ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

ARCP Final Report



Project Reference Number: ARCP2015-07CMY-Babel

Developing an operational water security assessment framework for application in diverse regions of Asia

The following collaborators worked on this project:

1. Mukand S. Babel, AIT, Thailand, msbabel@ait.asia
2. Victor R. Shinde, AIT, Thailand, victorshinde@ait.asia
3. Devesh Sharma, CURAJ, India, deveshsharma@curaj.ac.in
4. Nguyen Dang, TLU, Vietnam, dang@tlu.edu.vn

AIT Asian Institute of Technology

Table of Content

Project Overview

Project Duration	**:**	19 September 2014 to 30 December 2017
Funding Awarded	**:**	US$ 40,000 for Year 1; US$ 40,000 for Year 2
Key organisations involved	**:**	1. Asian Institute of Technology, Thailand. Dr. Mukand. Babel, Dr. Victor R. Shinde, Ms. Anyamanee Onsomkrit. 2. Central University of Rajasthan, India. Dr. Devesh Sharma, Mr. Swantara Dubey. 3. Thuyloi University, Vietnam (formerly Water Resources University). Dr. Nguyen Dang, Dr. Vu Thanh Tu.

Project Summary

The project had two objectives. The first was to develop an operational framework to assess water security at two different scales—city, and basin. The framework used the DPSIR technique to identify the various dimensions and indicators for the two different scales of assessment. In order to facilitate the measurement of water security the framework has a provision to quantify the indicators and dimensions between ranges 1 and 5 using reference standards from literature and expert opinion. These are then aggregated into an overall water security index to depict the water security situation of the city and basin. An interpretation system of the various magnitudes of the water security index was then established to elucidate the information portrayed by the index. The second objective of the project was to apply the framework in three study areas – India, Thailand and Vietnam. The areas included the Banas River Basin and Jaipur city in India; Chao Phraya River Basin and Bangkok city in Thailand; and Red River Basin and Hanoi city in Vietnam.

Keywords: DPSIR framework, India, Thailand, Vietnam, Water security.

Project outputs and outcomes

Project outputs:

- Operational water security assessment framework developed at city- and basin-scale
- Series of local workshops conducted to discuss water security related issues and solutions in the three study areas
- International symposium organized to serve as a platform for scientists and practitioners in Asia to deliberate on the challenges and opportunities for water security enhancement in Asia.

Project outcomes:

- Increased contribution to the scientific understanding of operationalizing water security
- Improved awareness for the need to strengthen water security among local stakeholders
- Network of like-minded organizations and individuals working on water security related topics formed.

Key facts/figures

- 2 Masters students, and 1 PhD student trained.
- 1 large international conference organized in Thailand that paved the way for two similar conferences in Germany, and Kenya.
- A network of 150 scientists and practitioners formed.
- 1 edited book currently being published (Publisher: Springer Nature)
- 1 special issue journal in Water Resource Management (IF 2.43) finalized.

Potential for further work

1. Focused research on each dimension of the water security separately, and expanding the list of indicators to capture additional aspects. This exercise would be particularly useful when a particular dimension of water security is found to be weak, and there is a need for additional analysis to bolster it.
2. Another area of research would be to look at how policies and plans to improve water security at various levels can be evaluated against the framework.
3. Evaluate projects and initiatives that are being proposed to improve water security against the framework developed by the study to get a sense of the magnitude of increase of water security.
4. Conduct research on water security enhancement measures that are likely to cause the largest increase in water security, using the assessment framework developed by the study.

Publications

Journal (in collaboration with external partners)

Special Issue on ""Water Security in Asia – Status and Prospects" in *Water Resources Management* (to be published in early 2018).
Publisher: Springer. Impact Factor: 2.437.
Guest Editors: Mukand Babel, Andreas Haarstrick, Lars Ribbe, Victor R. Shinde and Nobert Dichtl

Books (in collaboration with external partners)

Title: Water Security in Asia: Opportunities and Challenges in Context of Climate Change (to be published in late 2017).
Editors: Mukand Babel, Andreas Haarstrick, Lars Ribbe, Victor R. Shinde and Nobert Dichtl
Publisher: Springer Nature

Refereed journals

Babel M.S, Shinde V.R., Sharma D., Dang N.M., Onsomkrit, A. (2018). Operationalizing water security: A framework to assess water security at the operational unit. Invited for publication in *Water Resources Management* special issue on "Water Security in Asia – Status and Prospects". Publisher: Springer. Impact Factor: 2.437

Conference proceedings

Shinde V.R., Babel M.S. and Acharya S. (2017). Evaluating citizen support for water security enhancement. 2017 Water Security and Climate Change Conference. September 18-21, 2017. Cologne, Germany.

Onkomsrit A., Babel M.S., Shinde V.R. and Pandey V.P. (2016). Assessing water security at district level: A case of Bangkok. In Proceedings of the *Water Security and Climate Change: Challenges and Opportunities in Asia*, Nov 29-Dec 1, 2016 Bangkok, Thailand.
Mukand S. Babel, Anyamanee Onsomkri and Victor R. Shinde (2016). Framework for Water Security Assessment at City Scale. In Proceedings of the 7th International Conference on Water Resources and Environment Research (ICWRER2016), June 5-9, 2016, Kyoto, Japan.

Awards and honours

None

Pull quote

"The first step to enhancing water security is assessing it. Proper quantitative assessments of water security will go a long way in evaluating the interventions that are undertaken to improve water security. This project has done precisely that by developing an easy-to-use generic water security assessment framework that can be used across different climatic and socioeconomic conditions". Mukand S. Babel. Team Leader, ARCP 2015 07 CMY-Babel

Acknowledgments

The researchers acknowledge the support provided by their respective organizations – the Asian Institute of Technology, Central University of Rajasthan, and Thuyloi University (formerly Water Resources University)—to ensure that the project ran smoothly without any hiccups. The researchers also thank the water related government agencies in Thailand, India and Vietnam for their valuable suggestions and feedback on operationalizing the water security assessment framework. Acknowledgements are also due to partners who collaborated for the international symposium – Technical University of Braunschweig and Technical University of Cologne.

The researchers deeply acknowledge and appreciate the funding provided by APN for the conduct of this study. Without this funding support, the research would not have been possible.

1. Introduction

1.1 Background

Water is at the heart of sustainable development. Its significance for human survival, socio-economic development, and healthy ecosystems cannot be overemphasized. Within any system, water use sectors such as domestic, agriculture, industry and energy are interlinked. These sectors both use and pollute water (generating wastewater). Water resources must be managed sustainably if supplies are to be maintained for people and economic uses. Improving water security is, therefore, rapidly becoming a key point on the policy and development agenda both at national and international levels. For example, the recently adopted Sustainable Development Goals (SDGs) has a dedicated goal (SDG 6) to enhance global water security. As a result, a number of countries have incorporated national goals in their mid- to long-term policies in order to meet the global targets. Creating a water-secure society is therefore one of the top priorities for governments and policy makers across the globe. Water security is also a crucial element in contemporary science and policy agenda, and has been receiving increased attention in recent years (e.g.: APN's science agenda for 2013). A number of researchers and organizations have attempted to define, frame, and quantify water security in various ways (e.g. ADB 2016 and 2013; Cook and Bakker 2012; Grey and Sadoff 2007 etc.). Much of the earlier work in water security was conceptual where the key focus was on establishing the scope of water security. For example, the GWP (2000) framing included seven variables: meeting basic needs, securing the food supply, protecting ecosystems, sharing water resources, managing risks, valuing water, and governing water wisely. One of the most influential papers in this regard, Grey and Sadoff (2007) framed water security in terms of human and ecosystem health, with special emphasis on security from water-related risks. More recent studies include stakeholder participation (e.g. a recent APN project -Nikitina et al. 2009), virtual water (e.g. Zeitoun et al. 2010) in developing the framings for water security. It is only in the last few years that there have been attempts to measure the water security using selected indicators. Falkenmark and Molden (2008) quantified water security in terms of water stress and water shortage. Vorosmarty et al. (2010) analyzed the global threat to human water security and river biodiversity using four classes of stressors (indicators): watershed disturbance, pollution, water resource development, and biotic factors. ADB (2016 and 2013) evaluated the water security of all Asian countries using five dimensions: household water security, economic water security, urban water security, environmental water security, and resilience to water-related disasters. For other countries across the globe, several frameworks to assess water security now exist, as listed in the Table 1.

