Eco-Efficient Water Infrastructure: towards Sustainable Urban Development in Asia and the Pacific[1]

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[1] This document has been prepared without formal editing.

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Executive Summary

The purpose of this research is to evaluate the achievements and challenges in establishment of eco-efficient water infrastructure towards sustainable urban development in Asia and the Pacific. A series of policy measures relevant to eco-efficient water infrastructure for urban development are suggested on how to apply this approach to policy-making and implementation.

A myriad of water issues pertaining to Asia and the Pacific are reviewed in order to provide a thorough understanding of critical issues and challenges, i.e., water supply, water quality control, flood prevention policies, and ecosystem restoration efforts. The study classifies water challenges in the region as inclusive of urbanization, climate change and sustainable energy, access to water and sanitation services, water availability and use, and water-related natural disasters. Strategies which provide greater resilience, and integrated planning are urgently needed, and in this context, eco-efficient water infrastructure is regarded as an innovative approach to challenges facing the water sector for sustainable urban development in pursuing economic growth without compromising ecological integrity.

Eco-efficiency indicates more efficient resource use with less environmental impacts. The definition of eco-efficient water infrastructure used for this report is:

- The combination of physical (dams, embankments, piped water supply facilities, and wastewater treatment facilities) and non-physical infrastructure (laws, regulations, regulatory programs, government bureaus, and civil society groups) in the water sector for achieving an optimal level of water utilization and a less burden to limited water resources.

A list of structural and non-structural breakthroughs for eco-efficient water infrastructure have been explored, i.e., small-scale multipurpose dams, eco-efficient groundwater management, eco-efficient desalination plants, and the Low Impact Development (LID) projects. In addition, the report introduces the Active, Beautiful, and Clean (ABC) Waters Program in Singapore and Green School projects in order to evaluate the applicability of the concept to actual policy-making and implementation.

The foundation of eco-efficient water infrastructure has been laid in Indonesia and the Philippines. Indonesia has produced the eco-sustainable water infrastructure approach and has worked together with UNESCAP by launching the integrated rainwater and wastewater management system in Bandung, Indonesia (Institute of Technology Bandung and University of Pasundan Projects). As for the Philippines, the roadmap to eco-efficient water infrastructure has been established, and the country has also focused on small-scale pilot projects, such as the application of sustainable designs for green school development in Cebu, the Philippines since 2011.

A series of policy measures have been suggested. The first principle is **the Integrated Water Resources Management (IWRM) for urban development**. The integrated approaches embedded in IWRM require specific policy actions with regard to eco-efficient water infrastructure for urban development:

- Political willingness: political commitment, coordinating institutions, feedback system, and public awareness
- Legal, regulatory and administrative settings: eco-efficiency principle embedded in Basic Water Law and relevant laws and regulations at the city level, financial incentives or penalties to companies depending on how eco-efficient they are, appropriate standards and conditions of eco-efficiency in the water sector for urban development, and coordinating mechanisms (institutions, regulations, programs) between ministries and city bureaus, integrated planning between river basin management and urban planning for ecological efficiency
- Financial and economic practices: rational water tariffs with provision of safety nets for the poor and the marginalized in urban areas, and promotion of water saving technology for eco-efficiency in urban buildings such as apartments, schools, and hospitals
- Stakeholder participation: principle of stakeholder participation institutionalized in Basic Water Law and other laws and regulations at the city level
- Private sector involvement: institutional incentives for private sector stakeholders and improvement of service quality through private investment, advanced technology and management skills, and adequate regulatory settings prepared prior to invitation of private players for universal access to water and sanitation for the poor and the marginalized in urban areas

Decentralization is the second principle, which reiterates the importance of a delegated governance system in order to effectively lead to establishment and implementation of eco-efficient water infrastructure. There are several principles in establishment of decentralization in the water sector:

- Accommodation of diverse opinions in water issues applied to the lowest levels, even down to individuals
- Political, administrative and financial power of the central government shared with various stakeholders at the river basin and local levels
- Development of policies and strategies appropriate for socio-economic and environmental conditions at the local level based on the devolution of the managerial, administrative, and financial power to the community level
- A clarification of the roles of local, regional, and national level institutions and the set-up of efficient local level institutions for planning and decision making

As an example of decentralization in the water sector, a decentralized wastewater management system neatly reflects the main idea of eco-efficient water infrastructure. As found in the cases of Indonesia and the Philippines, community-level involvement is a crucial element to make local water and wastewater projects more efficient in both economic and ecological terms.

The third principle is associated with development of **New Water Sources**. Water reuse and wastewater recycling and rainwater harvesting remind the urgency to save water but also the potential to create new water sources that can be consumed and renewed in an environmentally friendly fashion. These approaches are more urgent and applicable in urban settings. There are several principles in order to adopt water reuse and wastewater recycling:

- Minimization of waste of water
- Minimization of freshwater demand
- Decreased wastewater treatment needs
- Site-specific and tailored approaches considering local circumstances
- Introduction of an appropriate level of fees for wastewater treatment
- Enactment of a regulatory framework to support installation of approved high performance water reuse and wastewater treatment systems in new buildings or renovated facilities through an issuance of permits in urban areas

Rainwater harvesting encompasses an array of functions; prevention of river flow drying; augmentation of water supply, control of non-point source pollutants, alleviation of heat island effect, and prevention of urban flood and restoration of the hydrological cycle. This approach is useful for those who suffer from a lack of sufficient water resources, particularly in urban areas.

The fourth policy principle is **Stakeholder Participation**. Decision-making may take longer than expected if more stakeholders are involved but the final outcome is more concrete. There are a series of principles to be put into practice for consolidating stakeholder participation in decision-making and implementation for eco-efficient water infrastructure:

- Establishment of multi-stakeholder process through laws, regulations, and ordinances at the central, regional, and local levels
- Invitation of diverse stakeholders: decentralized authorities, the private sector, civil society, and the marginalized
- Effective and inclusive communication and information mechanisms: public hearings, meetings, consultations online and offline
- Transparency and accountability guaranteed in the stakeholder participation process
- Dissemination of the concept and the need of eco-efficient water infrastructure for urban development to the lowest possible level

The final policy principle is **Eco-efficiency Education** which is closely linked to the experience of the green school cases of the Philippines and the Republic of Korea. As a useful platform, green schools can provide an adequate solution to enhance economic and ecological efficiency in the developing countries of the region. There are primary principles to be considered for promotion of green schools in the region:

- Political leadership and existence of national and or local strategies for green school
- Integrated planning of green school in the overall context of urban planning
- Enabling environments (institutional settings)
- Partnerships with local stakeholders
- Financing mechanisms to establish and operate green schools
- Eco-efficiency education curriculum for future generations

This approach shows that students can take useful lessons from eco-efficient systems in the school environments, which will have a positive impacts on future generations.

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1. Introduction

Development challenges in the Asia and Pacific region are immense. In 2011, 360 million people lacked access to improved water sources. Approximately 1.7 billion people lack access to proper sanitation services in the whole region. There is an urgent need to decouple economic development from environmental pressures in order to prevent the conventional development path, 'grow first, and clean up later' (UNESCAP, 2008; UNESCAP, 2013b). Urban areas in the region have become the epicenter of these challenges. About 1.96 billion people live in the urban areas of the region in 2012, and the number will grow up to 2.7 billion by 2030. These trends provide tremendous challenges in the management of urban areas in terms of providing adequate services to current and future generations (UNESCAP, 2008; UNESCAP, 2013b). Therefore, it is critical to provide workable and sustainable solutions for the sustainable management of infrastructure in urban areas.

Infrastructure development has played a pivotal role in accelerating socio-economic development in the Asia and Pacific Region over recent decades. Water infrastructure, in particular, is vital for people's livelihood and human survival and serves as a basic foundation to achieve sustainable development in the region. Confronted with formidable challenges due to the degradation of the environment and vulnerability by climate change, water infrastructure demands a paradigm shift towards more sustainable policy measures and implementation tools. Eco-efficiency for water infrastructure is, therefore, more necessary than ever before.

The purpose of this report is to evaluate the achievements and challenges in establishment of eco-efficient water infrastructure towards sustainable urban development in Asia and the Pacific. A list of adequate policy measures are explored on how to apply this approach to policy-making and implementation. The concept of eco-efficiency and its relevance to water infrastructure in the context of Asia and the Pacific will be reviewed and discussed. The research highlights a series of good practices, which include but are not limited to small-scale multipurpose dams, eco-efficient groundwater management, eco-efficient desalination plant, the Low Impact Development (LID) approach, the ABC Waters Program of Singapore, and Green School. The exploration of the on-going projects in Indonesia and the Philippines resonates the practicability of eco-efficiency for water infrastructure by evaluating integrated wastewater management and rainwater harvesting, and green schools coupled with the roadmaps.

Policy measures are extracted from the cases of Indonesia and the Philippines together with the appraisal of good practices. These embrace distinctive features, such as site-specific, decentralized, water and energy saving, environmentally friendly, and community-based. The specific policy approaches are the Integrated Water Resources Management (IWRM) for urban development, decentralization, new water sources, stakeholder participation, and eco-efficiency education.

The first part of the study discusses diverse issues and challenges in the water sector in Asia and the Pacific. The main discourses of eco-efficient water infrastructure are included in the second part, including the concept of eco-efficiency, the need of eco-efficiency for the water sector, and the approaches of eco-efficient water infrastructure. In the third part, the research sheds light on the community-based integrated water supply and wastewater treatment systems in Indonesia and the Philippines together with exploration of the good practices. The final part of the report is associated with the chapter of policy measures.

2. Issues and Challenges in the Water Sector in Asia and the Pacific

2.1 Overview of critical water issues

The centralized control system in water supply and sanitation services has contributed to enhancement of universal access to clean water and adequate sanitation services for several decades. However, the conventional cycle of water supply and sanitation services can result in great inefficiencies and cannot cope with a complexity of current challenges in the water sector. For instance, a number of freshwater bodies have been seriously degraded due to poor management of water resources, which is directly associated with acute water pollution and poses a serious threat to drinking water quality. Inadequate provision of sanitation services have brought about exacerbation of public health situations in many developing countries, particularly in slum areas which lack service provision. Rapidly developing countries have achieved a high degree of economic growth at the expense of ecosystems. This has, in turn, resulted in deteriorating living and health conditions for urban populations. Therefore, it is significant to take into serious consideration an innovative approach for providing a sustainable pathway and viable framework in enhancing water infrastructure.

In Asia and the Pacific, a total endowment of freshwater resources and the freshwater availability per capita are regarded as the second lowest in the world thanks to the size of total population and the misuse and overuse of water supply. The other fundamental challenge is deteriorating water quality, which is also connected with a low degree of ecological carrying capacity in the region. For instance, Bhutan, Indonesia, Malaysia, and Papua New Guinea encompass similar problems with regard to water resources management, i.e., soaring water demand, mediocre management of river basins, and overexploitation of groundwater resources, especially in their major urban areas. The situation of water management in semi-arid or arid countries within the region of Central Asia is even more acute (UNESCAP, 2012a).

In addition to such compounded risks, the water systems in the Asia and Pacific region are confronted with newly emerging challenges derived from climate change. Irregular patterns of extreme weather events, such as floods and droughts, have become of increasing concern. The linkage between climate change and water should be seriously considered in terms of design and operation of water infrastructure in the region.

2.2 Key challenges

The key challenges in the water sector of Asia and the Pacific are fivefold. First, meeting the needs of growing urban populations will provide its own challenges. Second, climate change has exacerbated a myriad of formidable challenges, and therefore, how to adapt to the adverse impacts of climate change is a key to achievement of sustainable development in the water sector, such as strategies to reduce Green House Gases (GHGs) and promote sustainable energy options. Third, it is urgent to continue to be committed to improving the universal access to water and sanitation services in the region. Fourth, the countries in the region must focus on how to increase the efficiency of water use as well as water availability through development of new water sources, such as water reuse and recycling and rainwater harvesting. Fifth, natural disasters have recently become intense and extreme due to climate change. It is imperative to nurture the capacity of resilience in each country of the region.

