Investing in Disaster Risk Reduction: Scale and Effect of Investment in Flood Orotection in Asia

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Abstract

Investment in disaster risk reduction (DRR) is indispensable for enhancing resilience and for achieving sustainable development. Therefore, understanding the current scale and effects of DRR investment is crucial for promoting DRR investment. This paper analyzes the current scale and trends of investment in flood protection and investment efficiency in Asia. The findings show that major flood-prone economies in Asia recently invested USD57 billion per year in flood protection, accounting for 0.26% of the total GDP of these economies. The total investment of nine developing economies accounts for 4.2% of their infrastructure investment. Low-income economies are unable to invest significantly in flood protection due to financial constraints and the need to invest in other priority areas. However, once economies reach the low-middle income stage, they have more financial leeway and can start increasing investment in flood protection. Asian economies have been investing efficiently in flood protection, with the benefits of investment increasing more than economic development and investment.

1. Introduction

Investment in disaster risk reduction (DRR) is indispensable for enhancing resilience and for achieving sustainable development. The guiding principle of the Sendai Framework for DRR stresses that disaster risk-informed investments are more cost-effective than primary reliance on post-disaster response, and recovery, and contribute to sustainable development (UNISDR 2015). The Yangon Declaration: The Pathway Forward was adopted at the Third Asia-Pacific Water Summit in 2017 by 20 heads of state, 15 ministers responsible for water issues, and other leaders. The declaration includes the goal of doubling investment to address water-related disasters and to increase water security in the Asia-Pacific region (Asia Pacific Water Forum 2017).

Floods are the most serious type of disaster in Asia, and the region is the most vulnerable to water-related disasters in the world. In 2016, they accounted for nearly half of all economic damage and over 60% of people killed as a result of all disasters in the region (Asian Disaster Reduction Center 2017). Nearly 2,500 water-related disasters struck the region between 1995 and 2015, killing some 332,000 persons and affecting a further 3.7 billion. Annual economic damage from water-related disasters including droughts is estimated at about USD 53 billion, with a death toll of 16,000 per year (Asian Development Bank 2016).

Understanding the current scale and effects of DRR investment is crucial to promoting DRR investment, as poolicymakers and decision-makers need this information to determine proper investment in DRR. However, the current scale of DRR investment is unclear among countries due to the limited availability of investment data. Moreover, what qualifies as DRR investment varies from country to country, with not all governments making budget data on DRR available, thus making comparisons challenging.

This paper analyzes the current scale and trends of investment in flood protection and investment efficiency in Asia. The paper begins with a literature review of investment in flood protection and economic damage, followed by an examination of the current scale of investment scales in Asia and the effects of this investment[1].

[1]This paper has been prepared as a part of the research project “Research on Demand Estimate of Infrastructure in Asia” conducted by the JICA Research Institute. The views expressed in this paper are those of the author and do not necessarily represent the official positions of JICA.

2. Investment in flood protection

A World Bank technical report estimates the annual costs of flood protection to be USD14.76 billion and the annual costs of climate change adaptation at USD1.74-3.21 billion over the period 2010-50 for developing countries in East and South Asia and Pacific regions (Ward et al. 2010). These costs are estimated theoretically without examining actual investment. The estimated costs cover flood protection works against the 50-year monthly flood in urban areas and the 10-year monthly flood in agricultural areas. It is assumed that no flood protection is in place in 2010 and that all protection works will be completed before 2050.

Various studies analyze the relationships between economic damage, economic development, and other factors. However, these studies do not examine actual investment data, nor study the relationships between investment and damage.

It can be concluded from recent studies that economic damage caused by disasters is increasing around the world, because more people and capital are located in hazardous areas (Kousky 2014). At the country level Raschky (2008) finds that there is a non-liner relationship between economic development and economic damage caused by disasters and that economic development can reduce damage, but at a diminishing rate. In addition to economic development, higher educational attainment, greater openness, a strong financial sector, and good institutions are important for reducing disaster-related deaths and economic damage (Toya and Skidmore2007). Neumayer, Plumper and Barthel (2014) find that economic damage from floods is smaller for countries where there is an expectation of high probability and large magnitude floods. This is because these countries are encouraged to invest more to mitigate damage. Kellenberg, and Mobarak (2008) find that the number of deaths from floods increases along with increases in GDP per capita until it reaches USD5,044 and then declines.

3. Current investment in flood protection

3.1 Data Collection and definitions

Budget data of flood protection and economic damage caused by floods were collected in twelve disaster-prone economies in Asia. Investments in flood protection by these economies are considered to comprise the majority of such spending in the region. All high-ranked economies in terms of economic damage by floods are

included as shown in Table 1. Total population and gross domestic products (GDP) of these economies account for some 90% of regional totals.

