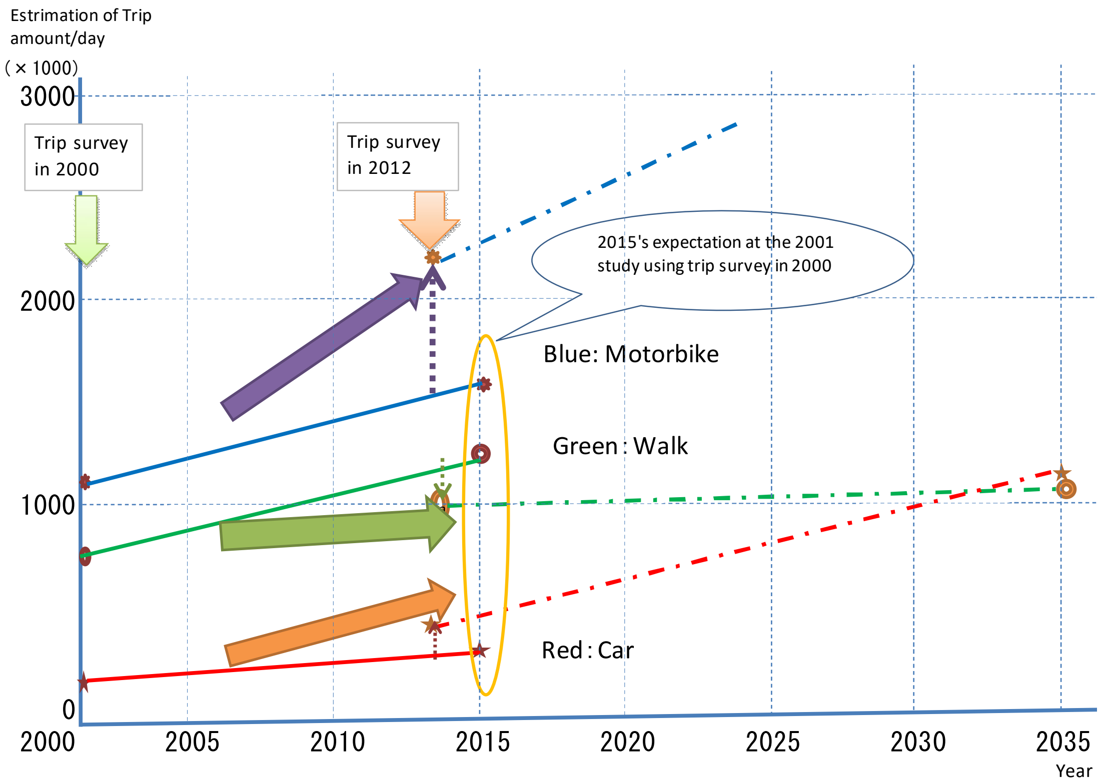


Figure-1 Phnom Penh urban transportation Study case

Next, Figure-2 shows how the development phases of the cities are related to the timing to start operating their metro systems in Asia. The trends of urban population and GDP per capita are plotted in the figure. The solid line shows US$ 3 billion of the product of per capita GDP multiplied by urban population. Dotted line shows US$ 30 billion of that. In JICA's survey, the time to start the metro operation in the respective cities (These cities are shown by cross marks) mostly falls between two lines. Currently, there are cities such as Quezon (the Philippines), Yangon（Myanmar）, and Hai Phong (Vietnam) in this range, and Phnom Pen is approaching this range(These cities are shown by circle marks). This indicates that railway construction plans will start in many Asian cities in the near future.