More than any other region, Asia and the Pacific has witnessed the intense trend of urbanization over the last few decades. Such phenomenal transformations have occurred thanks to three driving forces: 1) natural population growth; 2) rural to urban migration; and 3) reclassification of rural areas (UNESCAP, 2013b). The percentage of urban residents in the region reached 40% a decade ago and 46% in 2012 and will be expected to increase up to 50% by 2020, which means newly added 500 million dwellers. Over half of the world's biggest cities (10 megacities with 10 million or more residents) exist in Asia. By 2015, there will be 12 Asian mega cities, and the urban population is expected to outnumber the rural population by 2022 (ADB, 2008; UNESCAP, 2013b).

There are a number of problematic issues in relation to rapid urbanization, including inadequate access to water and sanitation services, the spread of communicable diseases, and the shortage of adequate and affordable housing. These challenges occur due to the lack of adequate institutional settings and an effective or efficient level of water infrastructure. An inappropriate level of piped water supply and sanitation services is a chronic issue in many developing countries of the region, such as Cambodia, Myanmar and Nepal.

The second challenging issue is the emission of Green House Gases (GHGs). In the 1990s, the Asia Pacific region contributed less than half of all global CO_2 to the world. Since then, the international architecture for reduction of GHGs has played a significant role in decreasing the total amount of GHGs in the rest of the world except for Asia and the Pacific. In the period between 1990 and 2010, the Asia and Pacific region produced over half of total global GHG emissions in the world compared with 12% from Europe and 15.2% from North America (UNESCAP, 2013b).

In order to tackle such a 'new' challenge, the region has to highlight the salience of promotion of sustainable energy options, i.e., hydropower, wind, solar photovoltaic and heat collection, geothermal, biomass and biogas, and tidal power. In 2012, the UN General Assembly declared the Decade of Sustainable Energy for All (2014-2024) with the three interlinked objectives to be achieved by 2030. First, universal access to modern energy services should be guaranteed. Second, the global rate of improvement in energy efficiency should be doubled, and third, the share of renewable energies in the global energy mix should also be doubled. In addition, the United Nations Conference on Sustainable Development (Rio+20 Conference) reiterated that access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health and helps provide basic human needs (UNESCAP, 2013a).

Universal access to water and sanitation services is the third challenging issue. By 2011, the population of the Asia Pacific region without access to safe drinking water had been halved from the 1990's level. However, the sanitation related component of the Millennium Development Goals (MDGs) target was not well achieved, far below the target level. Over 900 million people became better off with access to piped water supply between 1990 and 2010 (ADB, 2013; UNICEF and WHO, 2012). Access to improved water resources increased from 73% in 1990 to 91% in 2011, which indicates a successful outcome in terms of provision of water supply services in relation to the target 7.C of the MDGs. Another indicator is that 1.5 billion people came to have access to safe drinking water in the period between 1990 and 2011. Nevertheless, the whole picture is not necessarily bright. In 2011, there were still 360 million people without access to improved water resources, which accounts for 46% of the world's total number (ADB, 2013).

The need for improved sanitation services is even more acute than before. The progress in this field has been relatively sluggish in the region, and in 2011, more than 1.7 billion had no access to improved sanitation facilities. In order to meet the target of MDGs for improved sanitation services, the coverage of sanitation services in the region should be increased from 59% in 2011 to 68% by 2015, which appears to be unrealistic in early 2014. The picture is that less than 50% of the population in the region have access to improved sanitation facilities, and the percentages for Cambodia, India, and Nepal are 33%, 35%, and 35%, respectively (ADB 2013; UNESCAP, 2013b).

Fourth, water availability and use is discussed. In Asia and the Pacific, the total amount of renewable water resources in 2011 was estimated at 20,521 billion m^3, which is equivalent to about 38% of the total world's water availability. Southeast Asia within the region boasts of the largest renewable water resources, which is almost 31% of total regional water availability, whereas the contribution of the Pacific is the least, accounting for only 8%. Despite the abundant total renewable water resources, the level of renewable water per capita in the region is much lower than the global average.

Another imperative issue is associated with the high level of freshwater withdrawal in the region. Such a phenomenon should be understood in the context of the region's geographical size and large population, intensive irrigation practices and other economic activities. The future projection for water availability per capita is bleak, because the population in the region has steadily grown over the last two decades, and this trend may continue, essentially adding 15% more people between 2020 and 2030. More pressure is on the countries in the region, and urban areas are urgently required to improve the management of non-revenue water losses and water use per person per day (UNESCAP, 2013b).

The fifth challenge is the frequent outbreak of natural disasters in the region, particularly hydrological disasters, such as floods and droughts. Natural disasters trigger economic crises, rocketing food and energy prices due to a complex combination of shocks. These phenomena have been exacerbated by climate change over the last few decades (UNESCAP, 2013b).

Asia and the Pacific is regarded as the world's most disaster-prone region, and the largest number of people affected and killed by natural disasters have been recorded in the region between 2002 and 2011. According to the Emergency Events Database (EM-DAT), the most frequently occurring hazards are hydro-meteorological. Since 2000, over 1.2 billion people have been exposed to 1,215 hydro-meteorological hazards. In addition, 355 million people have been affected by 394 climatological, biological, and geographical disaster events. Bangladesh, Japan, Indonesia, and the Philippines are regarded as those with greater risk related to natural disasters (UNESCAP, 2013b). Water-related disasters typically account for approximately 90% of disasters in the form of floods, droughts, hurricanes/cyclones/typhoons, storm surges and landslides. The region is even more vulnerable to water-related disasters than before, which might eventually undermine potential of the region's ability to achieve sustainable development, poverty reduction, and other development targets. In 2011, the cost of flood disasters in the region grew, and the estimated insured loss was more than US$61 billion (ADB, 2013; Swiss Re, 2012).

According to UNDP, every dollar invested in preparedness can save US$7 in the aftermath of a disaster, and therefore, it is imperative to increase the level of resilience to water-related disasters in the region.[2] However, only 1% of international aid has been invested on preventing the impacts of natural disasters. The natural disaster prevention sector should be emphasized as one of the priority areas among policy makers in the region, since the investment in disaster risk reduction can generate direct benefits not only in financial but also non-financial ways. Nurturing resilience should be a key to achieving sustainable development (UNESCAP, 2013b).

3. Eco-Efficient Water Infrastructure

3.1 Concept of eco-efficiency

The rationale for the introduction of eco-efficiency for water infrastructure is closely linked to the dilemma on how to balance economic growth and ecological restoration. Conventional policy measures to ameliorate a level of pollution did not embrace any considerations for ecological aspects but mainly focused on how to abate a level of pollution through end-of-pipe management. In addition, environmental progress achieved through technical solutions can often be offset by increases in consumption. This means that sophisticated and well-designed pollution control policies or measures cannot dilute an increase of the pressure induced from the changing pattern of economic growth. Such circumstances have encouraged the international community to seek paths on how to reduce adverse impacts on the environment together with a continuous pursuit of socio-economic development. Eco-efficiency is an outcome from these efforts.

The concept of eco-efficiency was first introduced by Sturm and Shaltegger (1989) as a way of reporting environmental progress, particularly in production systems. The term was adopted by the Business Council on Sustainable Development in 1991, which was the turning point for dissemination of the concept within the business field (now the World Business Council on Sustainable Development – WBCSD) (Bohne, 2007; Ehrenfeld, 2005; WBCSD, 2000). The definition of eco-efficiency is referred to as 'the delivery of competitively priced

[2] The term, resilience, indicates 'the capacity of countries to withstand, adapt to and recover from natural disasters and major crises so that population can contribute to lead the living they value' (UNESCAP, 2013b).

goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle to a level at least in the line with the earth's carrying capacity' (WBCSD, 2000). Eco-efficiency indicates more added values with less environmental impacts. This is also understood as a ratio of some measurement of economic value added to some measurement of environmental impact. The term, 'eco', refers to both economy and ecology. Eco-efficiency is measured through the simple equation as follows:

$$\textit{Eco-efficiency} = \frac{\textit{Product or service value}}{\textit{Environmental influence}}$$

The practicability and theoretical significance of the concept is associated with its ability to reflect two of the three pillars of sustainable development, the environment and economy (Burritt and Saka, 2006; Ehrenfeld, 2005). There are two broad objectives of eco-efficiency. The first objective is to reduce the consumption of resources and the impact on the nature by minimizing, for instance, wastewater discharge, waste disposal and the dispersion of toxic substances. The second objective is to increase product or service value, i.e., product functionality, flexibility, and modularity. At the micro level, industrial companies or manufacturing lines opt for creating more value with less environmental impacts under the framework of eco-efficiency. At the macro level, each country is recommended to decouple environmental impacts from economic growth in order to achieve eco-efficiency (Brattebo, 2001).

Industrial and manufacturing companies in various sectors, including electronics, chemicals, metals, mining and forestry, have adopted eco-efficiency in response to the discourse of sustainable development. For instance, BASF, 3M, Dow, and Baxter International have produced company reports on measuring eco-efficiency of their business activities. Companies can maximize their productivity and commercial benefits through innovations whilst such activities do not cause natural environments to be damaged, especially decreasing impacts on natural resources. The idea of eco-efficiency has also been hailed in the business sector as an effective tool to assess environmental costs and physical environmental flows in the field of environmental management accounting for cleaner production (Burritt, and Saka, 2006). In the similar vein, eco-efficiency is useful in monitoring material and energy flows of stocks and life cycle thinking and entails the introduction of 3Rs – Reduce, Reuse, and Recycle (Ness, 2007).

At the macro-level, eco-efficiency can be applied to a set-up of national socio-economic development plans which are embodied with policies to ameliorate adverse impacts on the environment. The overall principle for eco-efficient socio-economic development plans is to ensure establishment of enabling environments for enhancing economic and social well-being concurrent with minimizing exploitation of resources and the amount of pollution. For instance, the European Environmental Agency (EEA) adopted the principle of eco-efficiency and relevant indicators to quantify the progress of sustainability with the goal of 'more welfare from less nature' and has emphasized decoupling resource overuse and pollutant release from economic development (EEA, 1998). An OECD report on eco-efficiency pinpointed the innovation as the key driver for the improvement of eco-efficiency and explored a myriad of policy tools for applying eco-efficiency, i.e. strong competition, regulatory incentives, dissemination of best practices, and the presence of a good climate for innovation (OECD, 2002).

Individual countries, such as the US, Canada, and the Nordic countries, have sought to adopt eco-efficiency for socio-economic development and environmental management plans. For example, the US government adopted the idea of eco-efficiency as part of the strategy of the US President's Council on Sustainable Development (PCSD) for achieving sustainability in the mid-1990s. There were several policy instruments suggested by the US PCSD, including performance-based management systems, an extended product policy, a shift in tax policies, subsidy reform and the use of market incentives, in favor of promotion of eco-efficiency (US PCSD, 1996).

With regard to governmental policies for eco-efficiency, WBCSD (2000) recommends three principles. First, externalities are internalized, and second, resources and pollutions should be priced adequately. Third, perverse subsidies are demolished, and appropriate incentives are introduced to reward those who succeed in avoiding pollution. These principles can be applied to the water sector. For instance, subsidies for water, electricity, and oil in the agriculture sector should be abolished, the irrational pricing of tap water and wastewater services should be avoided, and setting the 'right' prices for wastewater treatment services are necessary. All of these are a prerequisite to internalization of environmental costs. Simultaneously, governments have to develop and implement economic instruments for incentives and law enforcement on polluters and take into serious account shifting tax from labor and profits to resource and pollution.