Table 1: Existing frameworks for water security assessment

Authors	Elements of water security	Scale of assessment	Application in
Zeitoun (2011)	Human/Community security; National security; Water resources security; Food security; Energy security; Climate security	National	NA
Lautze and Manthrithilake (2012)	Basic needs; Food production; Environmental requirements; Risk management and independence.	National	Asia Pacific
Mason and Calow (2012)	Resource stress; Variability and risk; Basic human needs and productivity; Environmental needs; Governance	Generic	NA

ADB (2013, 2016)	Household water security; Economic water security; Urban water security; Environmental water security; Resilience to water-related disasters	National	Asia Pacific
Lankford (2013)	Volumetric sufficiency; Water quality; Flood protection; Water allocation/ equity; Dynamic apportionment; Productivity/ efficiency.	National	NA
UN-Water (2014)	Drinking water, sanitation and hygiene; Water resources; Water governance; Water-related disasters; Wastewater pollution and water quality	National	NA
Fischer et al. (2015)	Total renewable water resources per capita; Ratio of annual water withdrawal to total renewable water resources; Runoff variability; Ratio of external to total renewable water resources	National	Global
Sadoff et al. (2015)	Droughts and water scarcity; Floods; Water supply and sanitation; Ecosystem degradation and pollution.	National	NA

1.2 Rationale for the project

Most of these studies mentioned in 1.1 were carried out on a national level, and as pointed out by Vorosmarty et al. (2010) water security assessments at national scales can mask significant variations in security at the local scale. This means a country may be water secure with respect to a particular dimension at the national scale but the situation may be very different when considered at local scale. Cook and Bakker (2012) also warns that although national scale analysis enables important and useful conclusions to be drawn, it precludes a fine grained analysis of sub-national spatial and social variation of water security. Further, some indictors developed for national scale may not be suitable for local scale, and operationalizing of water security indices locally based on national scale assessments is fundamentally flawed. There are very few examples of local scale assessments of water security. Local assessments are imperative to actually operationalize the concept of water security because implementation of concepts like enhancing water security will usually require following a 'bottom up' approach. This project sought to address this knowledge gap by developing water security indices with different dimensions, and for different scales, so that actual operationalization of these indicators can be brought into effect.

1.3 Project objectives

The overall objectives of the study is to develop a framework to assess and quantify water security at an operational scale- city and basin.

The specific objectives are the project are:

1. To identify the appropriate dimensions of water security which will encompass a range of water security variables, for different scales (city and basin).
2. To develop a framework (resulting in the Water Security Index, WSI) to quantify the dimensions of water security, and the overall water security.
3. To implement the framework in diverse conditions of climate and socioeconomics.

1.4 Geographic scope of the project

In order to foster generalization of the water security assessment framework it was desirable to implement it under diverse/contrasting conditions of climate and socioeconomics. Accordingly, three study areas were selected for implementing the framework: Thailand, Vietnam, and Rajasthan (India). Rajasthan (India) is predominantly a desert with a hot and dry climate. Thailand is a tropical country with a mixture of wet and dry climate, while Vietnam has predominantly humid sub-tropical climate. In terms of per capita GDP (in USD), the values are 999, 3547, and 10,849 for Rajasthan (India), Vietnam and Thailand respectively. Additionally, it is important to note that Vietnam is one of the fastest growing economies in the world, as was Thailand during the period 1985 – 1996 when the average annual growth was 12.4%. Hence, Vietnam is currently going through the same phase which Thailand underwent late in the last century, so the current water security scene in Thailand may give some interesting insight into the future water security scene of Vietnam. Also, the management regimes in the three study areas are quite different. For example, in Vietnam policies are still oriented towards supply-side management while Thailand is moving more and more towards demand-side management. Rajasthan (India) faces acute water scarcity and relies on water supply from neighbouring states.

1.5 Linkage of project objective to national/local plans in the study areas

Water security features high on the priorities of the national/local policies and strategic plans in each of the three study areas. The agencies responsible for implementing these plans have been previously mentioned in point #2. Representatives from these agencies will be invited to the local workshops to contribute to the formulation of the framework to develop the WSI, proposed in this project. The ultimate vision of the project is to facilitate the uptake of water security into policy so that measures to reduce the water insecurity can be operationalized. The project partners will develop and test the WSI, which would then be presented to these local stakeholders, who we expect will lobby for its mainstreaming into regular operations through policy formulation.

The proposed project is very much in line with the national and local water management plans of the three countries. For example, in Thailand, the 11th National Economic and Social Development Plan (2012-2016) recognizes that the natural resources have been depleted, and the environment degraded. Hence emphasis has been placed on promoting more efficient use of water; integrated water resources management; ensuring preparedness for natural disaster response; conserving, restoring and creating security of natural resource and environmental bases. Similarly, in wake of the 2011 floods, the cabinet has approved the establishment of a single-command authority "National water policy and flood committee" for the country's water management and flood prevention, in an attempt to boost up the water security. Accordingly a master plan on water resources development has been developed in 2012, whose salient features include the following — Restoration and conservation of forest and ecosystem; management of major water reservoirs and formulation of water management plans; restoration and efficiency improvement of current and planned physical structures; information warehouse and forecasting & disaster warning systems; emergency plans for specific areas; selecting water retention areas and recovery measures; improving water management institutions; and create understanding, acceptance and participation for large scale flood management.

In Vietnam, a number of water related strategies and objectives have water security as the central theme. The National Water Resources Strategy (NWRS) of 2006 moves more towards entrusting market mechanisms with promoting effective and efficient water governance, thereby endeavoring to improve water security. Among the notable programmes and initiatives related to water security are the 'National strategy for rural water supply and sanitation', ‘Second national strategy and action plan for disaster mitigation and management (2001-2020)’. Recently, water security under the impacts of climate change is becoming an area of top priority in policy matters. A National Strategy of Climate change has been approved on 05th December 2011 with prioritized objectives such as: Food security, Energy security, Water sources security, Poverty elimination, Gender equality, Social security, Social health, Living conditions improvement, Natural resources protection in the context of Climate change. The National Strategy for Rural Clean Water Supply and Sanitation has also been updated by Ministry of Agriculture and Rural Development in 2011 where emphasis is on sustainable development in the context of fierce climate change.

The central theme of the National Water Policy of India (2012) seeks to promote the conservation and efficient use of water resources. The other main features are — to ensure access to minimum quantity of potable water for essential health and hygiene to all citizens, available within easy reach of households; to regulate river flows to meet ecological needs; to remove large disparities in water supply between urban and rural areas; to support a national water framework law; to adapt to climate change; to facilitate the management of floods and droughts. It is quite evident that each of these initiatives is crucial to improve the water security in the region. Water security also is a high priority in the State Water Policy of Rajasthan (1999) where emphasis has been placed on — judicious and economically sound allocation of water resources to ensure sustainable use of the resources; minimizing impacts of water resources on development of the natural environment; introduction of water saving devices and practices; maintaining acceptable water quality standards; recharge of groundwater aquifers etc. The State Water Policy is supported by a long term State Water Plan with planning horizon extending up-to the year 2045 (Water Resource Vision 2045). Water Resource Vision 2045 has been prepared to highlight the short term (up to 2015) and long term (up to 2045) thrust areas and action plan which are pre-requisites for successful implementation of the State Water Policy and Plan and achieving the objective of optimum use of every drop of scarce and precious utilizable water resource. The expected output of the project (WSI) can play an important role in identifying the areas of concern, and will be useful in leading to the development of better strategies and initiatives to address these concerns.