Table 1 Recent investment and global rank of economic damage of twelve economies in Asia

Economy	recent investment (billion USD, 2015 price) (year)	Share of GDP (%)	Budget data period	Global rank of economic damage for 1997- 2016	Sources
China	33.1 (2016)	0.28	1960-2016	2	Min. of Water Resources
Japan	17.5(2014)	0.39	1875-2017	9	Cabinet office, MLIT
Republic of Korea	1.9 (2016)	0.13	1992-2016	23	Min. of Land, Infrastructure & Transport
India	1.5 (2015)	0.07	1990-2015	3	Min. of Finance
Philippines	1.4 (2016)	0.44	1980-2016	8	Dep. of Budget Management
Indonesia	0.5 (2017)	0.05	2006-16	15	Min. of Public Works
Thailand	0.4 (2017)	0.09	2008-2017	4	Royal Irrigation Dep., Dep. of Public Works & Country Planning, Bangkok Metropolitan Administration
Taiwan	0.3 (2016)	0.06	1977-2016	24	Water Resource Agency
Vietnam	0.1 (2015)	0.05	2011-2015	14	Min. of Planning & Investment
Malaysia	0.1 (2017)	0.04	2006-2018	52	Min. of Finance
Bangladesh	0.06 (2017)	0.02	2014-2017	10	Min. of Water Resources
Pakistan	0.0007 (2017)	0.0002	1978-2017	5	Federal Flood Commission
Total	56.86	0.26			

Source: Author's elaboration, Eckstein, Kunzel and Schafer 2017

Expert teams visited government offices in the Philippines, Indonesia, Thailand, and Vietnam to collect data. In other countries professional people were contracted, and opened data were examined. Budget data in Myanmar is not available.

Data sources for budgets comprise public statistics and data provided by finance and planning ministries, line ministries, and other governmental organizations. Definitions of 'flood protection' in the budgets vary by country, a limitation of this study. When available, executed values of budget spending are used, and spending by local governments is included in addition to those of central governments. For example, the Japanese budget includes the actual expenditure of national and prefectural governments for protection works for floods, coastlines, and landslides, early warning and monitoring systems, dam construction, and rehabilitation. Some countries have not developed budget statistics for flood protection. In Thailand, the budgets of related agencies are amalgamated as the national budget for flood protection.

Sources for economic damage caused by floods are public statistics and data provided by disaster management ministries. These damage data usually cover physical damage. If government data are unavailable, other datasets are used: SIGMA developed by Swiss Re Institute, NatCatSERVICE developed by Munich RE, and the EM-DAT: Emergency Events Database developed by Centre for Research on the Epidemiology of Disasters.

All data are converted to 2015 prices by flood protection deflators of Japan and GDP deflators of other 11 economies. Japan produces deflators by sector including flood protection. Population data are obtained from the UN World Population Prospects. Economic data on GDP, per capita GDP, and deflators are obtained from the World Economic Outlook Database.

3.2 Recent investments in flood protection

The twelve economies have invested USD57 billion USD per year in flood protection recently, accounting for 0.26% of the total GDP of these economies. Investment is higher than the USD53 billion of economic damage in Asia estimated by ADB (2016). The most recently available data of investment and its share of GDP are shown in Table 1.

Flood protection investment in Asia is more than 15 times that of Europe and 25 times that of the US. Investments in Europe and the US are estimated at USD3.2 billion per year and USD2.2 billion per year, respectively

(Directorate-General for Environment, European Commission 2014; Multihazard Mitigation Council 2017; USACE 2017).

China invests USD33.1 billion, more than half of the total amount of all twelve economies, while Japan invests USD17.5 billion, which represents some 30% of the total regional investment. The share of GDP varies by economy: the Philippines's share of GDP is the highest, at 0.44%. China, Japan, and the Republic of Korea invest over 0.1% of GDP, but other economies invest less than 0.1%.

Of this total amount, USD 37.2 billion is invested by nine developing economies, excluding Japan, Republic of Korea, and Taiwan. Developing economies in the region invest an estimated USD881 billion in infrastructure (ADB 2017). Investment in flood protection accounts for 4.2% of total infrastructure investment. The amount is almost two and a half times the World Bank estimate of USD 14.76 billion. The World Bank estimates necessary investment required to secure a certain safety level against floods without considering actual investment and budgetary constraints (Ward et al. 2010).