3.2 Need of eco-efficiency for the water sector

Good access to clean water supply and proper sanitation services is one of the most basic foundations for developing countries to boost their socio-economic development. In order to achieve such fundamental platform, international communities have worked hard. The essential elements to improve basic water and sanitation services are piped water supply systems and large-scale and centralized wastewater treatment systems. In spite of tremendously positive outcomes brought about through these systems, i.e., scale effects and the consistency of services, there is growing recognition that such systems should be revised so as to cope with new challenges in the water sector. i.e., a high percentage of non-revenue water, a low degree of sanitation service coverage, and the deterioration of public health. In addition, economic losses from poor sanitation services take place in developing countries, for instance, in Cambodia, Indonesia, the Philippines, and Vietnam with an estimated of US$ 9 billion per annum (UNESCAP, 2012a).

A critical issue in the municipal water supply sector is how to tackle the non-revenue water challenge. At the global level, non-revenue water costs approximately US$ 14 billion per annum, and one third of the cost stems from developing countries. An eco-efficient approach to resolving the issue of non-revenue water is to introduce decentralized water infrastructure. Such a new attempt, however, needs more efforts from central and local authorities to consider at the time of planning and construction of infrastructure in an integrated way. In addition, financial viability should be double-checked with regard to the introduction of new water tariff systems. It may be necessary to revamp the water pricing structure so as to finance the newly established eco-efficient water infrastructure. The key to achieving eco-efficiency in water infrastructure is to diversify the water management system and to adopt an integrated approach with the careful consideration of local contexts (UNESCAP, 2012a).

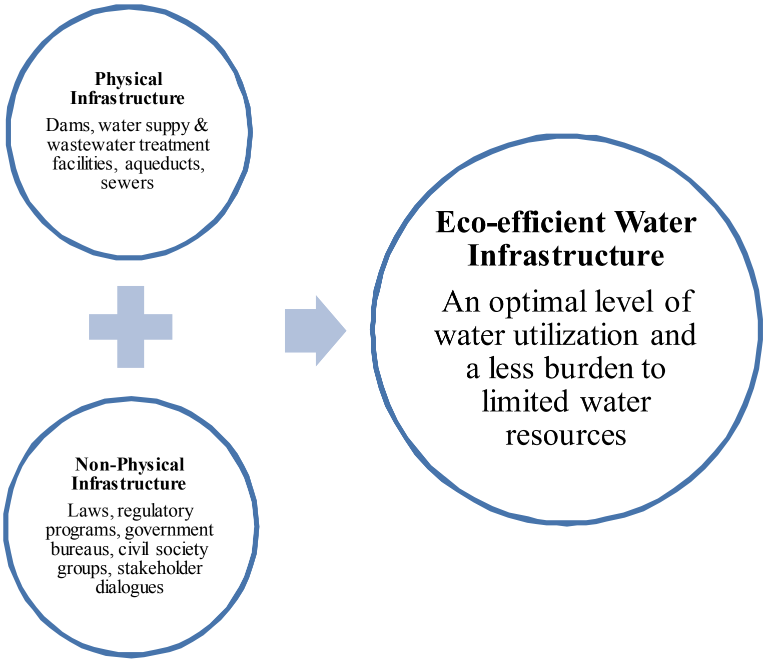
An inadequate management of water resources can bring about adverse impacts at the macro-economic level. For instance, the interconnectedness of climate change and water should never be under-emphasized. Climate change often spawns unprecedented extreme floods and droughts, which eventually cause human losses and economic downturn. One of the recent major flood events took place in Thailand, 2011 in which 13.6 million people were affected. The Thai government estimated the total amount of US$ 45.7 billion as the economic damages, and the overall GDP growth rate of the country in 2011 was shrunk from 3.5 to 2.6% (ADB, 2013; Yuvejwattana and Suwannakij, 2011).

3.3 Eco-efficient water infrastructure

In order to explore the application of eco-efficiency to water infrastructure, it is worthwhile to clarify the essence of infrastructure. The term, infrastructure, indicates physical infrastructure such as dams, embankments, piped water supply facilities, wastewater treatment facilities, sewers, and aqueducts. In addition, infrastructure includes non-physical or institutional infrastructure such as laws, regulations, regulatory programs, government bureaus, and civil society groups including environmental NGOs. Therefore, in order to assess the eco-efficiency of water infrastructure in countries, it is necessary to look into the dimensions of non-physical as well as physical infrastructure issues. Eco-efficient water infrastructure is defined as the combination of physical and non-physical infrastructure in the water sector for achieving an optimal level of water utilization and a less burden to limited water resources.

Eco-efficient water infrastructure embraces physical infrastructure in water and sanitation services, flood control and drought management, and ecosystem restoration. This approach requires the sustainable processes of design, construction, operation and maintenance with less environmental impacts. Non-physical infrastructure includes institutional frameworks and policy measures, which entail an optimal level of water utilization and a lesser burden on limited water resources. The application of eco-efficiency to water infrastructure is closely associated with the implementation of the life cycle principles in planning, design, construction, operation and maintenance. Also the establishment of institutional measures for eco-efficient water infrastructure should be guaranteed, including relevant legal, economic and regulatory instruments (UNESCAP, 2011). Figure 1 shows the concept of eco-efficiency water infrastructure.

Figure 1. Concept of Eco-Efficient Water Infrastructure



Source: UNESCAP (2011).

The conceptualization of eco-efficient water infrastructure implies the significance of balanced policies for tackling physical and non-physical dimensions. In many developing countries, various projects related to physical infrastructure have been over-emphasized thanks to socio-economic and political reasons. These projects are often decided by the elite at the central government without consideration of local environmental circumstances, which brings about inefficient water supply and wastewater treatment services, flood prevention and drought management systems, and ecosystem rehabilitation projects. In addition, centrally planned and controlled water and wastewater systems are energy-intensive, environmentally unfriendly, over-invested, and ill-designed against local needs. There is growing need for introduction of ecologically and economically efficient policies for water infrastructure with accommodation of decentralization and community-centered approaches.

An introduction of institutional reform in the water sector is urgent and a prerequisite for the success of establishment of eco-efficient water infrastructure. However, institutional reform in the water sector is not simple. For example, a rationalization of water and wastewater tariffs at the cost recovery level should be one of the primary principles for demand management, which reduces unnecessary water consumption in households, industrial and commercial units, and agricultural areas. However, this policy reform may lead to social resistance from different groups and even result in social conflict. This political risk often prevents policy-makers from executing a bold move for reform measures in the water sector. Nevertheless, the guarantee of enabling environments for the water sector will be the key to success of implementing eco-efficient water infrastructure. In particular, developing countries have to launch their institutional reform soon as possible so as to institutionalize the principles of eco-efficiency for the water sector.

4. Implementation of Eco-Efficient Water Infrastructure Projects

4.1 Good practices in eco-efficient water infrastructure

Since the concept of eco-efficient water infrastructure was first coined by UNESCAP in 2008, the innovative approach has been well received by the countries in Asia and the Pacific. There have been a list of relevant local projects, including the pilot projects. Economic benefits derived from the development of eco-efficient water infrastructure can be quantified from a few examples. The better access to clean water and sanitation services can make substantial contribution to economic growth via an increase of productivity and the enhancement of public health. UNESCAP (2012b) refers to the examples of the extent to which good water systems can have a positive impact on public health. An adequate level of access to clean water and efficient sanitation services can save US$ 63 billion per annum. Relevant health care savings are estimated at US$ 340 billion for individuals and US$ 7 billion for health agencies. In numerical terms, benefits of US$ 85 billion per annum can be made from the achievement of the Millennium Development Goals (MDGs) for water and sanitation services.

The following practices are recommended to the member countries in UNESCAP. The examples are closely linked to cutting-edge and environmentally friendly technologies and programs where water and other environmental components are managed in a sustainable way. The examples are small-scale multipurpose dams, eco-efficient groundwater management, eco-efficient desalination plants, the Low Impact Development (LID), the ABC Waters Program of Singapore, and Green School. These cases embrace a series of characteristics that are reflected in the chapter of Policy Measures in this report (See Table 1).

Table 1. Good practices in eco-efficient water infrastructure for urban development

	IWRM for Urban Development	Decentralization	New Waters	Stakeholder participation	Eco-efficiency education
Small-scale multipurpose dams	○	○			
Eco-efficient groundwater management	○	○	○		
Eco-efficient desalination plant		○	○		
Low Impact Development	○			○	
ABC Waters Program				○	○
Green School	○	○	○	○	○

Small-Scale Multipurpose Dams

Population growth, industrialization, and urbanization deteriorate stream flow regimes, especially in small streams, and the phenomena have been aggravated by climate change. Flood events, debris flows and landslides often entail natural disasters at small watersheds in mountainous areas. Local residents living along the mainstream of large rivers in many countries are relatively safe from floods, droughts, landslides and debris flows because of steady water supply from large-scale dams, associated water supply networks, and flood prevention systems. By contrast, those who dwell along small river basins are largely prone to a variety of natural disasters and an inadequate level of water supply services. One of the best possible solutions is to install decentralized or distributed water infrastructure system (UNESCAP, 2011).

The conventional approach to water management through large-scale dams has triggered multi-faceted impacts on the environment, which rings a bell to environmentalists. Possible negative impacts caused by large-scale dams have heavily been criticized by environmentalists, which, in turn, provides a new opportunity for engineers to explore innovative ways on how to minimize negative influences on ecosystems in building dams. This is one of the year-long discourses in international environmental politics – environment and development in parallel. Although multi-functional dams are economically efficient, dam engineers should ensure ecological efficiency. Small-scale multipurpose dams can be alternative methods to achieve eco-efficiency. Sabo dams[3] and small-scale hydropower dams are useful practices, and the Yangyang Small-Scale Dam in the Republic of Korea is shown in Figure 2, which was built and began operation in 2005 with an installed capacity of 5,804 MKW per annum (UNESCAP, 2011).

Figure 2. Small-Scale Dam in Yangyang, Kangwon Province, the Republic of Korea

Source: UNESCAP (2011).

[3] Sabo dams built in the upstream areas of mountain streams accumulate sediment and suppress production and flow of sediment. Those built at the exits of valleys work as a direct barrier to a debris flow which has occurred. International Sabo Network http://www.sabo-int.org/dott/ (accessed 21 November 2013).

As describe above, small-scale multipurpose dams can meet a variety of local demands, i.e. augmentation of water supply for households, irrigation projects, and industries, electricity generation, flood prevention, and inland navigation. These facilities may bring about negative impacts on the environment but the impacts are minimized, and ecological efficiency is improved.

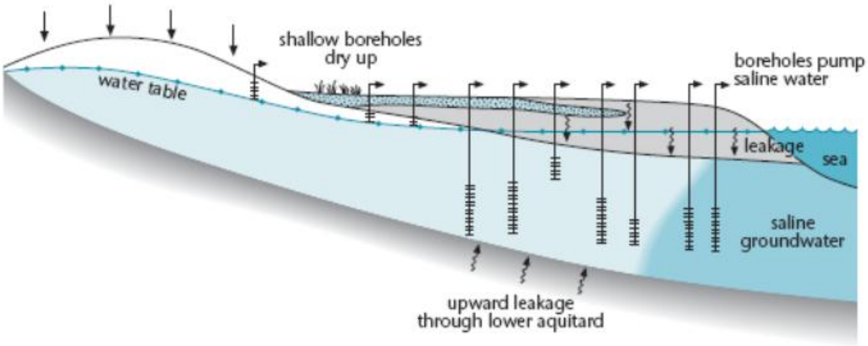
This new type of eco-efficient water infrastructure often embrace a constellation of positive benefits. First, these multi-purpose dams are built in order to maximize economic efficiency. Second, these dams can protect local communities against natural disasters, i.e. floods, debris flows, and landslides. Third, local small-scale dams designed for local circumstances are particularly useful providing steady water supply for households as well as other purposes, such as emergency water, in-stream flow, and water for the agricultural sector. Fourth, small-scale multipurpose dams can minimize adverse impacts of dam construction on the environment. Fifth, the new type of dams can provide a good venue for recreation activities. Last, these facilities can guarantee environmental and ecological protection through the provision of fish passages and in-stream flow regulations favoring water related leisure activities, fisheries, inland navigation, and irrigation projects (UNESCAP, 2011).