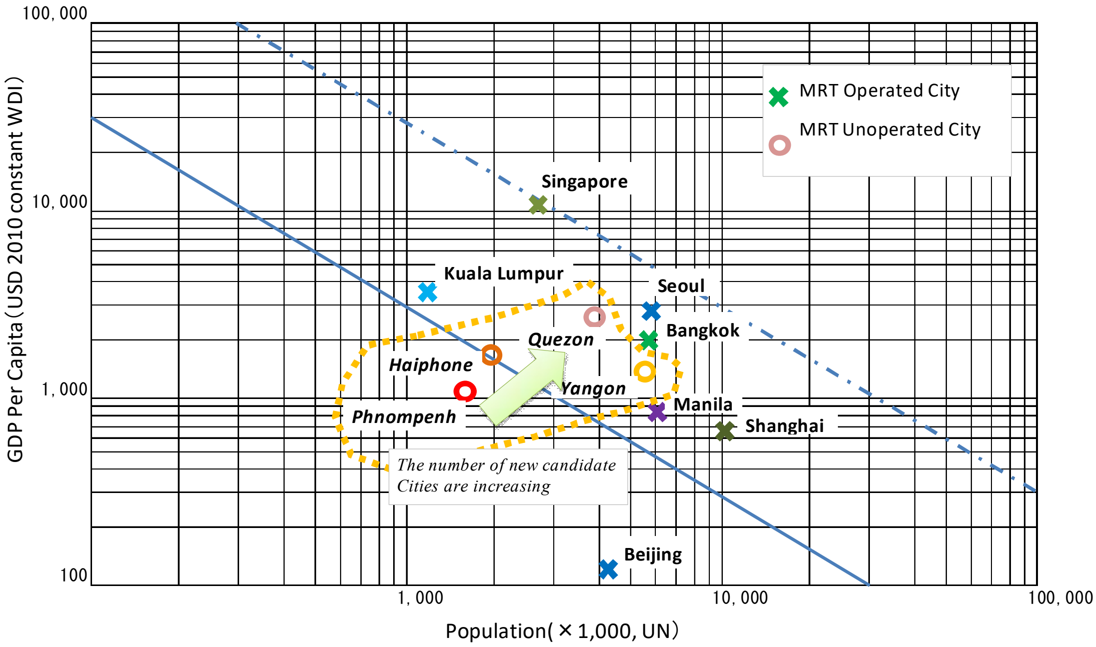


Figure-2 Per Capita GDP and Urban Population at the Time of MRT Introduction

Note: The red solid line indicates the GRDP of US$3 billion and the dotted line the GRDP of US$30 billion (constant 2010US$). GRDP of each city is calculated by multiplying the city population by GDP per capita.

Source JICA Report : The Research on Practical Approach for Urban Transport Planning 2011

In this micro estimation, I find and summarize the existing plans. However, most existing plans will be completed by around 2023. It is also necessary to consider the forecasted demand in cities where plans are considered afterward that point.

2-2 Impact of high-speed railway and issues to consider

Demand for high-speed railway in the Asian region is increasing as the demand for mass transportation between large cities increases. In this research, I summarize existing plans for high-speed rail, which is necessary—as is true of urban railways—to estimate the long-term demand for high-speed railways in these areas.

However, high-speed railways require high investment, operation costs and technologies for operation and maintain the system. To facilitate high-speed railway investment, it is necessary to consider various conditions for appropriate management and investment recovery. For this reason, I think that predicting future plans is more difficult than pridections for urban railways. In this chapter, I will discuss an example showing the importance of considering the profitability of high-speed railways.

High-speed railways are used for inter-city transport. The competitor for this service is airplane. The benefit of the high-speed railway, it is not only transportation for between the starting and ending points, but also for dealing with various intercity transportation on the way. In order to raise the value of the high-speed railway, it is also important to develop urban area along railway lines and increase the intercity transportation on the way.

See Box Articles

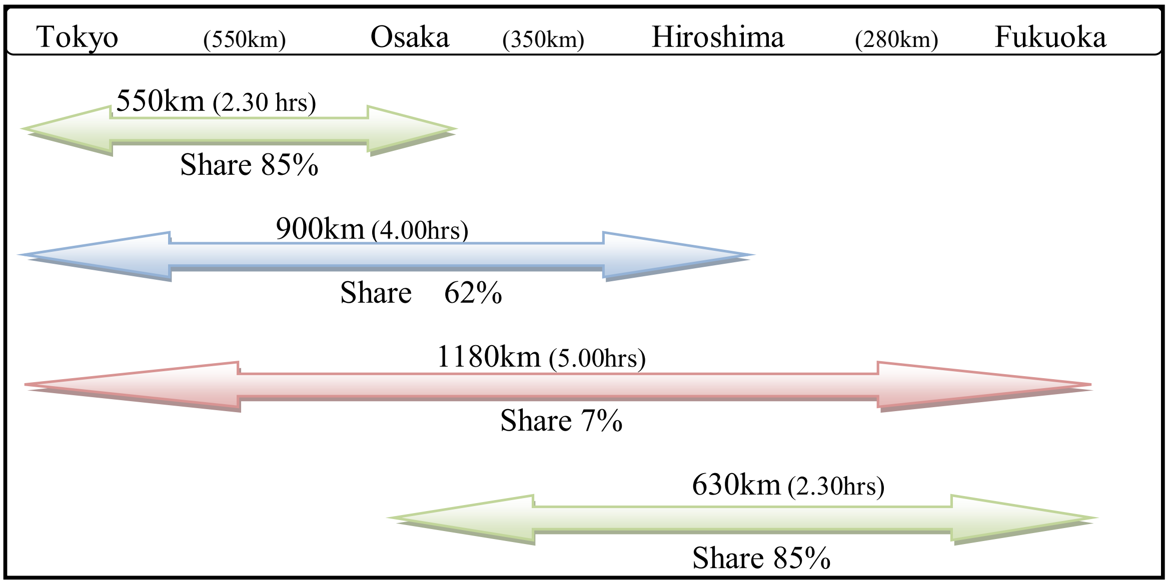
Box Articles: Japanese Shinkansen Experience