2. Methodology

2.1 Overview of project activities

Figure 1 presents the overall schematic of the project activities undertaken in the project. The first activity of the project was to conduct a thorough literature review on water security assessments to develop an academic context of the subject matter. In order to get a sense of the "operational" context of water security, stakeholder consultations with various government and non-governmental agencies were conducted. Based on this a first draft of the water security framework was developed at both city- and basin-scales. This draft framework was again presented to the stakeholders to solicit critical feedback, especially for the operationalization potential of the water security assessment. The framework was then fine-tuned to account for the critical feedback received from stakeholders and then applied in the three study areas.

2.2 Methodology for development of water security assessment framework.

2.2.1 Water security index (WSI)

The project used the DPSIR (Driving forces– Pressure – State – Impact – Response) approach to develop the framework for water security assessment. The framework results in an overall water security index (WSI) that comprises of various water security dimensions that take into account the driving forces that have an impact on water security. The choice of these dimensions depended upon a number of criteria/factors — e.g. data availability, ease of quantification, scope of applicability, conforming to interventions required, etc. Each dimension is represented by one or more indicators. The indicators conform to the SMART (**specific**, **measurable**, **attainable**, **relevant** and **time-bound)** criteria of assessment**.** Each indicator is then measured with respect to specific variables. The framework is presented in Figure 1. The framework has two shaded portions. The portion shaded in grey is the generic (and fixed) part of the framework which will be applicable to any study area. The portion shaded in blue is the variable part of the framework that will depend on site-specific situations and data. The outcome of this study should help informed decision making on water security enhancement and infrastructural development, which in turn will have a spiraling benefit for human health as well as economic development.

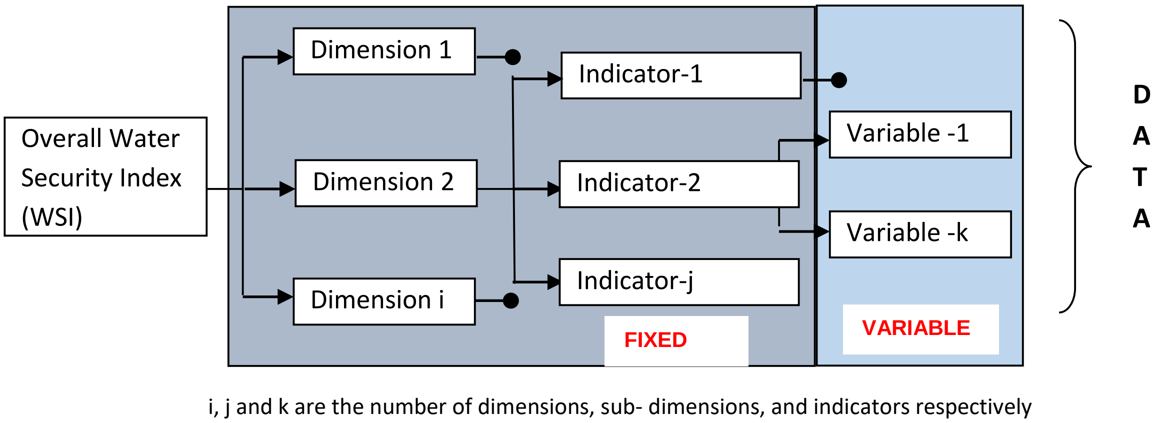


Figure 1: Water security assessment framework for both city- and basin-scale analysis.

2.3 Study area descriptions

2.3.1 Thailand

Chao Phraya Basin

The Chao Phraya River Basin, which has a geographical area of 158,587 km^2, is located in the central part of Thailand. There are eight main rivers in this basin that divide the basin into eight sub basins—Ping, Wang, Yom, Nan, Sakaekrang, Pasak, Lower Chao Phraya, and Thachin sub-river basins. This basin covers 31 provinces of Thailand that includes Bangkok (Figure 2). The average annual rainfall and runoff in the basin is 1,150 mm and 40,388 MCM respectively (Crown Property Bureau, 2012). The total population is 24,008,796 (2015). The Gross Domestic Product (GDP) in the Chao Phraya river basin was worth 8,147,432 Million baht in 2015 which consists of Nonagricultural GDP (7,813,915 Million baht) and Agricultural GDP (333,517 Million baht). Average GDP per capita is 167,923 baht.

Figure 2: Chao Phraya River Basin

Land utilization and holding in 2015 – 2016 of this basin comprised of agriculture area (55.44%), forest area (25.6%), built-up area (12.75%), water surface area (2.80%), and miscellaneous area (3.42%) The agricultural area in this basin is 52,944 sq.km while irrigation area is only 22,464 sq.km. Therefore, agricultural area dependent on rain fed irrigation is 30,480 sq.km. (57.6% of total agricultural area).

There are ten big dams of total capacity 25,911 MCM which account for 95% of total water storage in this basin. These dams are Bhumibol, Sirikit, Kio Lom, Khwaenoi, Mae Kuang, Kio Kho Ma, Mae Ngat, Thapsalao, Kra Siao, and Pasak dam. The remaining 5% of the water storage are in 70 medium reservoirs (capacity 992.19 MCM) and 757 small reservoirs (capacity 376.27 MCM).

The main water issues in the basin include flood, drought and water pollution. Floods in the basin are generally influenced by southwest monsoon and low depression or certain storms every year. Most flooding occurs in middle and lower part of the basin. Drought in the basin is caused by the long precipitation deficit. The Pollution Control Department of Thailand uses a Water Quality Index to evaluate the quality of surface water. The index is from 0 to 100, where

0 indicates the poorest condition and 100 is the best condition. In recent years, the water quality in the lower part of the basin has been deteriorating significantly. Although water integrated water resources management has been recommended by the National Water Policy, there are still a number of challenges. For example, the role and functions of the watershed committee have obstacles in practice. Furthermore, the scope of responsibility of the watershed committee does not encompass the trans- boundary basin.

Bangkok

Bangkok is the capital of Thailand. It is situated in the low flat plain of the Chao Phraya River which extends to the Gulf of Thailand. The total city area is 1,569 km^2. The city is divided into 50 districts and 154 sub-districts (Figure 3).