Eco-efficient Groundwater Management

Groundwater resources are useful for drinking, gardening, irrigation, and other various purposes. In many developing countries, groundwater resources are managed at individual or community levels. Because of that, this invaluable water resource is often neglected or ill-managed by water authorities, which often results in under-utilization or overexploitation by local users without relevant permits. In addition, the trend of rapid urbanization in developing countries in Asia and the Pacific over the past few decades has exacerbated such phenomena.

The overexploitation of groundwater resources often leads to depletion of groundwater resources. In addition, this trend has spawned a series of negative chain effects, including land subsidence or soil erosion, landslides, salinization of arable land, and ecosystem disruption. In particular, land subsidence derived from the drop of groundwater table and saltwater intrusion into arable land are the most serious problems in developing countries. These issues are related to the issues of universal access to water and wastewater services as well as food security. In addition, less groundwater resources can trigger a decrease of water flow to local streams and rivers, which jeopardizes ecosystems (Figure 3).

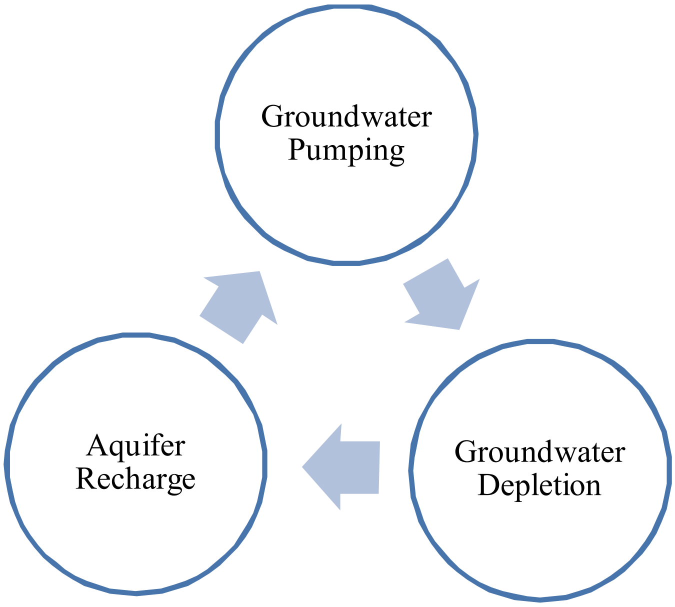
Figure 3. Impacts of Overexploitation of Groundwater



Source: UNEP (2003).

In order to avoid these challenges, eco-efficient groundwater management should be considered. The systematic monitoring and recharge system is a feasible solution. This system is implemented under the repeated cycling framework from groundwater pumping, groundwater depletion to aquifer recharge (See Figure 4). The process illustrates an important element in the principle of eco-efficiency for water infrastructure – water reuse and recycling (UNESCAP, 2011). Coupled with the new system, it is necessary to introduce institutional reform in regulating groundwater resources, i.e. an issuance of groundwater use permit, regular monitoring of groundwater tables, and close investigation of adverse impacts from overexploitation of groundwater resources at the national as well as community levels.

Figure 4. Eco-Efficient Groundwater Management Cycle



Source: UNESCAP (2011).

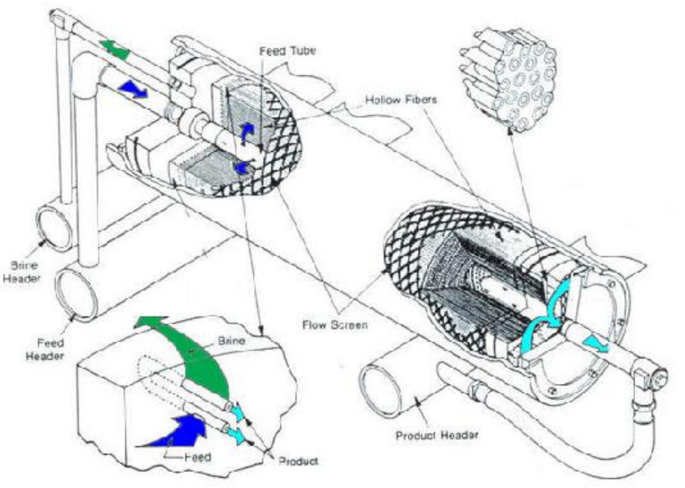
Eco-efficient Desalination Plant

Desalination is a viable option to make stable water supply for water scarce regions including Middle East, Northern Africa, and Southern European countries. Recently, more water stressed areas, i.e. the eastern coast of China, have taken into serious consideration the adoption of desalination plants to resolve water scarcity.

The most common desalination process is thermal process. But thermal desalination plants consume a vast amount of fossil fuels that emit carbon. The conventional approach in desalination lacks economic efficiency due to the high processing cost. The range of production costs for desalination plants in various regions range from US$1.0 to 1.8/$m^3$ (Frioui and Oumeddour 2008). Therefore, thermal desalination plants have actively been adopted primarily in oil rich countries, such as the United Arab Emirates, Saudi Arabia, and Oman. This type of desalination plants does not conform to the global climate change mitigation policy, which connotes that the thermal desalination plants do not embrace ecological efficiency.

Innovative solutions to seek eco-efficiency in desalination processes have been devised and proposed, including the Membrane Distillation (MD), the Reverse Osmosis (RO), and Electrodialysis (ED). MD indicates a thermally driven membrane process in which a hydrophobic microporous membrane separates a hot and cold steam of water. RO is a pressure-driven process that separates salty elements and freshwater with different concentrations across a semi-permeable membrane. Electrodialysis has been practiced for desalination of brackish water for the past three decades and utilizes an electric field to move the salt ions in the brackish water (Figure 5) (Charcosset, 2009).

Figure 5. Hollow-Fiber Membranes in a Large Reverse Osmosis Desalination Plant



Source: UNESCAP (2011).

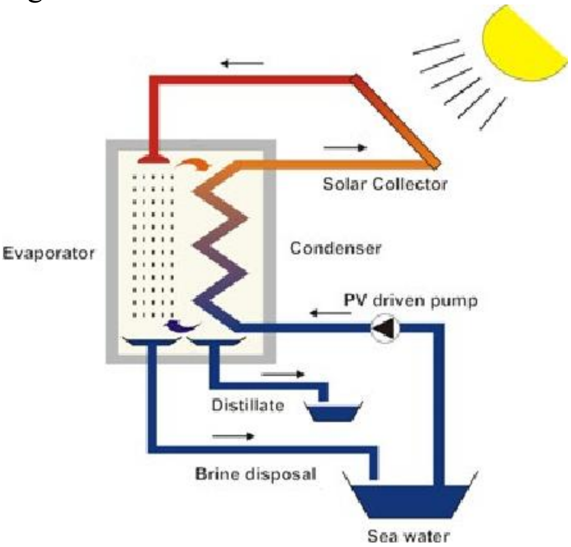
Desalination studies have shed light on increasing productivity with less environmental impacts. The nexus between water and energy has been a year-long research topic in the desalination industry. MD, RO and ED have widely been received and adopted in many desalination plants, because these technologies have paved the way for desalination managers to resort to less fossil fuels, which results in reducing costs and achieving economic and ecological efficiency.

Renewable energy options such as solar, wind, and geothermal energy have been highlighted as new energy sources to make desalination processes economically and ecologically efficient. Take an example of the combination between reverse osmosis and solar power (Figure 6). A desalination plant, powered by solar energy, is similar with a stand-alone system at a location without electricity grid. The significance of the system lies in the fact that solar-powered desalination plants work well for small-sized local communities within or away from large cities. This also means that energy-scarce local communities can have better access to clean water through this system in semi-arid and arid areas. This type of plants is often found in the remote areas of the Egyptian desert, rural areas of Jordan, and remote communities in Australia (Charcosset, 2009; Mathioulakis et al., 2007).

There are some challenges related to this option. Reverse osmosis requires high power pressure and consume a large amount of energy. Solar photovoltaic (PV) systems as seen in

Figure 6 do not require fossil fuels for generating energy in the desalination process but need a great deal of energy to manufacture solar panels (UNESCAP, 2011). In addition, a range of environmental impacts have to be discussed. Discharged water from desalination plants can increase temperatures in seawater, and the residues from pre-treatment and cleaning chemicals, as well as heavy metals from corrosion, may cause ecosystem damage on the ocean bottom (Lattemann and Hopner 2008). It is vital to tackle possible adverse impacts from desalination plants through environmentally friendly and energy saving technologies and related institutional setting and regulatory frameworks. And it is necessary to closely monitor the operations and maintenance of desalination plants. The new types of desalination plants reflects continuous efforts to maximize economic efficiency and achieve ecological efficiency at the same time.

Figure 6. Reverse Osmosis with Solar Photovoltaic (PV) Plant



Source: EAI (http://www.eai.in)

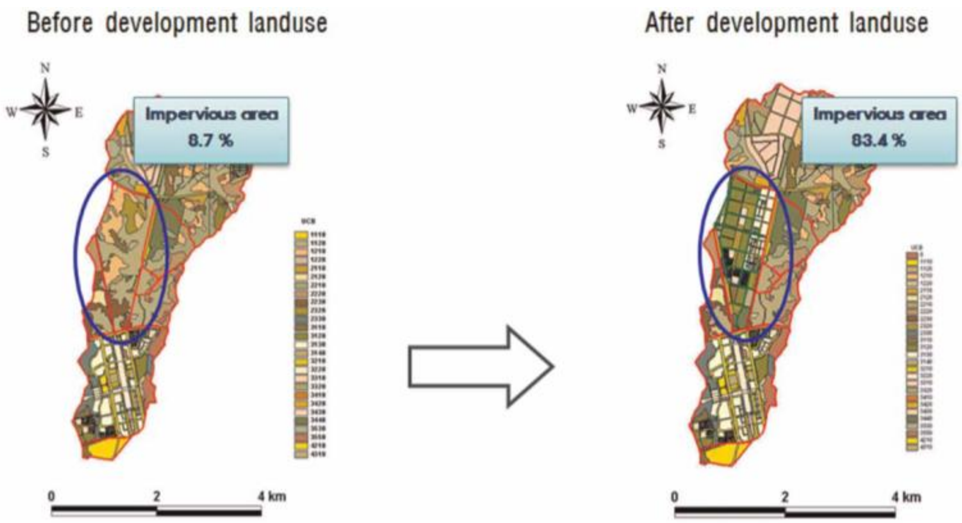
Low Impact Development (LID)

The Low Impact Development (LID) is a new approach to water infrastructure, particularly appreciating ecological efficiency as well as social inclusiveness in urban areas. LID was introduced in the United States in the late 1990s as a means to mitigate the negative impacts of increasing urbanization and impervious surfaces. The main purpose of this approach is to preserve the pre-development hydrology of a site. Compared with the typical storm water design, the LID design advocates more prudent approach at the planning stages so as to preserve the site as much as possible in an undisturbed condition. If any disturbances are necessary, the LID approach ensures the reduction of the impact on the soils, vegetation, and aquatic systems on the site.