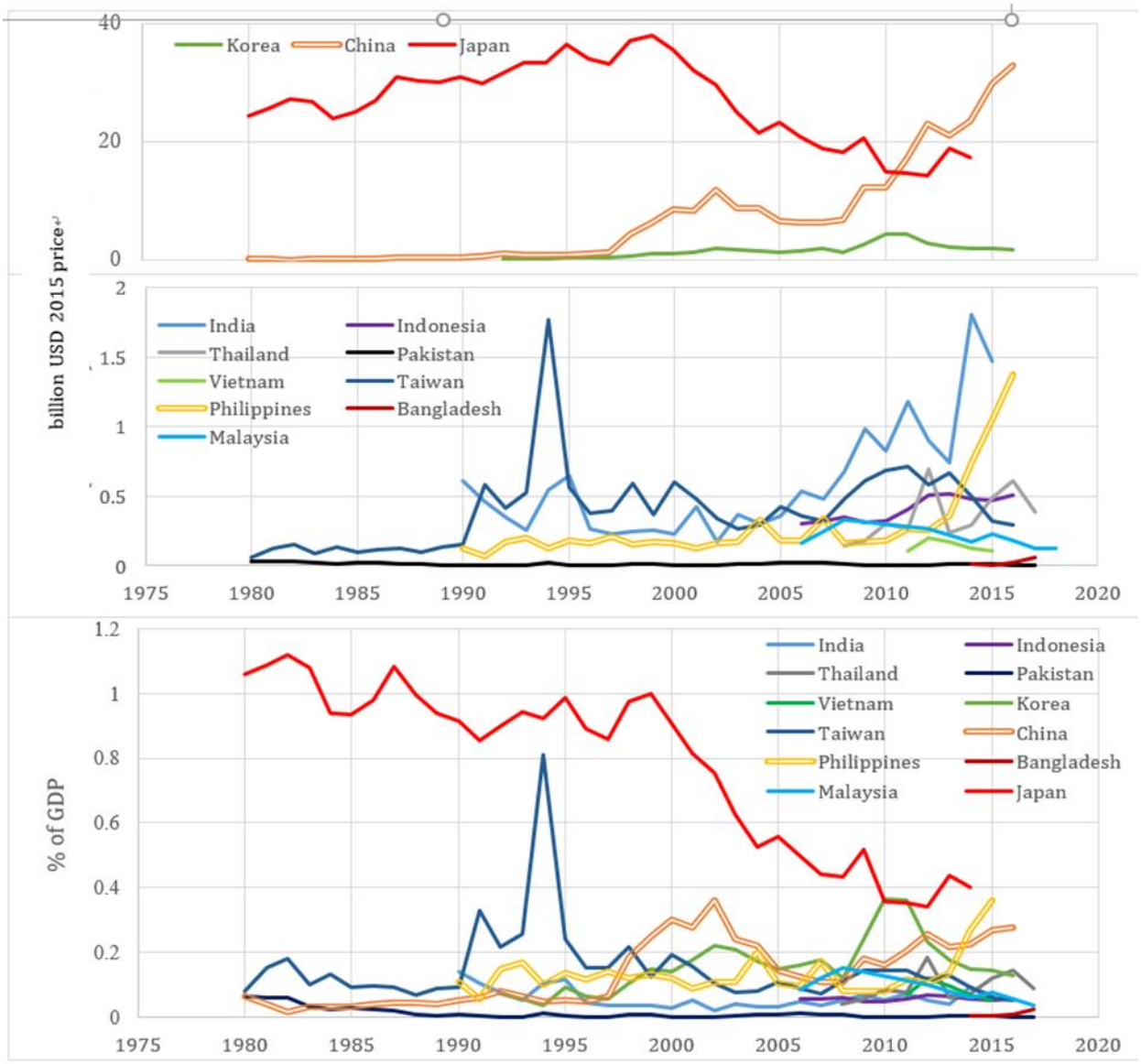

Figure 1: Trends in flood protection investment in twelve major countries in Asia

Source: Author's elaboration

3.3 Trends in investment

China, the Philippines, India, and Indonesia have increased their flood protection budgets as a reaction to recent disasters (Figure 1). China started increasing their flood protection budget in the late 1990s following a series of floods. In particular, the flood from 1997 until 1998 was the largest flood disaster of Yangtze River since

1954 (Ye and Glantz 2005). The county has increased its flood protection budget by over 6 times from 1996 to 2006 and over 5 times from 2006 to 2016.

The Philippine government increased their flood protection budget by over 8 times from 2008 to 2016. Typhoons Ondoy and Pepeng caused serious floods and landslides in Metro Manila and Luzon Island in September and October 2009 (GFDRR 2016). The total economic damage in 2009 is estimated at USD1.1 billion, or 0.56% of GDP. Following 2009, several typhoons caused serious damage with Typhoon Yolanda, in particular, resulting in a high tide disaster on Leyte Island, leading to economic damage of USD2.3 billion, or 0.89% of GDP in 2013.