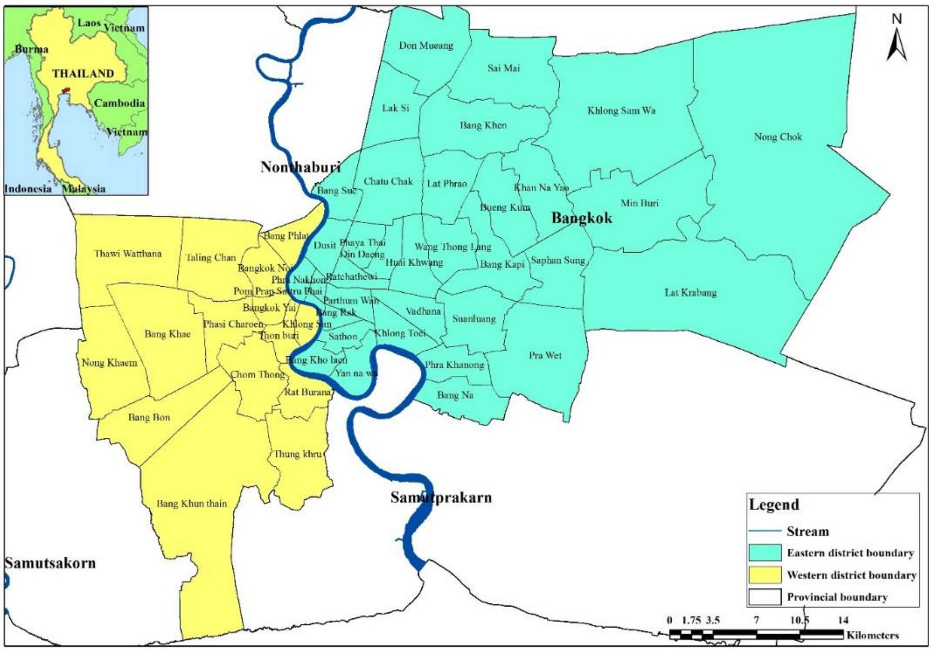


Figure 3: Map of Bangkok

The total population was about 5.68 million (2013) by registered record or about 8.30 million (2010) of daytime population. The average population density of registered record was about 3,625 persons/km^2 in 2013. The total Gross Provincial Product (GPP) of all final goods and services produced within the province in 2013 was 129,353.37 Million USD, which accounted for approximately 30% of the country's GDP. Bangkok is highly commercialized and the non-agriculture GPP of Bangkok is 99.94 % of the total GPP. The GPP per capita is 15190.86 US$. Bangkok has a monsoon type of climate, which can be classified into three main seasons: rainy (May-October), cool (November- January) and hot (February-April). The average annual rainfall during the period of 1982-2011 was 1,672 mm. The average annual temperature during the period of 1982-2011 was 28.6°C.

The water used in Bangkok is mostly from surface water sources (99%), with the Chao Phraya River being the main source. The water supply coverage in Bangkok is almost 100%. Groundwater extraction in Bangkok is prohibited because over-extraction of groundwater in the past led to groundwater level decline, degradation of water quality and land subsidence.

In the past, domestic wastewater were directly discharged to public drains and canals without treatment because of which these bodies became highly polluted. Since 1990, Bangkok has initiated a major programme of central wastewater treatment schemes to improve water quality in the canals and in the Chao Phraya River. Currently, Bangkok has combined wastewater treatment systems. In 2014, there were eight wastewater treatment plants (WWTP). These include Sripaya, Rattanakosin, Chongnonsi, Din Daeng, Chatuchak, Nongkhaem, and Tungkru WWTP.

Bangkok is the city with many canals (1,161 canals) (WQMO, 2013). The total length of canals in Bangkok is 2,604 kilometers (WQMO, 2013. Most of treated and non-treated wastewater drains into these canals making those increasingly deteriorated.

Bangkok is located in the flood plains of the Chao Phraya River, which suffers flooding during the monsoon season. The main reason for this is that the ground levels in the city are only 0.5 to 1.7 meters above mean sea level. Bangkok is effected by both inundated flood and storm flood. Recently, there have been actions taken to mitigate flooding problems by constructing barriers enclosing the area to prevent water flowing in from surrounding areas. The enclosed area has been provided with drainage system to drain off flood water into the Chao Phraya River. The capacity of the flood barriers is enough to prevent the water in the river as high as +2.50 m above mean sea level from flowing into the area. The capacity of the drainage system in the enclosed area can also handle rainfall intensity of up to 60 millimeters per hour. The pump has a capacity of 850 m^3/s.

The land use in Bangkok comprises of urban and bulit-up area (63.4%), agricultural land (26.9%), forest land (0.2%), miscellaneous land (6.9%) and water bodies (2.6%).

2.3.2 India

Banas River Basin

Banas river basin is located in the eastern part of Rajasthan (largest state of India). It originates from Aravalli hills and descends in a South-West direction of Rajasthan State. It stretches between 24°15' to 27° 20' North latitude and 73° 25' to 77° 00' East longitudes. Banas is a major tributary of the River Chambal with catchment area of about 51,651 km^2 and length of about 512 km. Total 13 districts of Rajasthan are falling in the Banas basin as shown in Figure 4.

The basin has both the lowest and the most uncertain rainfall. Rainfall is erratic and unevenly distributed, leading to crop failures and frequent drought situations. For the period 1950-2015, annual rainfall in the Banas basin ranges from 250 mm to 1033 mm with mean annual rainfall of 647 mm. Out of total rainfall, about 95% falls during the four monsoon months (June-September). The mean maximum temperature in the basin varies from 32.1°C to 33.2°C with a mean value of 32.7°C, whereas the mean minimum temperature in the basin varies from 17.5°C to 20.7°C with a mean value of 19.1°C.

The highest maximum temperature in the basin varies spatially within a range of 43.2°C to 46.3°C with mean value 44.9°C, whereas lowest minimum temperature in the basin varies spatially with a range of 1.8°C to 6.1°C with mean value of 3.8°C *(Water Resources*

Department, 2014). The mean annual evaporation in the basin is about 2100 mm, which is more than 3.2 times of mean annual rainfall.

The mean availability of surface water in Banas basin is 4,837 MCM, from which 4,039 MCM is considered as economically usable water at 50% dependability and according to the planning department only 84% of water is usable *(State Water Resources Planning Department 2010, Government of Rajasthan).* In the year 2010, the net ground water availability of the basin was 2291 MCM and gross use of groundwater is 3204 MCM. It means state of groundwater development is 140 % falling in the category of overexploitation.

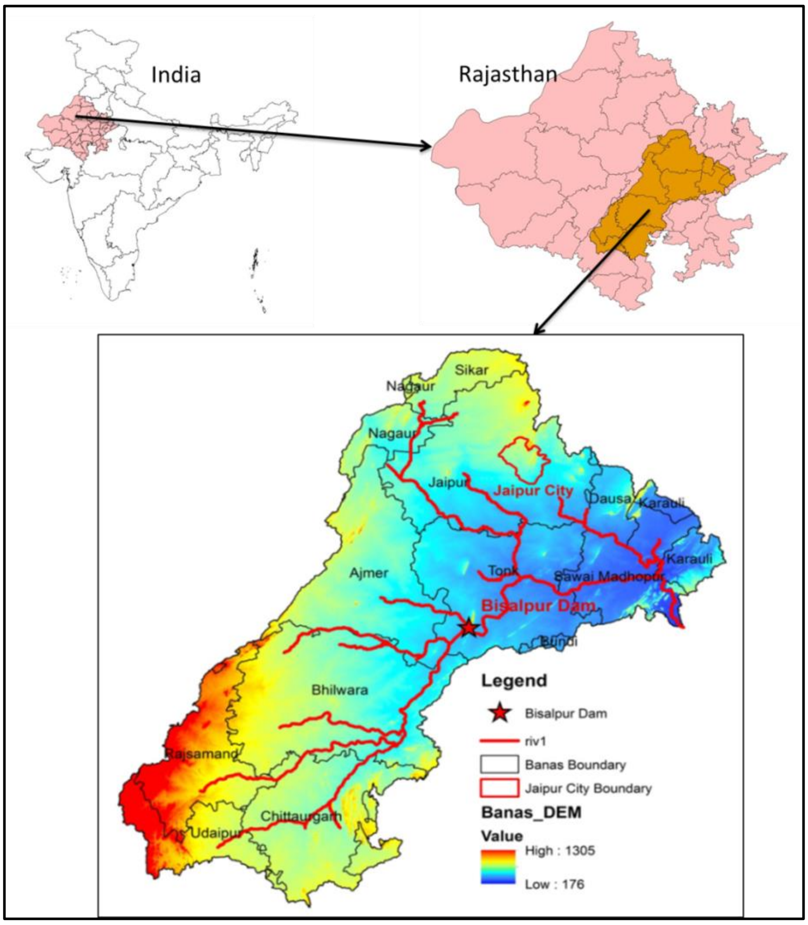


Figure 4: Banas river basin with district coverage

Jaipur

Jaipur is the capital of India's largest state of Rajasthan and tenth largest metropolitan city in India. It is the fastest developing city in India and is situated in the semi-arid eastern part of Rajasthan. Jaipur city was originally built with water management and traditional water conservation techniques incorporated into its urban plan. The Jaipur has been selected in the list of hundred smart cities under the Smart City Mission of Ministry of Urban Development (MoUD), Government of India. The boundary of the city extends from 26º46' N to 27º01' N latitude and 75º39' E to 75º57' E longitude with an average elevation of 431 m occupying an area of approx. 467 km^2 (Figure 5).