More importantly, the LID approach intends to maintain the pre-development runoff volume whereas the conventional approach to storm water management concentrates on the control of peak flow rates. The examples of facilities created from the LID concept are bio-retention or rain gardens, permeable pavements, rain barrels and vegetated roof systems or green roofs (Dietz, 2007). Conventional storm water management strategies focus on large-scale, centralized treatment plants, and water storage facilities. LID puts an emphasis on local and decentralized methods that preserve natural systems and rainwater on a site and helps turn storm water from a waste product to a resource (UNESCAP, 2012a; US EPA, 2013).

Lee et al. (2013) displays the recent research of LID design for a new town of Cheon-an city, the Republic of Korea. The country witnessed an unprecedented level of flood damages in urban areas in 2010 and 2011, which kindled growing interests in LID and decentralized rainwater management as a new platform to decrease the hydrologic impacts of urbanization and to ameliorate flood damages. The study results on the new town of Cheon-an city indicate that if the LID approach were introduced, the storm water runoff would be reduced at 6-16% (peak runoff) and 33-37% (runoff volume) compared with conditions prior to the introduction of LID (See Figure 7). This implies that LID can play an instrumental role in reducing flood damages in urban areas, and recharge groundwater resources, thereby providing a sufficient amount of water for ecosystem rehabilitation.

Figure 7. Low Impact Development Study on Cheon-an City, the Republic of Korea



Source: Lee et al. (2013).

ABC Waters Program

The validity of eco-efficiency in water infrastructure lies in enhancement of the overall quality of life of local residents. Malone-Lee (2011) maintains that eco-efficiency is useful improving existent processes in water resources management. In addition, the eco-efficient approach leads to creation of new products and exerts a positive impact on markets by introducing innovative ideas and way of thinking alongside new rules.

Malone-Lee's arguments stem from the experiences of Singapore with regard to the 'ABC Waters' program. A represents 'Active,' which encourages local residents to be involved in diverse water activities, and B for 'Beautiful', which aims to integrate reservoirs and waterways with the urban landscape. C means 'Clean', which improves water quality. The project intends to shift the policy emphasis related to construction and operation of water infrastructure, from cost to value, from mono-use (i.e., flood control and water supply) to multi-functionality (i.e., beautification, cleansing and community engagement). In addition, the project facilitates active engagement of the public in water infrastructure, which culminates in bridging water infrastructure with social life and community well-being (Malone-Lee, 2011).

The case of the ABC Waters Program of Singapore explicitly elucidates the extent to which the eco-efficiency of water infrastructure can contribute to the improvement of the quality of living of local residents in urban areas. Eco-efficient water infrastructure can not only provide a solid foundation for continuous socio-economic development and increase the sustainability of urban areas but also help achieve a better quality of living in urban settings.

Green School

Green school is defined as an environmentally friendly and resource-efficient school. Green school nicely fits in the concept of green growth by encompassing the element of eco-efficiency and integration in the fields of school planning, designs and constructions. This approach includes the integrated principle of resource efficiency, eco-efficient technologies and materials, and the conservation of green space and the environment. In addition, as for the education purposes, green school raises the ecological awareness of students and broader school communities, including teachers, students' families and neighbors, on the significance of the low carbon, resource-saving lifestyle as one of the key elements of sustainable development and poverty alleviation (Hong, 2013).

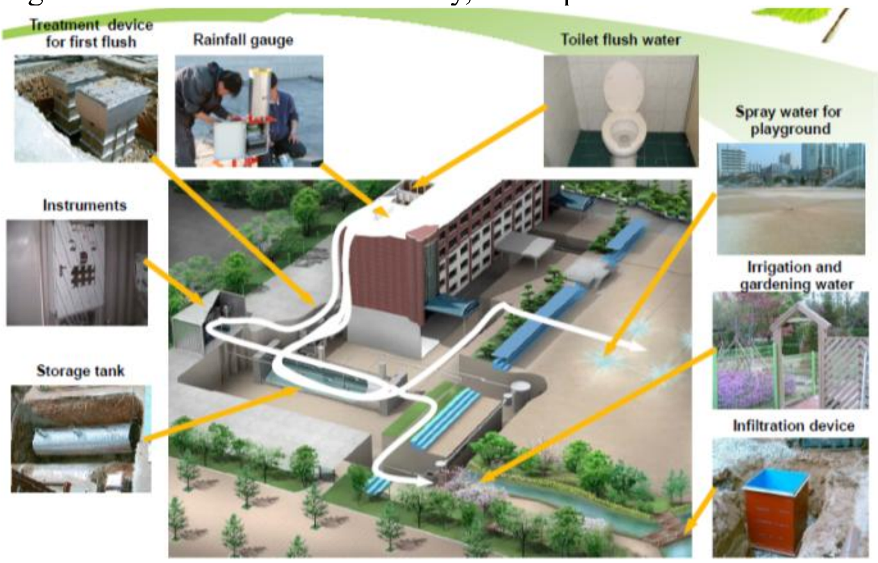
This new type of school is even more significant for urban water management, since the growth of population in urban areas of developing countries has brought about more pressure on water availability as discussed earlier. The intensity of resource consumption in urban areas, including water, urgently requires a new approach to resolving the complexity of challenges in various fields, including solid waste management, water supply, sanitation, and urban drainage and flood management. Green schools in cities can pioneer diverse education programs and pilot projects, which can later be trickled down to semi-urban and rural areas as good practices (GWP, 2013).

The distinct features of green school are fourfold. First, this approach advocates resource efficient schools including water, energy, and materials. Second, innovative architectural designs and building codes are introduced. Third, the green schools are designed to be disaster-resilient. Fourth, the green schools pursue partnerships with diverse stakeholders including the private sector, school communities and the general public. Fifth, the eco-efficient and socially inclusive practices embedded in the green schools serve as useful examples for educating future leaders (Hong, 2013).

As one of the good practices in green school, Hong (2013) refers to the case of the Republic of Korea. The Korean government has embarked on the Green School Initiative, primarily led by the Ministry of Education, Science and Technology, and part of the Environment-friendly Green School Development Project since the launch of low carbon green growth strategy in 2009. The total planned investment for the project reached around US$ 300 million. The government also enacted the Green Building Creation Support Act and introduced the Korea Building Design Criteria for Saving Energy, which encouraged new schools to adopt the Green School Initiative.

Thanks to the strong support from the central government, the overall assessment of the project has turned out to be positive. A total number of 110 schools adopted the new initiative between 2009 and 2010. This initiative has been incorporated into a broader framework of green buildings, mainly located in cities within the low carbon green growth vision of the ROK. In addition, the Guidelines for Establishment of Low Carbon Green City Development Plan was drawn up by the central government in August 2009, which attempted to promote the eco-efficiency of resource use through renewable energy supplies, including solar PV and wind power and adopt disaster resilient water management systems in an urban setting (Hong, 2013) (See Figure 8).

Figure 8. Green School in Ilsan City, the Republic of Korea



Source: Kim R (2009).

The Korean case illustrates that socio-political and economic commitment from the public sector has contributed to promoting green schools in society, especially in urban areas. It may be too early to judge the extent to which the Green School Initiative receives good feedback from the general public as well as various stakeholders in society, i.e., the business sector, civil society, and local communities. But the willingness of the central government to initiate such projects will be one of the key conditions to determining the success of relevant projects in other developing countries of the region.

4.2 Current projects in Indonesia and the Philippines

Indonesia

Roadmap to Eco-Sustainable Water Infrastructure in Indonesia
Indonesia is regarded as one of the water rich countries in Asia and the Pacific in terms of the total renewable water availability (UNESCAP, 2012b). The average annual rainfall reaches over 2,500 mm per annum, however, this sufficient amount of rainfall falls unevenly throughout the year. The rainy season, which lasts between May and September, receives 80% of annual rainfall. The problem of uneven precipitation is compounded by an uneven

distribution of water resources in various regions. For instance, an average annual precipitation of Java and Bali reaches 2,000 mm whereas the Nusa Tenggara area receives precipitation between 400 and 600 mm. Indonesia encompasses a high level of vulnerability in terms of water resources management thanks to the spatial and temporal distribution of precipitation (Abal and Samekto, 2013).

More specifically, Indonesia's water and sanitation services lag behind when compared with the industrializing countries of the region. Rapid economic growth and urbanization have brought about economic well-being for many Indonesians, however, such development has been at the expense of water quality. The deterioration of water quality in water bodies has not only damaged ecosystems as a whole but also poses a serious threat to the quality of drinking water. The response from the central and local governments has not met the rate of the deterioration of water quality in local water bodies, and water infrastructure has not been adequately revamped or retrofitted (Abal and Samekto, 2013). Confronted with these challenges, the Indonesian government has embarked on the water sector reform and has introduced the concept of Eco-Sustainable Water Infrastructure (ESWIn).

Eco-sustainable water infrastructure is defined as 'an integrated approach in water infrastructure development to achieve ecological and economic efficiency through: 1) maximizing the value of water related services; 2) optimizing use of natural resources; and 3) minimizing impacts on ecosystems' (Abal and Samekto, 2013). The essence of eco-sustainable infrastructure is similar with that of eco-efficient water infrastructure.

Indonesia's approach attempts to reflect the recent outcomes of the Rio+20 conference that emphasized a shift to green economy in the context of sustainable development and poverty reduction. Also, the Indonesian government stresses the approach as an implementing strategy to achieve the Millennium Development Goal (MDG) 1, poverty reduction and MDG 7, environmental sustainability (Abal and Samekto, 2013). The eco-sustainable water infrastructure of Indonesia reminds the value and contribution of eco-efficient approach to water infrastructure by referring to a series of significant international events for achieving sustainable development.

The government of Indonesia is now in the process of drawing up a Strategic Road Map to Implement Eco-Sustainable Water Infrastructure in Indonesia in collaboration with UNESCAP. These efforts imply that the country has devoted itself to undertaking proactive policy measures in order to apply the principles of eco-efficiency to the recently reformed water management system.

Alongside these efforts, UNESCAP, the Korea International Cooperation Agency (KOICA), and the Indonesian government have teamed up to launch rainwater harvesting projects at the community level in 2011, which epitomizes the extent to which the national-level commitment can be trickled down to community levels. This case sketches the dual track approach to implementation of eco-efficient water infrastructure, which includes the strategic roadmap for ESWIn from the central government (top-down) and the rainwater harvesting project at the community level (bottom-up).

Pilot Project – Integrated Rainwater and Wastewater Management System in Bandung, Indonesia

Two pilot projects have been planned to implement the model systems for integrated rainwater and wastewater management with local partners, the Bandung Institute of Technology (ITB), the Pasundan University (UNPAS), and the Bandung City Government. The official launch of the project was in October 2012, and UNPAS finished construction of the model system in May 2013. Building works at ITB were completed in late 2013. Rainwater harvesting is one of the pilot projects, which is designated in the National Long Term Development Plan (2005-2025) by the Indonesian Government, particularly focusing on the household level (Abal and Samekto, 2013). These project experiences will become a useful asset to draw up the national development plan on water infrastructure, particularly for the Five Year National Development Plan 2010-2014 (Pasundan University, 2012).

The project for ITB aims to develop, implement and apply innovative models for bio-eco engineering technology in the Cikapundung River, Bandung, Indonesia. The major components of the model at ITB are composed of technology, policy measures, capacity building and stakeholder participation. As part of the project, a demonstration site was constructed on stream restoration through bio-eco engineering technology. The project has introduced community-based eco-hydrology interventions for setting up ecosystem services to help integrate environmental considerations into the wider Integrated Water Resources Management (IWRM) plan. An important feature embedded in the project is the introduction of rainwater harvesting technologies in order to design, construct, and monitor a drinking water supply system for communities (ITB, 2012).