India has increased its budget, but the budget scale is relatively small at less than 0.1% of GDP. The Indonesian Government has increased its budget for flood protection by 30% since 2006. Jakarta, the capital of Indonesia, suffered from flooding in 2002, 2007, and 2013 (Budiyono et al. 2015).

Thailand more than doubled its flood protection budget in 2012 following the 2011 flood disaster. This disaster caused enormous damage to the national economy, at over 14 % of GDP. However, the country has not consistently increased its budget, and actually decreased the budget in 2013.

The budget trends of the high-income economies of Japan, Taiwan, and the Republic of Korea do not show a clear direction. Following a series of serious flood events in the 1940s and 1950s, Japan increased its flood protection budget until 2000. However, the government has halved investment since 2000 because of its severe financial situation (Ishiwatari 2019), and decreased its share-of-GDP from around 1% to below 0.4%.

The Republic of Korea increased its budget in 2010 and 2011 to implement a special program (Ishiwatari et al. 2016) but decreased it back to the original scale from 2012. Taiwan is fluctuating with its budget. Malaysia, which plans to join the high-income economies, has stabilized its budget recently.

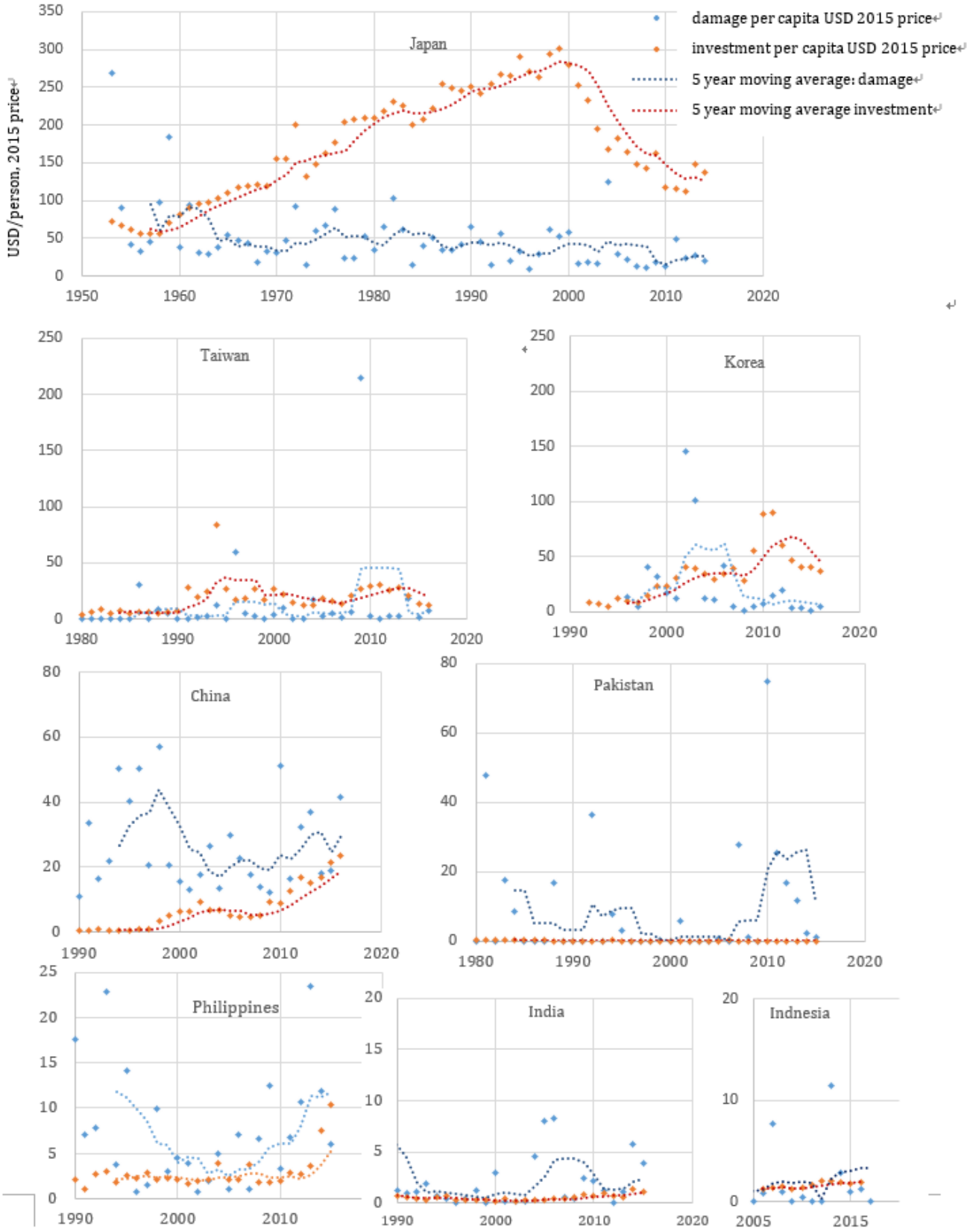

Figure 2: Trends of investment and damage in eight Asian economies

Source: Author's elaboration

3.4 Relationship between investment and damage

Figure 2 shows the trends of budget per capita for flood protection and economic damage per capita by floods of the eight economies for which budget data are available for 10 years or more. The budget and damage amounts are divided by population to compare amounts among these economies.

The three high-income economies of Japan, Republic of Korea, and Taiwan, in general, invest more in flood protection than they suffer in economic damage. The maximum amounts of damage suffered recently are similar – in the range of USD150 – 250 per person among these three economies. This amount is two to twenty times higher than the amount suffered in developing economies.

Japan has continued to invest in flood protection at the scale of several times the amount of economic damage since the 1970s. The country succeeded in halving flood damages per capita from the 1950s. The benefits of flood protection investment must have been larger than the amount of decreased damage, since assets has accumulated in at-risk areas during economic growth. Tsukahara and Kachi (2016) estimate the annual benefits from flood protection investment became positive in the mid-1970s and reached at over JPY6 trillion, or USD55 billion, in the mid-1990s.

The Republic of Korea has invested more in flood protection than the amount of economic damage from 2007 and decreased damage from the mid-2000s. Taiwan invested in flood protection more than the amount of economic damage from the 1990s except for three years. Typhoon Morakot led to the worst flooding in 2009 in the last 50 years in Taiwan (Ge, Zhang and Pen 2010).