Jaipur has experienced rapid population growth; the population of Jaipur city has increased by more than 10 times in the last 50 years. In 2001, the population of the city was 2.3 million and in 2011 the city population increased to 3.07 million, which reached to 3.54 million in 2016. Due to this increasing trend of population, the population density in 1971 was 3416 persons per sq. km. and increased to 6285 persons per sq. km. in 2011 (*Jawaid et al., 2017*).

According to *Jaipur Master Plan 2025*, the city is likely to attain a population of 6.49 million by the year 2025 with 5.3% annual growth rate.

The mean temperature of Jaipur city is 36 °C, varying from about 18 °C in January to about 40 °C in June (*Jaipur Municipal Corporation*). The average annual rainfall is 630 mm of which 90% takes place in the monsoon period.

The Public Health Engineering Department (PHED) maintains the city water supply from surface water source (Bisalpur Dam) and groundwater sources (tube wells). The Bisalpur- Jaipur Water Supply Project (BWSP) has been proposed to reduce city dependence on ground water sources and other supplies.

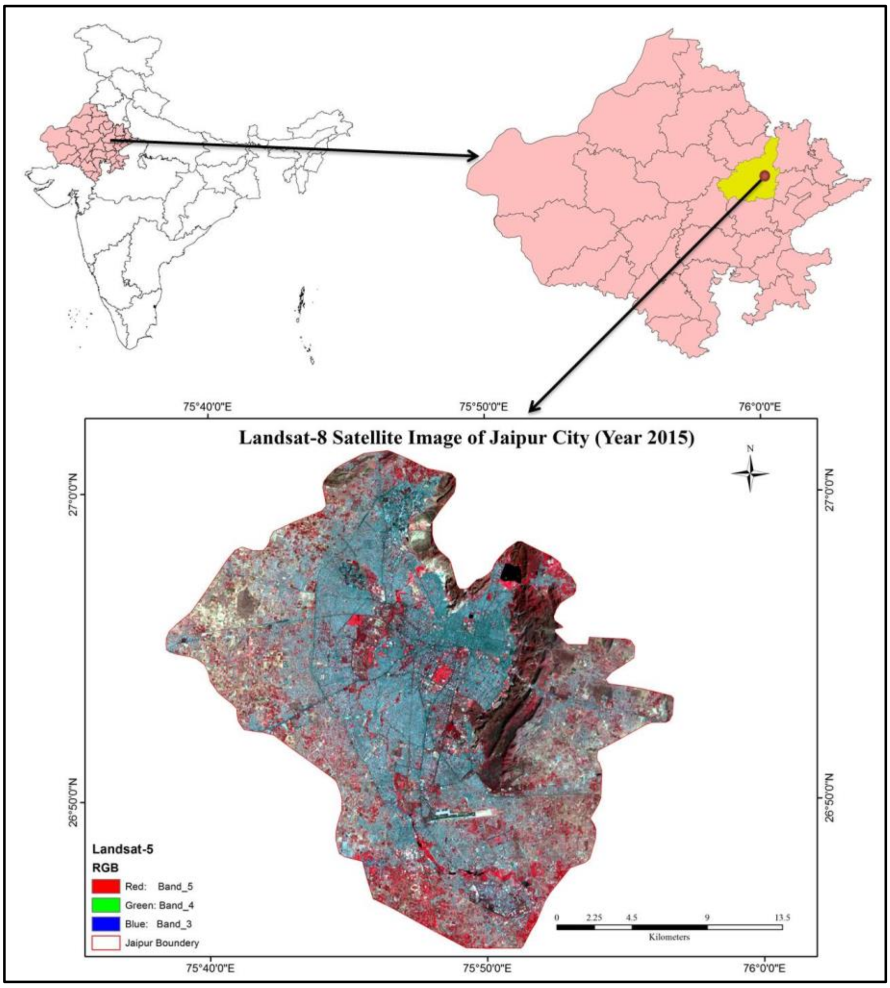


Figure 5: Map of Jaipur city

In 2010, the piped water supply system from Bisalpur Dam was commissioned. Bisalpur Dam, located 117 km away from Jaipur, has been providing drinking water since year 2010. The city had a water supply with an availability of 126.5 litres per capita day (lpcd), serving almost 86.5% of the population (*City Development Plan, 2014*). The present supply of water in the city is 430-440 MLD, from which 340-350 MLD is from Bisalpur dam and 90 MLD from tube wells. Due to increased ground water withdrawals, the groundwater level is declining in the city. In 2015, *Central Ground Water Board* (CGWB) declared all the 13 blocks of Jaipur city under dark zone because groundwater level in the city had depleted by 25 metres.

2.3.3 Vietnam

Red River-Thai Binh River Basin

The Red River-Thai Binh river basin is a trans-boundary river basin that flows through three countries Vietnam, China and Laos with a total area of approximately 169.000 km^2 of which around 87.840 km^2 is the territory of Vietnam, accounting for 51.3% of the entire basin area (Figure 6).