With regard to implementing strategies, the ITB project highlights water quality monitoring before and after the project and community involvement in operating and monitoring the project. Community involvement is one of the key elements of the project, because local community members have been encouraged to increase their capacity of maintaining and managing rainwater and wastewater management facilities. In addition, the project team has provided advice on financing mechanism for sustainable development. The range of community involvement also includes an establishment of targets with partners and local communities. Project partners are Puslitbang Air (Research and Development Center for Water), PDAM (District Drinking Water Company), Puslitbangkim (Research and Development Center on Human Settlement), and the Asia Green Resource Institute (ITB, 2012).

The expected outcomes from the ITB project are fourfold. First, the project will produce models and guidelines for stream restoration through bio-eco technology. Second, the pilot application of integrated rainwater harvesting and wastewater treatment technology will be undertaken for the local communities. Third, local communities are involved in elaborating eco-hydrology methods, for instance, a design of a bio-filtration techniques to manage waste streams before the wastes join the local stream connected with the Cikapundung River and to enhance ecological links between various water components. Last, the integrated rainwater harvesting guarantees steady drinking water supply for the communities (ITB, 2012).

The other pilot project in Indonesia has been undertaken at the Pasundan University (UNPAS), Bandung. The purpose of the UNPAS project is to enhance public awareness and capacity development for planning and to implement an integrated rainwater and wastewater management systems in order to achieve water security and to mitigate adverse impacts derived from climate change. In this project, the dormitory building of the university has been chosen in order to enhance water supply through rainwater harvesting.

Rainwater potential in Bandung is immense. The average monthly rainfall between 2006 and 2010 in Bandung reached the range between 142 to 322 mm with an average rainfall of over 150 mm per month, which indicates that rainwater can become a stable source of clean drinking water. In general, the quality of rainwater in the area is relatively good but due to possible pollutants in the air, collected rainwater should be treated prior to distribution and consumption (Pasundan University, 2012).

This rainwater harvesting project will be expected to bring about a series of benefits. First, this enables a stable provision of clean water source, and second, the heavy reliance on surface and groundwater resources is reduced, thereby reducing impacts on the environment. Third, in connection with the second benefit, this method prevents a drop of groundwater table and reduces the risk of landslide on the campus of UNPAS. Fourth, there is an effect of water conservation that leads to higher water availability and sustainability in the long term (Pasundan University, 2012).

The Philippines

Roadmap to Eco-Efficient Water Infrastructure in the Philippines
In 2008, UNESCAP and the National Economic and Development Authority (NEDA) in the Philippines agreed to collaborate for the promotion and development of eco-efficient water infrastructure and to disseminate the idea of eco-efficiency, the planning of system change and capacity building. As an early result, the National Strategy for Eco-Efficient Water Infrastructure Development in the Philippines was established in late 2009.

Although the Philippines boasts of its abundant water resources in the form of surface and groundwater resources (over 5,100 m^3 per capita in 2010), water availability varies from island to island because of diverse topography and geology, the uneven precipitation patterns, and the quality of the natural resource environment. Water scarcity becomes a major issue in large cities, such as Metro Manila and Cebu City, because of population growth, industrialization, and urbanization.

In the urban areas of the Philippines, tap water supply is not a stable option for the public. It is groundwater that may serve as a main water source for the household as well as industrial uses. This phenomenon has led to overexploitation of groundwater resources, a decline of groundwater tables, groundwater contamination, saltwater intrusion and land subsidence. The overexploitation of groundwater in the country partly results from the lack of relevant regulations on water permits (NEDA, 2013). The case of groundwater in the Philippines delineates the need to introduce more eco-efficient approach for water infrastructure, which should strengthen the government's policies on physical and non-physical infrastructure development and management.

The Philippines succeeded in developing the Strategic Roadmap for Eco-Efficient Water Infrastructure (EEWIN) in February 2013, which incorporates the primary ideas of the EEWIN into plans, programs, projects, and operation systems. The roadmap presents the policy direction of the country with regard to the integration of the EEWIN in development, consolidation, and operational phases of water resources management and exploitation.

This new approach to water resources management has been regarded as an effective solution to enhance water supply and sanitation infrastructure in the country. Over the past few years, adverse impacts from climate change have urged the government of the Philippines to pay more attention to disaster risk reduction and management. The EEWIN is even more instrumental than ever as a proactive strategy to response to new challenges in the water sector. The approach of the EEWIN has been incorporated into the 2011-2016 Philippine Development Plan (PDP) (NEDA, 2013).

The main objectives of the roadmap are fourfold. First, the roadmap suggests a policy guideline for the development, integration and implementation of the EEWIN philosophy and the related technologies and methodologies. Second, the roadmap identifies the areas for possible coordination and partnership with the private sector in the implementation of EEWIN. Third, the government's interventions and programs on the EEWIN promotion will be prioritized through the roadmap. Fourth, the roadmap displays the responsibilities of government and provides corresponding timelines for the government-led programs (NEDA, 2013).

In the roadmap, the government provides the long-term plan for 25 years with the vision of attaining efficient and sustainable water resources management through EEWIN development. There are four major focus areas: 1) sustainable urban water management in order to create livable cities; 2) alternative water source development, such as rainwater harvesting; 3) agricultural water resources management, i.e. rice self-sufficiency program; and 4) industrial/economic zone water management. The short term plan (5 year roadmap) concentrates on addressing the weaknesses in the water sector which retard development, i.e. the absence of enabling environments (policies, laws, and regulations), the fragmentation of institutions, and weak capacity (NEDA, 2013).

Pilot Project – Application of Sustainable Designs for Green School Development in Cebu, the Philippines

The case of green school in Cebu, the Philippines shows a good practice in the metamorphosis of building design towards more eco-efficient, resilient, and flexible one. Considering the environment, society, and economy in achievement of sustainable development, the green school project neatly reflects the essential elements within its own design. The green school project can help sustain the environment and mitigate climate change effects through storm water management, temperature moderation, emission reduction and water conservation. Second, the project can bring in the benefits of a healthy and productive society through enhancement of the users' health, comfort, and productivity. Third, economic benefits can be generated through the green school project, which are: 1) water and energy saving; 2) a decrease of operational management budget; and 3) a multiplier effect of cost reduction (KORA, 2013).

In the green school project, rainwater harvesting is an element with which the principle of eco-efficiency is applied. Rainwater is collected from the roof to the gutter and stored in elevated tanks supplying water by gravity or by a pump to the school's toilet facilities, gardening and other use. The overall benefits of rainwater harvesting in the project are as follows: 1) conservation of water; 2) stable water supply against emergency situations, i.e. storms and disasters; 3) reduction of run-off and erosion; 4) water for firefighting; and 5) reduction of mosquito breeding grounds against the outbreak of dengue fever (KORA, 2013).

The idea of green school is not only applicable to newly built schools but also to existing schools with environmentally unfriendly materials and designs. In the case of Gabaldon School, the approach of eco-retrofitting has been proposed (KORA, 2013). The objectives of the proposal are to eco-retrofit the existing Gabaldon School buildings with green school design elements and to conserve the school as a cultural heritage with the intention to promote the value of preserving local culture. Technical details in the proposal include the use of sustainable local building materials, the architectural design that allows the school building to breathe and ventilate, an installation of special windows which allow natural light to filter into the interior space, and the roof ventilating elements together with wide open window systems.

The experiences of eco-retrofitting in the Gabaldon School are summarized, following the three main pillars in achievement of sustainable development as seen in Table 2. As for the environment, the project aims to enhance indoor environmental conditions, level down storm water and alleviate the contamination of freshwater resources. In addition, air temperatures will be lowered, the heat island effect, dust particles and air-borne toxins will be reduced, and the improvement of air circulation is possible coupled with provision of flora and fauna habitats in the surrounding areas of the school. The social and health benefits of the project are associated with the enhancement of health, comfort, and productivity of the users, pollution abatement, and encouragement of social interaction. Economic benefits include water conservation, solar energy generation, and the reduction of operation management costs (KORA, 2013).

Table 2. Benefits of Eco-Retrofitting of Gabaldon School

Environment	Social and Health	Economic
Enhancement of indoor environmental conditions	Improvement of the users' health, comfort, and productivity	Water conservation
Alleviation of storm water and reduction of the contamination of freshwater resources	Reduction of pollution	Adoption of solar photovoltaic (PV) power
Lowering of air temperatures	Encouragement of social interaction	Reduction of operation management costs
Reduction of heat island effects		
Improvement of air		

circulation		
Provision flora and fauna habitats		

Source: modified based on KORA (2013).

5. Policy Measures

An array of policy measures are presented for achievement of eco-efficiency in water infrastructure regarding sustainable urban development, such as the adoption of integrated approach in water resources management, and the change of operation and management practices in water infrastructure. This policy shift should take the direction from a single-purposed and centralized to a decentralized and multi-purpose way. Faced with formidable challenges in the urban areas of Asia and the Pacific, an innovative approach to creation of new waters is required, including rainwater harvesting, water and wastewater reuse and recycling. Stakeholder participation becomes even more crucial at the community level which makes decisions for water infrastructure development and management more concrete and politically legitimate. The experience of green schools in the Philippines and the Republic of Korea explicitly indicates the importance of eco-efficiency education for the next generation in terms of dissemination as well as implementation of the idea of eco-efficient water infrastructure (UNESCAP, 2012a).

5.1 Integrated Water Resources Management (IWRM) for Urban Development

The Integrated Water Resources Management (IWRM) is worth paying attention to in relation to policy measures for promoting and implementing eco-efficient water infrastructure in urban development. The definition of IWRM is 'a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (GWP, 2000). The concept advocates the maximization of the economic and ecological benefits together with social inclusiveness.

These elements are relevant to the core ideas of eco-efficient water infrastructure. UNESCAP (2012a) discusses the extended aim of IWRM, which is to avoid the sector-based policy fragmentation and remove inefficiency in governance structures together with an adequate degree of integration of sectors and policies. This can bring about more eco-efficient and socially inclusive water infrastructure.

The integration principle of IWRM and eco-efficient water infrastructure requires the integration of natural and human systems. The natural systems embrace freshwater and coastal zone, land and water resources, surface and groundwater resources, water quality and quantity, and upstream and downstream. As for the human systems, there are all policies considering impacts on water, integrated with economic, food, energy policies, and stakeholder participation in policy planning and decision process. In addition, water supply and wastewater services, and public private partnerships are considered (GWP, 2000).

This study primarily pays attention to urban development in association with IWRM. IWRM for urban development sheds light on the complexity of issues in urban development linked with water issues at the river basin and national levels. As discussed earlier, there have been diverse challenges in urban development, especially in developing countries, due to rapid urbanization, inadequate public services and out-of-date urban planning models. Water management is regarded as one of the most formidable challenges.

In order to tackle these challenges, it is necessary to have a closer look at urban problems in an integrated fashion and call for balanced approaches to both urban development and river basin management in order to achieve sustainable economic, social, and environmental goals. Such approaches should embrace not only water supply, sanitation, and urban drainage and flood management but also solid wastes management and coordination of water services. In addition, cities should introduce integrated urban water plans, urban development master plans, and other facilities plans such as transport and housing within the framework of city plans (GWP, 2013).

An appropriate set of policy approaches and actions are suggested. These components are presented in Table 3, which delineates the extent to which IWRM related policies can have positive impacts on the enhancement of the overall water resources management. To make one step further, one of the major outcomes from the UNESCAP's 2011 report is to present a list of policy measures on eco-efficient water infrastructure. The policy approaches for eco-efficient water infrastructure delve into the complexity of political, institutional, and financial issues coupled with consideration of democratic decision-making and introduction of public private partnership schemes (UNESCAP, 2011). Urban development elements have been reflected into these policy suggestions, which encompass the crucial components of the case studies in this report.