China is increasing its flood protection budget, which is still less than the amount of economic damage. Economic damage per capita has decreased since the 1990s but stabilized in the 2000s. Share-of-GDP damage decreased from the range 1–4% in the 1990s to the range of between 0.2 and 0.5% in the 2000s. The Philippines started increasing its flood protection budget from 2009, but the effects of investment have not yet become apparent. Pakistan has invested in flood protection at a rate of much less than the amount of economic damage.

Figure 3 shows the relationships between GDP, damage, and budget per capita for countries in the developing stage with a GDP per capita of under USD12,000, which is the threshold between middle- and high-income economies. Data of Taiwan from 1997 and other developing economies are used.

These economies increase investment in flood protection as their economies develop (Figure 3). The economies invest less than USD1 per person or 0.1% of GDP at the stage of less than USD1,300 of GDP per capita. This range is larger than the definition of low-income economies below some USD1,000. Once economies reach the

level of low-middle income economies, they are able to start increasing the budget. Large-scale flood disasters become the trigger for increasing investment in flood protection, as shown in the cases of Japan, China, Indonesia, India, and the Philippines. The economies with over USD1,700 of GDP per capita invest at least USD1 per person or 0.05% of GDP. The average scale of investment is estimated at 0.12-0.16 % of GDP in Asia at the middle-income economic stage with reference to a coefficient by using a least-squares method.

Until the occurrence of large-scale disasters, economies invest limited amounts for flood protection at the low-income development stage due to financial constraints and the need to invest in other priority areas. The Public Expenditure and Financial Accountability program reveals that most countries did not prioritize investment in flood protection and invested instead in other sectors, such as social services and infrastructure. The Bangladeshi government prioritized social services – particularly education and health – before 2011 and shifted priority areas to power, transport and human development after 2011 (World Bank 2016a). The development program in Pakistan focused on investment in vital infrastructure and human resource development in the 2010s (Government of Pakistan and development partners, 2012). The Indian government increased investment in social services in the 2000s (Jena, 2010). The Philippines government prioritized highway and education in the 1990s and 2000s, increased the budget for education, health, social protection by three times from 2010 to 2016, and is currently increasing infrastructure investment including flood protection (World Bank 2010 & 2016b).

3.5 Efficiency of investment

The budget and damage data presented in Figure 3 was averaged by GDP per capita group (Figure 4 (a)). Average damage per capita does not show an increasing trend from USD1,500 until USD5,000 of GDP per capita. Also, share-of-GDP damage decreases during the stage from USD1,500 to USD5,000 of GDP per capita. The values of assets exposed to flooding increase according to economic development. Thus, the amount of damage that did not increased can be considered to be a benefit of investment in flood protection.