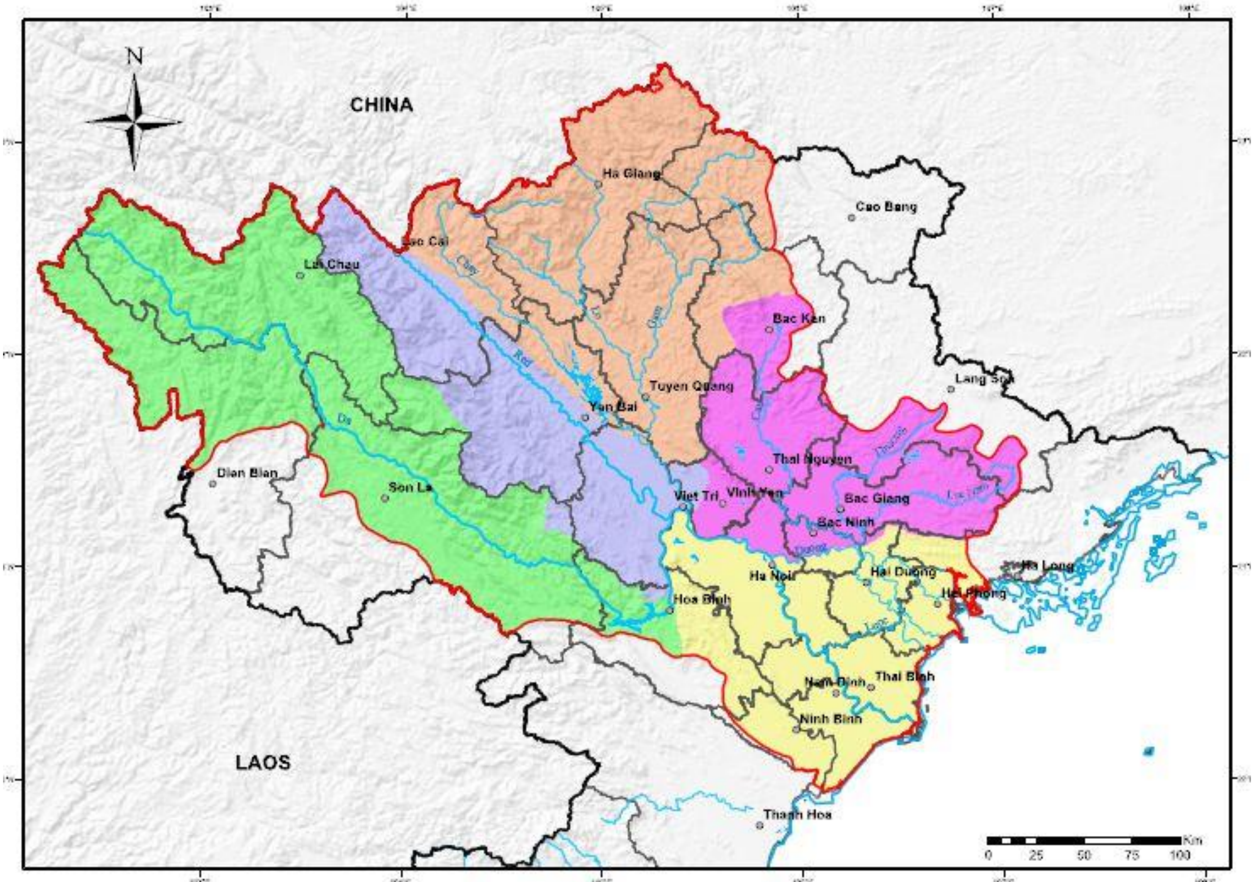


Figure 6: The Red – Thai Binh river basin in the territory of Vietnam (from left to right and up to down: Da sub-basin, Thao sub-basin, Lo sub-basin, Red River Delta, and Upper Thai Binh sub-basin). (Source: AECOM Asia Co. Ltd. and GFD, 2012)

The delta area, located entirely within the territory of Vietnam is estimated to be about 17,000 km^2, and the length of the Red river in the territory of Vietnam about 328 km. The basin is bounded from $20^{0}23'$ to $25^{0}30'$ North latitude, and from 100^{0} to $107^{0}10'$ East longitude.

The basin is both influenced by the Asia tropical monsoon and because of its proximity to the Pacific coast. Then it is often influenced by powerful ocean climate in summer and winter. The climate is milder in summer than in the continental tropics, but colder in winter. The average annual temperature is 23.3°C. The highest temperature in July with the average high temperature at 28.8°C. The lowest temperature in December with the average is around 15.9 to 18.2°C. The average annual relative humidity is about 84%. The maximum relative humidity occurs in the months of summer and spring. In these months the relative humidity is usually higher than 86%. The rainfall is plentiful but not evenly distributed across the basin. Furthermore, the rainfall is mainly in the monsoon season. The distribution of rainfall in the basin strongly depends on the terrain and the arrangement of the mountains: wind direction and lee. High terrain and the wind direction leads to heavy rainfall in Bac Quang, Muong Te, Hoang Lien Son. The highest rainfall reaches 600-700 mm/week or 1200 mm/month in some areas, especially in Bac Quang where the rainfall is up to 549 mm/year. In the areas behind the mountain such as Yen Chau, Son La plateau, Nghia Lo valley, upstream of Gam river the rainfall is less, ranging from 1200 to 1600 mm/year. In the flat plains, the average rainfall is around 1400 mm to 2000 mm/year.

The average amount of the flow in the basin is about 118 billion m^3 in Son Tay corresponding to 3743 m^3/s. If Thai Binh river, Day river and delta area are considered, the total flow reaches to 135 billion m^3, of which 82.54 billion m^3 (approximately 61.1%) flow is produced in Vietnam and 52.46 billion m^3 (approximately 38.9%) is produced in the territory of China. However, due to terrain and uneven distribution of rainfall, the flow in different parts of the basin is also very different. The flood flow in the Red River has the characteristics of flood in mountain rivers, with multi-peaks, quick to reach the peak and also recession with large amplitude.

In the basin, the main economic sector is agriculture. The area, yield, and production fluctuates due to instability of the planting schedule and increasing urbanization. Urban areas and industry is expanding and thriving. In the industrial areas associated with urban areas such as Hanoi, Nam Dinh, Ninh Binh, Ha Dong, Phu Ly, Tam Diep, and the chain satellite towns of Hanoi, many factories of machinery equipment, high technology, construction materials and electronics have been built. The population in urban areas is growing very quickly, the investment in cities is increasing to support expansion.

Hanoi

Hanoi city - the capital of Vietnam - is one of the oldest cities in Southeast Asia. The city is located in the northern region of Vietnam, situated in the Vietnam's Red River delta, nearly 90 km (56 miles) away from the coastal area. Hanoi contains three basic kinds of terrain, which are the delta area, the midland area and mountainous zone. In general, the terrain gradually lowers from the north to the south and from the west to the east, with the average height ranging from 5 to 20 meters above the sea level. The hills and mountainous zones are located in the northern and western part of the city. The highest peak is at Ba Vi with 1281 m, located in the western part of the region.

The city features a warm humid subtropical climate with plentiful precipitation. It experiences the typical climate of northern Vietnam, where summers are hot and humid, and winters are, by national standards, relatively cold and dry. Summers, lasting from May to September, are hot and humid, receiving the majority of the annual 1,680 mm. The winters, lasting from November to March, are relatively mild, dry (in the first half) or humid (in the second half), while spring (April) can bring light rains. Extreme temperatures have ranged from 2.7 °C to 40.4°C.

Hanoi has a dense network of rivers with many tributaries of the Red River network running through it. The Red River flows into Hanoi after the confluence of Da, Lo and Thao river, then flows through the Ba Vi district to Phu Xuyen district. The total length through the territory of Hanoi is about 127 km. So, the flow regimes in rivers located in Hanoi city are strongly affected by the flow regimes of Red river basin.

Hanoi is divided into 12 urban districts, 1 district-level town and 17 rural districts with a total area of 3,344.47 km^2. The city had a population of 7,100,000 in 2013 and average population density was 2100 person/km^2. According to a recent ranking, Hanoi is assessed to be the fastest growing city in the world in terms of GDP growth from 2008 to 2025. In the year 2013, Hanoi contributed to 10.1% GDP, exported 7.5% of total exports, contributed to 17% of national budget and attracted 22% investment capital of Vietnam. Per capita income of the city was about 2500 USD/person/year in 2013 and was expected to be 2750 in 2014. Regarding industry, with eight existing industrial parks, Hanoi is building five new large-scale industrial parks and 16 small- and medium-sized industrial clusters.