(1) Japanese experience; Shinkansen and airplane share

(Note : Shinkansen is Japanese High-speed Railway)

Between Tokyo-Hiroshima city, it takes 4 hours by Shinkansen. Shinkansen has been competing with airplanes to get share of passenger in this section. For destinations closer than that, the share of the Shinkansen is larger. There is only 7% Shinkansen share between Tokyo and Fukuoka where the traveling time is 5 hours.

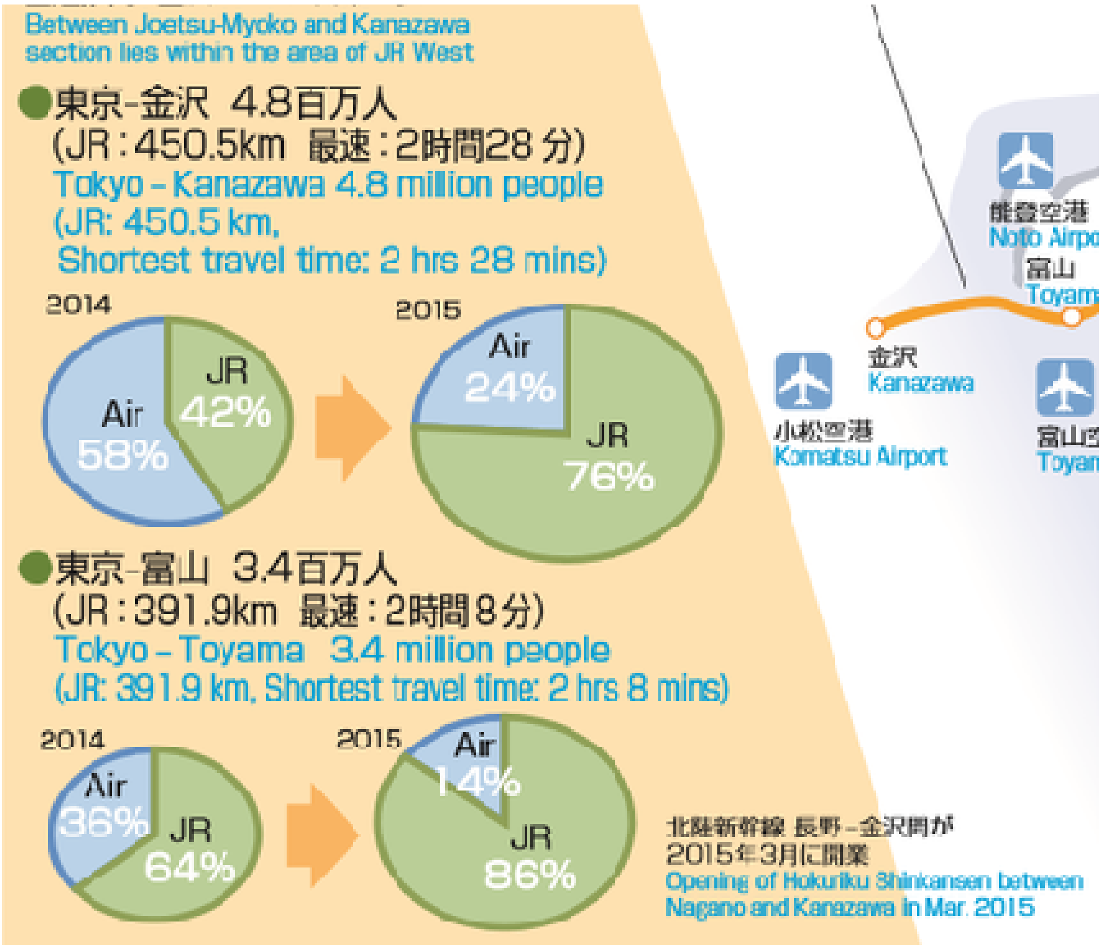
The role of the Shinkansen to deal with various intercity transportations is more important than linking Tokyo and Fukuoka.