Average damage at the range of USD5,000 and USD6,000 of GDP per capita is several times larger than that of other ranges of GDP per capita because of the 2011 Thailand flood. This Thailand flood, with economic damage totaling USD728 per person, is an incomparably large-scale disaster. Since the scale of floods reached levels beyond the designed safety of the invested-in invested, economic damage became unprecedented in scale.

The benefit of investment was calculated based on some assumptions (Figure 4 (b)). It is assumed that damage potential increases in proportion to GDP growth per capita. This is because the damage per area increased

in urban areas at the same pace as GDP per capita during economic growth until the 1980s in Japan (Fig. 5). Since at-risk areas expand as the economy develops, this assumption is on the lower side. The actual benefit of the investment is assumed to be the difference between the damage potential and the actual damage amount. Since structural measures could not prevent flood damage fully in the 2011 Thai flood, the damage of the Thai flood is excluded from this benefit calculation.

It was found that Asian economies have been investing efficiently in flood protection. The benefit increases as the economy develops and investment increases, until it becomes larger than the investment from the development stage of USD4,000 of GDP per capita.

The scale and effects of investment in flood protection can be summarized according to development stages as follows:

(a) Low-income economies (GDP per capita of less than about USD1,000): Economies can invest limited amounts in flood protection. Economic damage increases as the economy develops.

(b) Lower-middle-income economies (GDP per capita in the range of between USD1,000 to USD4,000): economies start investing in flood protection and damage does not increase.

(c) Upper-middle-income economies (GDP per capita in the range of between about USD4,000 to USD12,000): Economies continue to increase investment in the amount and share-of-GDP, and benefit from the increases in investment. Once the scale of floods reaches levels beyond the designed safety of the invested-in structures, economic damage becomes unprecedented in scale, as shown in the case of the 2011 Thailand flood.