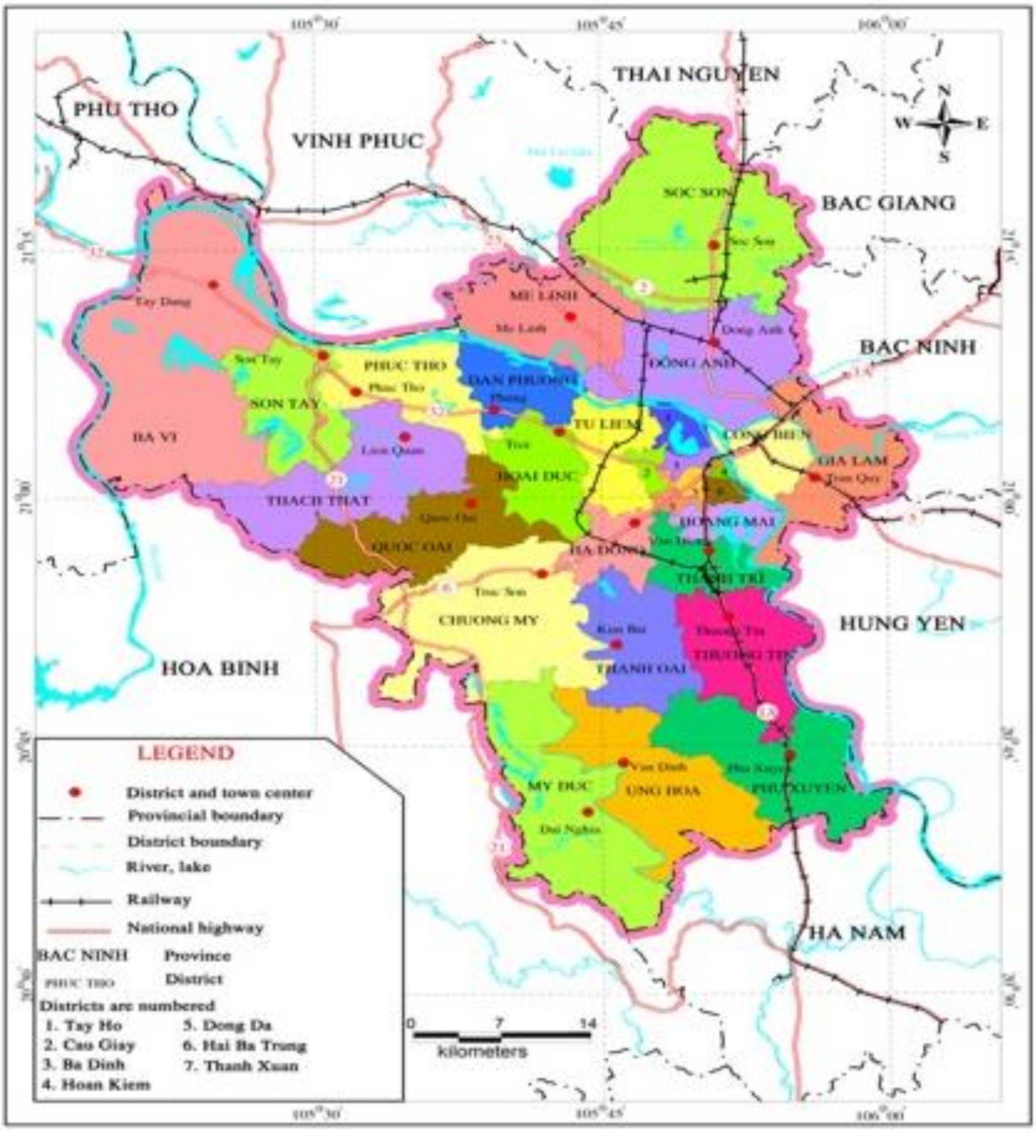


Figure 7: Map of Hanoi city

The centre of the city includes 11 urban districts and 1 rural district namely, Ba Dinh, Hoan Kiem, Dong Da, Hai Ba Trung, Cau Giay, Tay Ho, Thanh Xuan, Hoang Mai, Bac Tu Liem, Nam Tu Liem, Thanh Tri, and Ha Dong. The region has a total area of 306.93 km^2 with total population of 3181.5 (thousand persons). The region has the highest average population density that is 10366 person/km^2 (2013) in comparison with others in the city. This area was the centre of the old city before expanding to Hanoi city in 2008, and almost all the districts in this region are urban areas. And the unit has high speed of urbanization. In the area, there are seven large concentrated industrial zones with a total area of more than 350 ha. According to the results of water quality observation of Le Trinh's research, almost all the rivers and lakes in the area are polluted severely because of wastewater fromf resident areas and industry parks. The water quality is only class B2 or lower. The proportion of vegetation land in this area was very low with 2.4 m^2/person according to statistical data in 2009.

The Northern unit encompasses five districts namely, Gia Lam, Long Bien, Dong Anh, Soc Son, and Me Linh. According to statistical data in 2013, the unit had a total area of 805.82 km^2 with total population of 1426.2 (thousand persons) and second highest average population density around 1770 person/km^2. Within the area, there are three concentrated industrial zones and many industrial parks with a total area of more than 1500 ha. The proportion of forestry land in this area was fairly high according to statistical data in 2013.

The Western area has six rural districts and one town, including Dan Phuong, Hoai Duc, Quoc Oai, Thach That, Phuc Tho, Ba Vi, and Son Tay town. This area has a total area of 1147.1 km^2 with a total population of 1311.1 (1000 persons). The unit has the lowest average population density around 1143 person/km^2 compared to other units within the city. The proportion of forestry land in this area was highest according to statistical data in 2013.

The Southern unit has six rural districts, namely, Chuong My, Thanh Oai, Thuong Tin, My Duc, Ung Hoa and Phu Xuyen. This unit has a total area of 1064.7 km^2 with total population of 1290 (thousand persons) and an average population density around 1212 person/km^2. There are some industrial clusters in the area. Water pollution in this area is serious due to wastewater and pollutants from upstream area. The rate of vegetation land to total land is fairly low within the area.

3. Results & Discussion

3.1 City scale water assessment framework

Table 2 presents the framework developed for city-scale assessment. The framework comprises of five dimensions and twelve indicators. Following is a description of the framework.

Dimension 1: Water supply and sanitation: This dimension captures the ability of the city to provide water to its citizens for consumptive and non-consumptive activities. Four indicators have been identified to represent this dimension. The first of these is ***water availability***, which throws light on how much water is available to citizens to carry out their day-to-day activities. There are a number of variables that can be used to measure this indicator. Some of these include *per capita water use*, *number of people using improved water resources*, *investment in water supply facilities*, and *percentage of imported water*. The second indicator is ***accessibility*** which indicates the percentage of the city population that has access to clean drinking water. Potential variables to measure this indicator are *population access to piped water supply, service area coverage for piped water supply, average distance travelled to fetch water from improved water sources, safe drinking water inaccessibility*. The third indicator is ***quality of water supplied*** which ascertains if the water supplied by the city government meets the national/international standards. Potential variables to measure this trait include *customer satisfaction with water quality, type of water treatment employed, coliform count of water supplied, residual chlorine in water, turbidity of water, pH of supplied water*. The fourth indicator under this dimension is ***hygiene and sanitation*** that depicts the level and nature of sanitation facilities in the city and their impact on human health. Suggested variables to measure this dimension are *number of people using improved sanitation facilities, waterborne disease factor, and investment in sanitation facilities*.

Dimension 2: Water productivity: This dimension considers the economic aspect of water security and captures the ability of the city to value water as an economic good. A single indicator, ***economic value of water***, has been identified to represent this dimension. It is expected to throw light on how judiciously water is used in terms of economic benefits. Potential variables for measuring this indicator are *commercial/ industrial revenue per drop, water wealth, and water price*.

Dimension 3: Water-related disasters: Cities are very vulnerable to disasters because of their high population density, and trends of urban development. Furthermore, most cities are the major contributors to a country's GDP so water related disasters in cities have the potential to impact the nation as a whole. Two indicators have been used to represent this dimension. The first is the city's ***resilience against disasters*** which indicates how well the city is naturally protected against disasters (especially floods). Potential variables to measure this dimension are *coping potential factor, flood damage, proportional area of flooding, and GPP per capita*. The second indicator is ***disaster mitigation interventions*** that throws light on the kind of measures that have been taken by the city government to mitigate disasters. Potential variables to measure this indicator are *drainage factor, and investment in flood control*.

Table 2: City-scale water security assessment framework developed by the project.