Table 3. Comparison of Integrated Policy Approaches between Water Management and Eco-Efficient Water Infrastructure for Urban Development

Integrated Policy Approaches	Water Management	Eco-Efficient Water Infrastructure for Urban Development
Political Willingness	Political stability	Political willingness Coordinating institution Feedback system Public awareness
Legal, regulatory & administrative settings	Basic water law Adequate legislations & regulatory programs at the urban, basin, and national levels Cross-sectoral collaboration River basin management	Eco-efficiency principle embedded in Basic Water Law and laws and regulations at the city level Financial incentives or levying penalties to companies depending on how eco-efficient they are Appropriate standards and conditions of eco-efficiency in the water sector and urban development Coordinating mechanism (institutions, regulations, programs) between ministries and city bureaus River basin management and urban planning for ecological efficiency
Financial & economic practices	Rational water tariffs, water savings, full-cost recovery	Rational water tariffs with provision of safety nets for the poor and the marginalized in urban areas (esp. the informal urban sector) Promotion of water saving technology for eco-efficiency in

		urban buildings, i.e., households, schools, and hospitals
Stakeholder participation	Institutionalization of stakeholder participation in planning and policy-making	Principle of stakeholder participation embedded in Basic Water Law and other laws and regulations at the city level
Private sector involvement	Enhancement of service quality	Institutional incentives for private players and improvement of service quality through private investment, advanced technology and management skills in urban areas Adequate regulatory settings prepared prior to invitation of private players to ensure universal access to water for the poor and the marginalized in urban areas

Source: modified based on UNESCAP (2011).

5.2 Decentralization

Decentralization should be included as one of the crucial components in the national water plan for eco-efficient water management. In many countries in Asia and the Pacific, water resources planning and decision-making processes have been dominated by the center. Such practice has contributed to a decent level of achievement in the water sector as a whole, including water and sanitation services and flood prevention. However, numerous cases illustrate that the central planning system in water management has resulted in deterioration of water supply and sanitation services and inefficient flood control measures in local areas. The central governments in the region have often been ill-informed of the real needs at the local level since the top-down approach has prevailed.

In response to such challenges, the government has to take into account the basic and crucial needs at the lowest possible level in water management. Continuous checks should be necessary in relation to whether actions or policies at community levels are justified. The need to accommodate diverse opinions in water issues is applied to the lowest levels, even down to individuals. A new national water strategy should encompass the decentralized approach to water issues, and the officials at the center should be ready to share their political, administrative and financial power with various stakeholders at the river basin and local levels. This transformation will then create the enabling environment in establishment of the principle of stakeholder participation.

The devolution of the managerial, administrative, and financial power to the community level can facilitate development policies and strategies, which are appropriate for social, economic and environmental conditions at the local level. This new mode of water policy also contributes to establishment of sound governance structures that meet the demands of local residents. Decentralization can accelerate streamlining of the governmental bureaus at the center and redefine the roles and functions of diverse bureaus related to water management, which becomes a foundation to establish eco-efficient water infrastructure. The following paragraph shows a list of principles for decentralization in eco-efficient water infrastructure:

- Accommodation of diverse opinions in water issues applied to the lowest levels, even down to individuals
- Political, administrative and financial power of the central government shared with various stakeholders at the river basin and local levels
- Development of policies and strategies appropriate for socio-economic and environmental conditions at the local level based on the devolution of the managerial, administrative, and financial power to the community level
- A clarification of the roles of local, regional, and national level institutions and the set-up of efficient local level institutions for planning and decision making

The success of decentralization hinges upon a clarification of the roles of local, regional, and national level institutions and the setup of efficient local level institutions for planning and decision-making. Without these foundations, there are several risks that might result in jeopardizing the decentralized system, such as the reinforcement of local elite groups, anti-government movements in different ethnic and interest groups, the marginalization of less dynamic regions and the fragmentation of national unity (OECD, 2001).

Box 1. Decentralized wastewater management system

The main objectives of decentralized wastewater management systems are threefold: 1) public health management; 2) water and energy conservation; and 3) environmental protection. Regarding public health management, this decentralized system can help reduce water-borne diseases, i.e., diarrhea, thereby improving public hygiene. Water losses and energy consumption can decrease thanks to the design, construction and operation of the system that carefully consider local demands. In addition, tailored services to dilute water pollution pertaining local environmental conditions can not only bring about amelioration of the level of water pollution but also enhance water environments through discharging adequately treated wastewater to local ecosystems (UNESCAP, 2012a; US EPA, 2012).

Useful examples in the decentralized wastewater management system can be found in Vietnam and China. A treatment process through the baffled septic tank with anaerobic filter turned out to be the most appropriate solution for wastewater treatment in the residential areas of Vietnam. As for China, the use of underground, individual household scale, and anaerobic digesters have been promoted since the 1970s so as to deal with rural organic wastes. The Chinese practice shows that the decentralized wastewater treatment systems (digesters) have produced the biogas and the fertilizers that are used as an energy source and used for agricultural production, respectively. There are numerous cases on the application of such decentralized wastewater treatment systems in other developing countries, i.e., Brazil, Columbia, and India (Massoud et al., 2009).

5.3 New Water Sources

Conventional methods to develop water resources refer to engineering projects, such as dams, aqueducts, and canals in both developed and developing countries. These methods are unsustainable in the long term, because dam reservoirs are highly subject to evaporation due to continuous sunlight, which results in reducing water resources rather than increasing. There is no ‘new’ water that is mobilized through the water transfer or diversion projects. This approach even triggers climate change and ecosystem disruption.

There has been an urgent need to mobilize new water resources in urban areas, particularly in water shortage countries. As new water resources, water reuse and recycling and rainwater harvesting have become good candidates in recent years. These new water resources reflect some of the principal ideas behind eco-efficient water infrastructure, i.e., ecological efficiency, through the reuse and recycle of wastewater and the interception of rainfall, and economic efficiency through the reduction of water supply costs in both options.

The first example is the water reuse and recycling system. The fundamental principle of water reuse is to minimize the waste of water. In many cases, clean and potable water is inefficiently provided and exploited for irrelevant purposes, such as for car washing, gardening, toilet use, and agricultural use. The two primary objectives of water reuse are to minimize freshwater demand and to decrease wastewater treatment needs. Similar with the discussion of decentralized wastewater treatment systems, water reuse also requires site-specific and tailored approaches pertaining local circumstances.

On top of the introduction of such new technical methods, it is imperative to take into serious consideration institutional reform. As the first step, the central and local governments in Asia and the Pacific need to introduce an appropriate level of fees for wastewater treatment and enact a regulatory framework to support installation of approved high performance wastewater treatment systems in new buildings or renovated facilities through an issuance of permits. Additional laws require new property owners to go through water and wastewater audits ensuring that they should install facilities for wastewater reuse and recycling (Kim T, 2010). The following paragraph shows several principles for implementation of water reuse and wastewater recycling under the framework of eco-efficient water infrastructure:

- Minimization of waste of water
- Minimization of freshwater demand
- Decreased wastewater treatment needs
- Site-specific and tailored approaches considering local circumstances
- Introduction of an appropriate level of fees for wastewater treatment
- Enactment of a regulatory framework to support installation of approved high performance wastewater treatment systems in new buildings or renovated facilities through an issuance of permits

Rainwater harvesting is the other new water source that should be promoted for eco-efficient water infrastructure. The primary functions of rainwater harvesting are prevention of river flow drying, augmentation of water supply, the control of non-point source pollutants, alleviation of heat island effect, and prevention of urban flood and restoration of the hydrological cycle as discussed from the cases of Indonesia and the Philippines. In particular, this approach is useful for those who suffer from a lack of sufficient water resources in urban areas and remote communities that are not tapped into stable water supply systems (Kim T, 2010). The method is regarded as a practical approach to achievement of a decentralized water management. (Kim R, 2009; Lee et al., 2010).

Box 2. Rainwater harvesting in Korea

A successful case of rainwater harvesting in Korea is the Star City Project in Seoul, which is a major real-estate development for more than 1,300 apartments. The complex consists of four 37-58 story buildings, and the rainwater harvesting system in the Star City has been in operation since 2007. The research result in 2011 maintains that approximately 26,000 m^3 of water was saved per annum thanks to rainwater supply. Also, about 8.9 MWh of electricity was reduced from June 2007 to May 2008 via the use of 26,000 m^3 of rainwater (Han and Mun, 2011).

The Star City Project with rainwater harvesting has culminated in inducing growing interests in installation of rainwater harvesting systems at urban buildings in Korea and has become a modality to be followed by many localities. The successful operation result of the rainwater harvesting system has made 47 local authorities enact relevant laws and regulations. In addition, a series of ministries at the central government began to embark on rainwater harvesting programs, i.e., the Green School Project (2009-2012) by the Ministry of Education, Science and Technology, and the Project for Rainwater Storage and Infiltration (2009-2014) by the National Emergency Management Agency. The Ministry of Environment enacted the Law to Promote and Support Water Reuse in June, 2009, which promotes the wide application of rainwater harvesting facilities (Kim R, 2009).

5.4 Stakeholder Participation

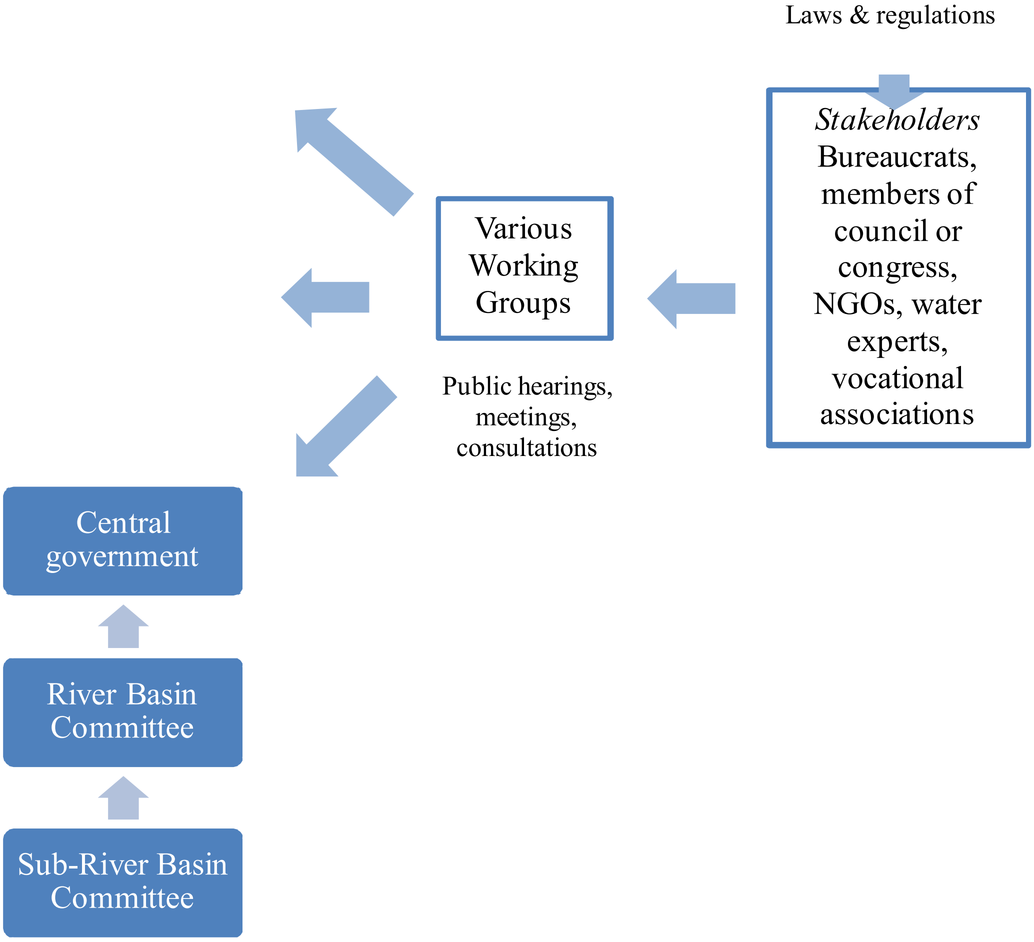
The magnitude of public participation in water policy-making and implementation has been widely discussed and accepted in the international water community. In particular, eco-efficient water infrastructure puts an emphasis on the role of local communities. But it is still uncommon to find an adequate institutionalization of public participation in water decision-making and implementation in the world, including Asia and the Pacific. One of the fundamental causes to delay an institutionalization of public participation is a conventional approach of the bureaucrats to this idea, who are in charge of water policy. Bureaucrats often believe that more engagement of the public might slow down decision-making and implementation with unnecessary comments and interventions, which can spawn an increase of transaction costs. But a consensus through the public participation approach can guarantee a smooth development of projects and policies in the water sector through reaching consensus.