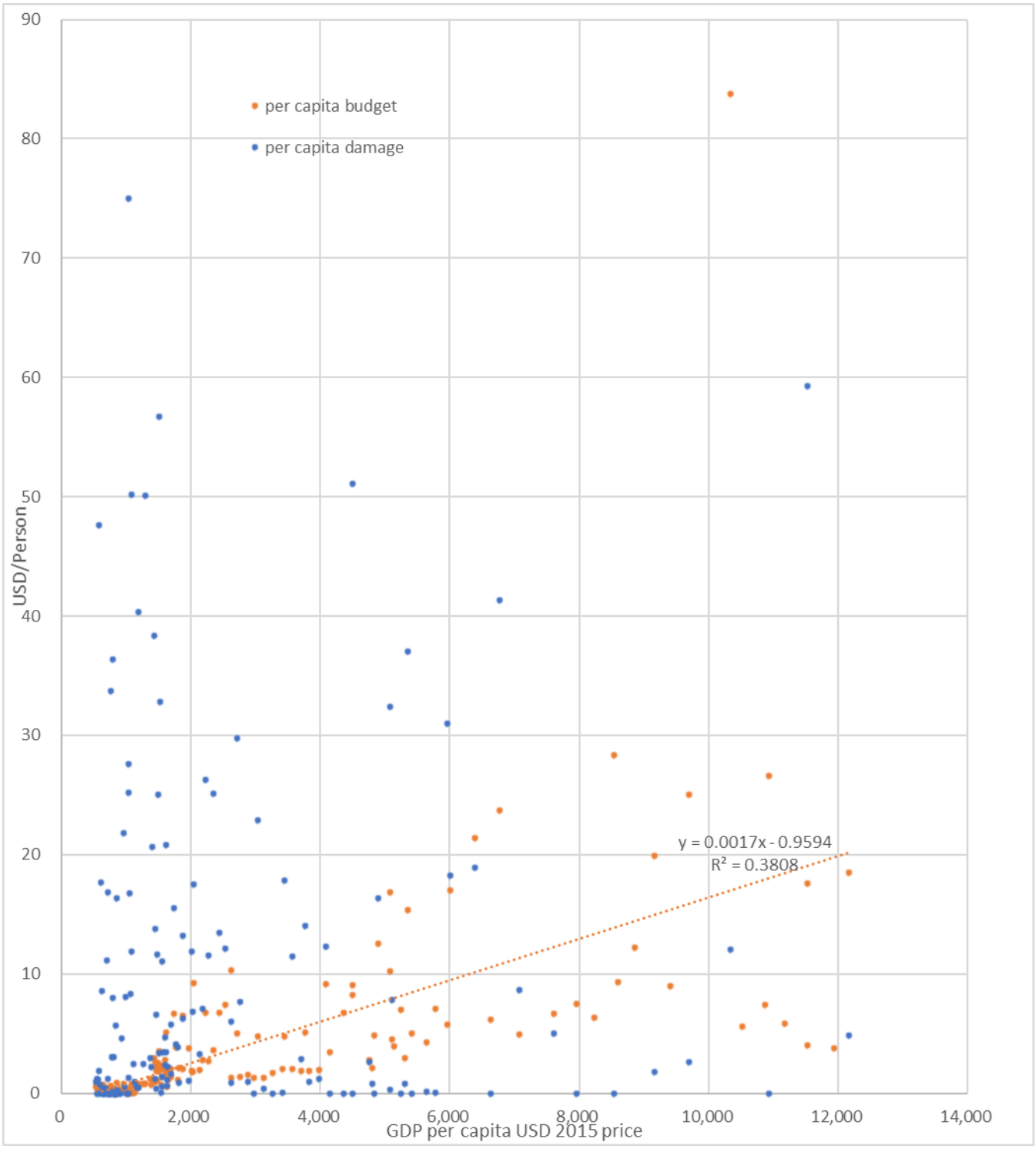

Figure 3: Relationship between GDP, budget, and damage (damage caused by 2011 flood in Thailand, USD728 per person, is not shown) Source: Author's elaboration