Source: JR West Fact Sheet 2016

(2) Impactt of Hokuriku Shinkansen

Hokuriku Shinkansen started it operation in 2015, and has impacted the choice of travel mode. The Hokuriku Shinkansen connects Tokyo to Toyama and Kanazawa in two to two and a half hours, respectively. It can be seen that the percentage of travelers using airplanes versus Shinkansen（Japan Railway : JR) has changed drastically before and after the opening of Hokuriku Shinkansen.



Source : JR East Fact Sheet 2016

Thus, in order to realize a high-speed railway, it is necessary to consider various conditions.

3. Estimation method

I took the following measures to detail each plan:

1) I extracted plans for urban railways and high-speed railways from governments' announcements, news articles, specialty magazines such as Railway Journal, JICA development survey, etc.
2) Based on the above information, I confirmed the official announced plans of the national government, city, and specialty companies like MRT company, or these media reports.
3) Based on information acquired through the public announcements, I extracted information such as project titles, contents of the plans (scale of the projects, routes, project costs, construction periods) and approval information.
4) I assigned the following rank to each project

"A": Construction stage or the plan approved

"B": Detailed information released to the public.

"C": Concept stage, with at least the planned route cleared

Note: In this case, I calculated the cost using the unit price (avarage) of the project in the country or in a neighboring country.

"D": Only the names of plans were mentioned and their contents could not be confirmed

4. Result

The Result of Case 1 (A + B) and Case 2 (A+ B+ C) are shown below.

For reference, I also compared the total infrastructure demand estimate and traffic infrastructure estimate shown by ADB.

(1) Case 1 （A+ B）

(a) Total High-speed railways and Urban railways

	Investment (USD billion)	ADB Trans %	ADB Total %
HSR + URT	1438	17.22%	5.53%
Exclude China	216	2.59%	0.83%
Exclude China and India	97	1.17%	0.37%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100%

(b) Urban railways

	Investment (USD billion)	ADB Trans %	ADB Total %
URT	865	10.36%	3.33%

Exclude China	128	1.53%	0.49%
Exclude China and India	64	0.77%	0.25%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100%

(c) High-speed railways

	Investment (USD billion)	ADB Trans %	ADB Total %
HSR	573	6.86%	2.20%
Exclude China	88	1.06%	0.34%
Exclude China and India	33	0.40%	0.13%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100.00%

(2) Case 2 （A+ B+ C）

(a) **Total High-speed railways and Urban railways**

	Investment (USD billion)	ADB Trans %	ADB Total %
HSR + URT	1766	21.14%	6.79%
Exclude China	542	6.49%	2.09%
Exclude China and India	172	2.07%	0.66%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100%

(b) Urban railways

	Investment (USD billion)	ADB Trans %	ADB Total %
URT	912	10.92%	3.51%
Exclude China	175	2.10%	0.67%
Exclude China and India	77	0.92%	0.30%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100%

(c) High-speed railways

	Investment (USD billion)	ADB Trans %	ADB Total %
HSR	854	10.22%	3.28%
Exclude China	367	4.40%	1.41%

Exclude China and India	95	1.14%	0.37%
ADB 2030 Transportation	8353	100.00%	32.13%
ADB 2030 Total	26000		100.00%

From these results the following was extracted:

1) As for Case 2, in relation to the urban and high-speed railways, construction demand is estimated at 1.8 trillion USD for Asia, including China, which is a substantial amount. By comparing the total infrastructure demand of US$ 26 trillion estimated by ADB, the total amount of urban and high-speed railway plans is around 6.79%. This indicates that active investment in the Asian region is taking place.
2) As for Case 2, the scale of these investments between 2016 and 2020 - as most of the available project information relates to these years - is equivalent to 1.1% of the GDP of Thailand, 0.17% of Indonesia's GDP, and 0.26% of the GDP of the Philippines.
3) Most of the existing urban railway plans (Ranked A, B) will be completed in 2023. In most developing countries, it was difficult to identify next plans or visions with clear policy.
4) Some high-speed railways in developing countries adopt a sub high-speed railways (Operates at a speed of 100 to 160 km / h through the improvement of existing railways) at the implementation stage. It is assumed this is based on the financial condition of each country, the construction and operation costs, and so on.

5. Consideration

In this estimation, I compiled, analyzed the plan contents of existing urban railways and high-speed railways. The following points are areas where further consideration is necessary.

1) For urban railways, most of the developed plans are scheduled to be completed by 2023. From now on, we should think about demand as of 2030.
2) For high-speed railways, it is also necessary to consider demand through 2030, taking into consideration the matters stated in 2.(2).

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