To make participation more effective, it is imperative to bring in as many as stakeholders possible at various levels who are engaged in water issues. The broad range of participation brings in diverse benefits: 1) embarking on debates for new ideas and information; 2) identifying issues that should be addressed; 3) clarifying the capabilities necessary to address them; and 4) reaching a consensus on the need for action that spurs effective implementation.

The government may play a key role but much more crucial element is an establishment of multi-stakeholder processes. The processes should include a variety of stakeholders, i.e., decentralized authorities, the private sector, civil society and the marginalized. Good communication and information mechanisms should be accompanied together with transparency and accountability (OECD, 2001).

Diverse participation methodologies can be applied from the initial stage of the planning process to implementation. The participation of public and private organizations, the government and non-government organizations in the management of water resources as well as acknowledgement of their rights and responsibilities for the use, maintenance and conservation of water resources should be properly understood. Figure 9 portrays the basic concept of public participation in water policy.

Figure 9. Public Participation in Water Policy



Source: UNESCAP (2011).

Participation is a key element to achievement of political legitimacy in achieving eco-efficient water infrastructure. Public participation in decision-making and implementation in establishment of eco-efficient water infrastructure at the center and local levels is ideal, but it is hard to implement such process due to logistical problems in many countries in Asia and the Pacific. A more practical approach is stakeholder participation. Stakeholder participation is a more practical option to reflect public opinions because key stakeholders represent the opinions from the general public. The identification of key stakeholders can be possible through interviews and meetings (UN Water, 2008).

Stakeholders in the development of eco-efficient water infrastructure should be well informed and have a good understanding of what eco-efficiency means and why this innovative approach is needed for water infrastructure. This process is on-going through a considerable number of public hearings, meetings, consultations, and workshops as seen from the case of the Philippines in establishment of the roadmap for eco-efficient water infrastructure. The central and local governments should ensure that this new knowledge should not be consumed by the elite only but be well understood by the public. Then, it is imperative to have a provision of diverse channels for stakeholders to be engaged in decision-making and implementation.

It is crucial to invite local communities on board to introduce new ideas and information for enhancing water and wastewater infrastructure, including eco-efficiency. It is both a means and ends. That is why the pilot project of Indonesia in the report strives to encourage local communities to be involved in designing eco-hydrology methods in order to manage wastewater reuse and recycling and rainwater harvesting facilities on their own. The information should be shared so that mutual knowledge between the elite and the lay public, particularly at the community level can be established to move forward policies, programs and projects with regard to eco-efficient water infrastructure. The following embraces a series of principles for implementation of stakeholder participation in the development of eco-efficient water infrastructure:

- Establishment of multi-stakeholder process through laws, regulations, and ordinances at the central, regional, and local levels
- Invitation of diverse stakeholders: decentralized authorities, the private sector, civil society, and the marginalized (including the informal urban sector)
- Good communication and information mechanisms: public hearings, meetings, consultations online and offline
- Transparency and accountability guaranteed in the stakeholder participation process
- Dissemination of the concept and the need of eco-efficient water infrastructure to the lowest possible level

Box 3. Local community involvement in decision-making in Thailand

The experience of the Towards Ecological Recovery and Regional Alliance (TERRA) in Thailand highlights the importance of local community involvement in decision-making and implementation with reference to ecosystem protection, which is linked to increasing ecological efficiency. The Thai local NGO encouraged the people of Ban Pah Chan village in the Ubonratchathani Province, which is located in the Lower Mekong River Basin, to map and monitor river ecosystems in March 2011. Since the village people had lived in the area from generation to generation, they were well aware of river morphology, sub-ecosystem, and land use in the river bank. In consequence, TERRA succeeded in conducting an in-depth study on the ecosystems in the region (Kim G, 2013). This case implies that community-centered policies in the water sector can enhance ecological efficiency for local residents through an increase of fish catch, and a rise of tourism industry.

5.5 Eco-Efficiency Education

The green school can serve as a useful platform to embark on eco-efficiency education for water infrastructure, which includes particular relevance and large potential in Asia and the Pacific. This approach will be an adequate solution to enhance economic and ecological efficiency in the developing countries of the region, which lacks a good level of educational facilities for basic education. Also, many developing countries in the region embrace a large portion of young people in their demographic structure, and eco-efficient green schools would play a pivotal role in providing useful learning environments and education programs for the next generation (Hong, 2013).

There are six items in assessment of the quality of green schools for eco-efficiency education in the region: 1) political leaderships and existence of national and/or local strategies; 2) integrated planning of green school in the overall context of urban planning; 3) enabling environments (institutional settings); 4) partnerships with local stakeholders; 5) financing mechanisms; and 6) green school as education for next generations (Hong, 2013).

Hong (2013) provides several reasons why the green school initiative will positively contribute to local communities in developing countries as seen from the case of Cebu, the Philippines. First, the health and performance of students in green schools can improve. This approach reduces environmental impacts through application of solar PV power, rainwater harvesting, and wastewater recycling and reuse systems. In addition, environmentally friendly and eco-efficient designs, constructions and recycling efforts provide positive impacts on those who are undertaking educating activities on the premises.

Second, the cost savings of green schools occur via eco-efficient designs, construction, and operation of the facilities and buildings. Examples are energy-efficient heating and air conditioning systems, energy-efficient lighting and occupancy sensor, day-lighting strategies, water-efficient fixtures. All the facilities can level down operation and maintenance expenses. Water use can be minimized through rainwater harvesting.

Third, for a broader perspective, local communities with green schools enjoy the benefit of the rise of property values and incomes. Investment into green schools can eventually raise the profile of local communities, which culminates in creation of a positive cycle of more investment in the communities and more jobs available in the areas.

Fourth, green schools may buttress local economies in the long term. Green schools require eco-efficient designs, construction, and maintenance, which require more eco-friendly building materials, engineers with green techniques, and consultants with relevant experiences. All these elements can consequently bring about benefits to local economies. According to a research conducted by Rutgers University in the US, each US$1 million of spending on school construction produces US$ 467,000 in income, over US$ 13,000 and US$ 16,000 in state and local tax revenue, respectively, and US$ 611,000 in gross state product and local jobs (Rainwater and Harkte, 2011).

Fifth, students can learn a variety of issues related to environmental engineering and sciences through green school facilities. In addition, the concept of eco-efficiency is easily understood by letting the students pay attention to eco-efficient practices of the facilities within the school, i.e., rainwater harvesting, wastewater reuse and recycling, and solar PV energy. Sixth, green schools can become an arena where local communities' people can gather and discuss various issues for sustainable local communities. The general public in local communities can take lessons from adoption of eco-efficiency in daily living from green schools (Hong, 2013). This can be a plausible way to encourage local communities to have a better understanding of eco-efficiency, green growth, and sustainable development in the long run. The following paragraph illustrates the principles for establishment of eco-efficiency education through green schools:

- Political leadership and existence of national and or local strategies for green school
- Integrated planning of green school in the overall context of urban planning
- Enabling environments (institutional settings)
- Partnerships with local stakeholders
- Financing mechanisms to establish and operate green schools
- Eco-efficiency education curriculum for next generations

6. Conclusions

This study has evaluated the achievements and challenges in establishment of eco-efficient water infrastructure towards sustainable urban development in Asia and the Pacific. The outcomes of the research not only reflect what has been done with regard to the experiences taken from the project launched between 2011 and 2013 but also revisit the concept of eco-efficiency and its relevance to water infrastructure management and development that was initiated by UNESCAP in 2008.

A myriad of water issues pertaining to Asia and the Pacific have been reviewed in the first part to have a good understanding of critical issues and challenges, which are pressing in the region, i.e., water supply, water quality control, flood prevention policies, and ecosystem restoration efforts. The report has classified diverse water challenging issues in the region as urbanization, Green House Gases (GHGs) and sustainable energy, access to water and sanitation services, water availability and use, and natural disasters. Strategies beyond coping are urgently needed, and in this context, eco-efficient water infrastructure is regarded as a proactive approach to such elusive challenges in the water sector with which the countries in the region can continue to pursue economic growth without serious damage to ecosystems.

The concept of eco-efficiency has been revisited to remind the salience of its connectedness with water issues in the region, and the conceptualization of eco-efficient water infrastructure emphasizes the balance between physical and non-physical infrastructure development and management in society. The usefulness of eco-efficient water infrastructure lies in the fact that this approach can serve as a practical tool to tackle some of the fundamental problems in water resources management, such as non-revenue water challenge. It is becoming more urgent to adopt an eco-efficient approach to the complexity of water challenges, aggravated by adverse impacts of climate change.

A list of structural and non-structural breakthroughs for eco-efficient water infrastructure have been explored, i.e., small-scale multipurpose dams, eco-efficient groundwater management, eco-efficient desalination plant, and the Low Impact Development (LID) projects. In addition, the report introduces the Active, Beautiful, and Clean (ABC) Waters Program in Singapore and Green School projects in order to evaluate the applicability of the concept to actual policy-making and implementation.

The foundation of eco-efficient water infrastructure has been laid in Indonesia and the Philippines. The case study on Indonesia illustrates that the country has been actively engaged in adopting the concept of eco-efficient water infrastructure so that its modified version has been produced, the eco-sustainable water infrastructure approach. As the practical cases, the country agreed to work together with UNESCAP by launching the integrated rainwater and wastewater management system in Bandung, Indonesia (ITB and UNPAS Projects). As for the Philippines, the roadmap to eco-efficient water infrastructure has been established following the introduction of the concept in 2008, and the country has also focused on small-scale pilot projects, such as the application of sustainable designs for green school development in Cebu, the Philippines since 2011.

A variety of policy measures have been suggested. The first principle goes to the Integrated Water Resources Management (IWRM) for urban development. This requires continuous policy shift and institutional reform that are tuned to managing the whole new system for eco-efficient water infrastructure with a special focus on diverse issues in urban planning and development. Decentralization is the second principle, which reiterates the importance of delegated governance system in order to lead to implementation of eco-efficient water infrastructure. As found in the cases of Indonesia and the Philippines, community-level involvement is a crucial element to make local water and wastewater projects more efficient in an economic and ecological term.

The third principle is associated with development of new water sources. Water and wastewater reuse and recycling and rainwater harvesting reminds the urgency to save water but also the potential to create new waters that can be consumed and renewed in an environmentally friendly fashion. The fourth policy principle is stakeholder participation.

Decision-making may take longer than expected if more stakeholders are involved but the final outcome is more concrete. The last policy principle is eco-efficiency education which is connected with the experience of the green school cases of the Philippines and the Republic of Korea. Young students can take good lessons from eco-efficient systems at the green schools, which will have a positive impacts on the next generation.

Urban areas in Asia and the Pacific Region are projected to expand substantially in the future. Cities in the region are at a crossroads in infrastructure development in order to buttress economic growth and deal with rapid urbanization and population growth. The introduction of eco-efficiency principles and policy measures for water infrastructure will therefore be essential for urban areas of the region in terms of their sustainability, enhanced quality of life, and competitiveness (UNESCAP, 2008).

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