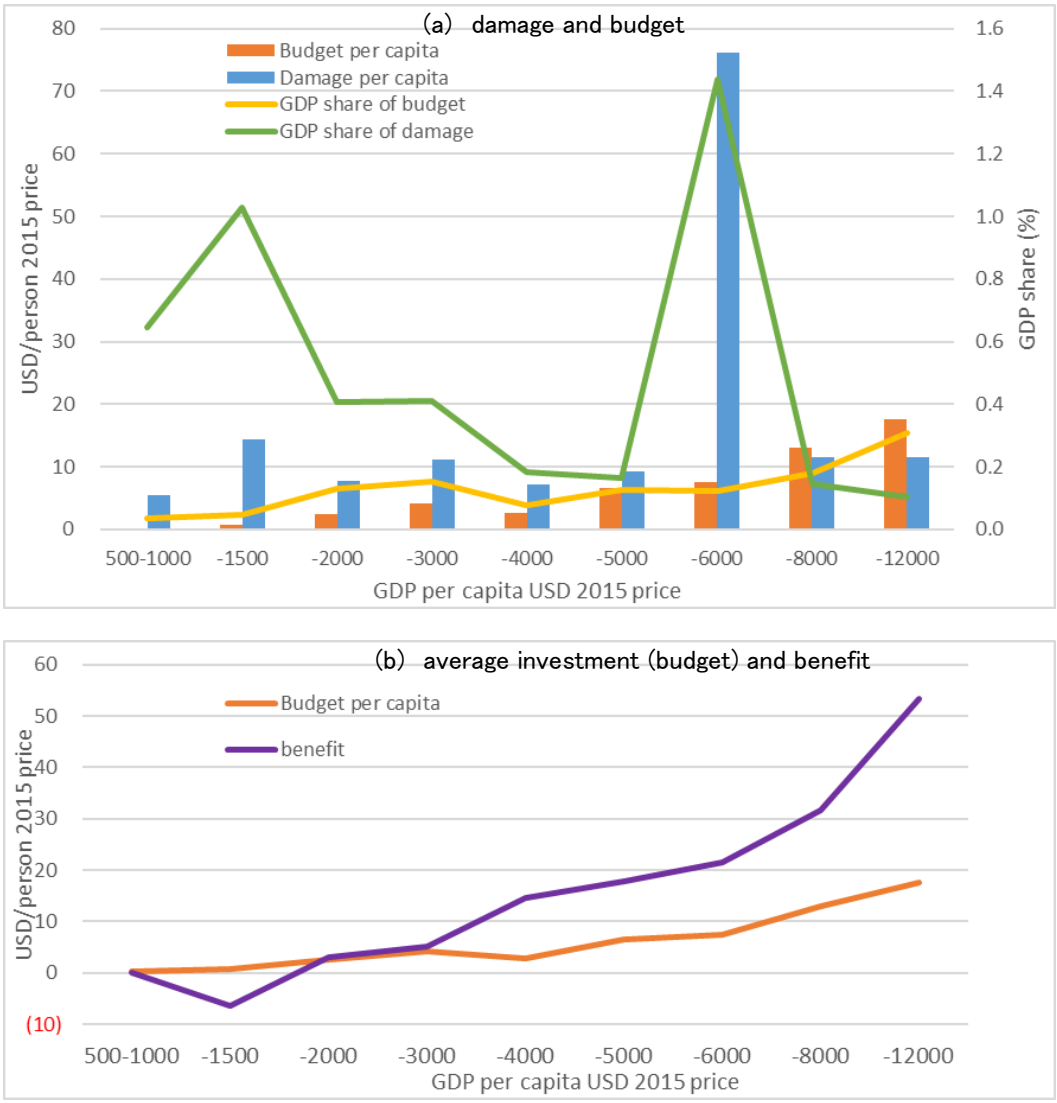

Figure 4: Trends of average damage, investment, and benefit in flood protection

Source: Author's elaboration

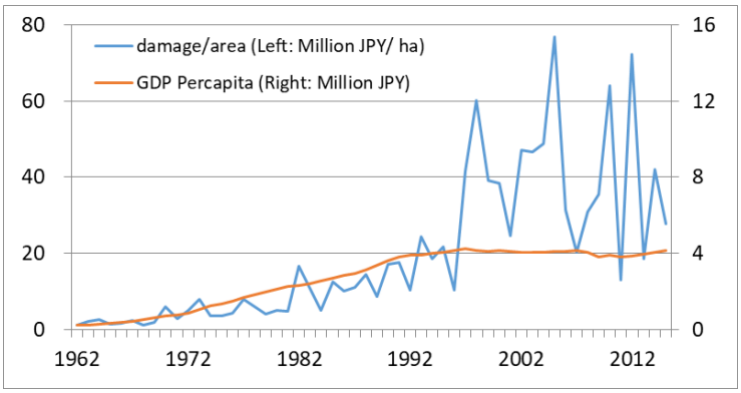

Figure 5: Trends of economic damage in urban areas and per capita GDP in Japan

Source: MLIT (Yearly)

4. Conclusion

It was found that major flood-prone economies in Asia have recently invested USD57 billion per year in flood protection. This amount accounts for 0.26% of the total GDP of these economies (Table 1). The total investment of nine developing economies accounts for 4.2% of their infrastructure investment. These data are basic information for formulating effective investment plans for flood protection. Policymakers and decision-makers can refer to the investment situation of other disaster-prone countries and determine their investment scales-according to developing stages.

The three high-income economies of Japan, Republic of Korea, and Taiwan invest more in protection than the amounts they suffer in economic damage caused by flooding. Japan and Korea succeeded in decreasing flood damage. China, the Philippines, India, and Indonesia have increased their flood protection budgets as a reaction to recent disasters. China has decreased the amount of damage suffered since the 1990s, but other economies have not yet been able to show the clear effects of investment (Figure 2).

Economies cannot invest in flood protection at the low-income economies development stage because of financial constraints and the need to invest in other priority areas. The economies with less than USD1,300 of GDP per capita can invest less than USD1 per person or 0.1% of GDP. Once economies reach the low-middle income stage, have more financial leeway, they start increasing investment in flood protection. The economies with over USD1,700 of GDP per capita invest at least USD1 per person or 0.05% of GDP, and invest 0.12-0.16% of GDP on average (Figure 3).

Asian economies have been investing efficiently in flood protection. It was found that the benefits of investment are greater than economic development and increases in investment (Figure 4b). Although the economy has developed, flood damage does not increase during the economic development stages from USD1,500 of GDP per capita until economics reach around USD 5,000 of GDP per capita (Figure 4a). This can be considered to be real benefits of investment in flood protection begin. Economic development increase vulnerability to flooding and more assets are exposed to floods.

The limitation of flood structures become clear. These structures can prevent societies from frequent flooding, but once the scales of floods reaches levels beyond the designed safety of invested-in structures, economic damage become unprecedented in scale as shown in the cases of floods in Thailand, 2011 and Taiwan, 2009.

5. Considerations: Policy recommendations

Governments should consider their investment approaches for flood protection according to their respective development stages to mitigate the economic damage caused by floods. At the low-income economic stage, they should focus on low-cost solutions while considering their limited financial capacity. These solutions include low-cost structures using local materials and community-based efforts as well as software measures, such as warning and evacuation systems and flood fighting (Matsuki 2013). Once the governments have more financial leeway at the middle-income economic stage, they should increase investment in larger scale structures such as river works, dykes, and dams.

Flood disasters are unfortunate events but can also be opportunities to increase investment in flood prevention, as the case countries show. Following disasters, political will and public awareness are enhanced. Governments should use these opportunities to establish financial mechanisms, formulate long-term financing plans and national and local strategies, and strengthen institutions and legislation to secure long-term investment.

Additional research into investment in flood protection should be conducted to promote policy reforms for flood protection. It is not clear how investment in flood protection contributes to economic development nor what scale of investment is required. While cost-benefit analyses are applied to practical projects, research into investment at the national level remains limited. The scale of investment required for flood protection needs to be estimated. Demand estimations are necessary to establish policies for securing sufficient financial resources. Otherwise, policymakers are unable to understand demand correctly. Research should therefore be conducted into the scale and efficiency of investment at the national level.

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