DIMENSION	INDICATOR	POTENTIAL VARIABLES	SOURCE	SUGGESTED WAYS TO MEASURE
WATER SUPPLY AND SANITATION	Water availability	1. Per capita water use		Total domestic water consumption/City population
		2. Number of people using improved water sources	UN WATER (2006)	
		3. Investment in water supply facilities	UN WATER (2006)	
		4. Percentage of Imported water		Imported water/Total raw water
	Accessibility	1. Population access to piped water supply	UN WATER (2006)	Population of the city with access to piped water supply/City population
		2. Service area coverage for piped water supply.		
		3. Average distance traveled to fetch water from improved water sources		
		4. Safe drinking water inaccessibility	Babel and Wahid (2008)	The ratio of population without access to improved drinking water resources to the total population
	Quality of water supplied	1. Customer satisfaction with water quality		Number of employees/Number of customers in water utility
		2. Type of water treatment employed.		
		3. Coliform count of supplied water		
		4. Residual chlorine		Percentage of residual chlorine monitoring points satisfying the remnant requirement
		5. Turbidity of water		
		6. pH of supplied water		

	Hygiene and sanitation	1. Number of people using improved sanitation facilities	UN WATER (2006)	
		2. Water borne disease factor	UN WATER (2006)	Hospitalized cases of water borne diseases/Total hospitalized cases
		3. Investment in sanitation facilities	UN WATER (2006)	
WATER PRODUCTIVITY	Economic value of water	1. Commercial/industrial revenue per drop		Non-agricultural GPP/ Non-agricultural water use in the city
		2. Water wealth		Total Income of people/Water used
		3. Water price		
WATER-RELATED DISASTERS	Resilience against disasters	1. Coping potential factor		Investment in disaster response mechanisms/ Total city budget
		2. Flood damage	Koontanakulvong et al. (2013)	Economic damage caused by floods
		3. Proportional area of flooding and water	Xiao et al. 2007	Flooded area/Total city area
		4. GPP per capita		Total Gross Provincial Product / Total population
	Disaster mitigation interventions	1.Drainage factor		Total open space (green)/ Total city area
		2. Flood control investment		Budget for flood protection
WATER ENVIRONMENT	State of natural water sources	1. Natural water quality factor		Dissolved Oxygen (DO) concentration/Minimum required standard for DO
		2. Water Quality Index		Country-specific
		3.. Biochemical oxygen demand in water bodies	Mehr (2011)	
	State of pollution	1. Wastewater treatment factor		Amount of treated wastewater/Total wastewater generated

		2. Water pollution	Babel and Wahid (2008)	The ratio of the untreated wastewater to the total water resources
WATER GOVERNANCE	Overall management of the water sector	Institution factor		Questionnaire
	Potential to adapt to future changes	Adaptability factor		Questionnaire
	Citizen support for water security	Public support factor		Questionnaire

Dimension 4: Water Environment: This dimension captures the ability of a city to protect and maintain its water bodies and resources. Two indicators have been used to represent this dimension. The first is ***state of natural water resources*** that depicts the current condition of natural water bodies in the city. Potential variables to measure this indicator are *surface water quality factor, water quality index, and Biochemical Oxygen Demand in water bodies*. The second indicator is ***state of pollution*** that evaluates how well the water bodies in the city are protected from pollution. Potential variables to measure this indicator are *wastewater discharge factor, and water pollution*.

Dimension 5: Water governance. This dimension captures the ability of the city government to manage the water sector and plan for anticipated changes. Three indicators have been used to represent this dimension. The first of these is ***overall management of the water sector*** that depicts the picture of the overall management of the various elements of the water sector in the city. The suggested way to measure this is through a questionnaire to evaluate the management practices of the major water related institutions in the city (institution factor).

The second indicator is ***potential to adapt to future changes*** (adaptability factor) that evaluates how well equipped the city is to cope up with emerging pressures on water security. The suggested way to measure this is also through a questionnaire to examine if the plans and policies for water sector development consider long-term drivers of water security. The questionnaire for institution factor and adaptability factor is presented in Table 3.

Table 3: Questionnaire for evaluating the governance dimension for city-scale water security

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**
Institutional factor					
1. Is public opinion sought when developing water-related plans for the city?					
2. Is there a provision for general public to register their grievances?					
3. Is there an official mechanism to monitor Non-Revenue Water (NRW)?					
4. Is there a provision to incentivize water conservation?					
5. Does the organization consult other water organizations during the development of annual or long-term plans?					
Adaptability factor					
1. Does recycling and/or reuse of water take place in the city?					
2. Is there a centralized database for water related information?					

3. Is there a system to forecast water availability and quality?					
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term city master plans?					
5. Is there a mechanism for the organizational staff to upgrade water-related knowledge?					

The third indicator is ***citizen support for water security***, which is based on the premise that any policy or plan related for water security enhancement cannot be achieved without citizen support. The suggested way to measure this is also through a questionnaire survey presented below:

1. If the government imposes a water conservation fee (20% of your water bill/month) to safeguard water resources, how likely are you to comply?
   □ Very likely
   □ Likely
   □ Neutral
   □ Mostly unlikely
   □ Highly unlikely

2. How willing would you be to using recycled water in your house?
   □ Very willing
   □ Willing
   □ Neutral
   □ Mostly unwilling
   □ Highly unwilling

3. How willing would you be to pay an additional tax (20% of your water bill/month) to reduce the impacts of disasters like floods?
   □ Very willing
   □ Willing
   □ Neutral
   □ Mostly unwilling
   □ Highly unwilling

4. How well do you agree to 'income-based' payment of water fees? i.e. people with less income pay less fee and people with more income pay more fee.
   □ Strongly agree
   □ Agree
   □ Neutral
   □ Disagree
   □ Strongly disagree

5. How well do you agree to the notion that water should be subsidized because it is a basic human need? Subsidized means that the government charges the consumers only a fraction of what it takes to actually supply good quality water.

□ Strongly agree
□ Agree
□ Neutral
□ Disagree
□ Strongly disagree

6. How interested would you be to volunteer regularly (say, four times a year) in a water-watch programme, to observe and report problems that deteriorate the quality of water in rivers and local water sources? For example, problems include pollution from industry; garbage been dumped in the water, etc.
   □ Very interested
   □ Interested
   □ Neutral
   □ Slightly interested
   □ Not interested

3.2 Basin scale water assessment framework

Table 4 presents the framework developed for basin-scale assessment. The framework comprises of five dimensions and eight indicators. Following is a description of the framework.

Dimension 1: Water availability: This dimension looks at the water availability in the basin to sustain human activities. The indicator used to represent this dimension is ***sustainable basin exploitation***, which throws light on how much water is available in the basin to sustainably carry out various activities. Potential variables to measure this indicator are per capita water availability, water scarcity and water variation.

Dimension 2: Water productivity: This dimension considers the economic aspect of water security and captures the ability of the basin to value water as an economic good. A single indicator, ***economic value of water***, has been identified to represent this dimension. It is expected to throw light on how judiciously water is used in terms of economic benefits. Potential variables to measure this indicator are *commercial/industrial revenue per drop, agriculture, aquaculture and livestock revenue per drop, and water consumption for industrial goods*.

Dimension 3: Water-related disasters: This dimension is intended to capture the effects of floods and droughts in the basin. Hence, two indicators have been used to represent this dimension. The first is the ***flood factor*** to present the effects of floods in the basin, and the measures taken to mitigate impacts. Some variables to represent this indicator are *flood damage, proportional area of flooding, flood occurrence frequency, population living in hazardous zones, and flood control capacity*. The second indicator is the ***drought factor*** to present the effects of droughts in the basin, and the measures taken to mitigate impacts. Potential variables to measure this indicator are *drought damage, proportional area of drought, drought occurrence frequency, and ratio of irrigated area to arable area*.

Table 4: Basin-scale water security assessment framework developed by the project.

DIMENSION	INDICATOR	POTENTIAL VARIABLES	SOURCE	SUGGESTED WAYS TO MEASURE
WATER AVAILABILITY	Sustainable basin exploitation	1. Per capita water availability	Falkenmark (1989)	Surface runoff/Population
		2. Water scarcity	Babel and Wahid (2008)	Annual per capita water resources availability
		3. Water variation	Babel and Wahid (2008)	The coefficient of variation of precipitation over the last 50 year
WATER PRODUCTIVITY	Economic value of water	1. Commercial/industrial revenue per drop		Non-agricultural GPP/ Non-agricultural water use in the basin
		2. Agricultural, aquaculture and livestock revenue per drop		Agricultural, Aquaculture and Livestock GPP/ Agricultural, Aquaculture and Livestock water use in the basin
		3. Water consumption of industrial goods	AWDO 2013	The quantity of water used to produce the industrial goods consumed/the amount of water withdrawn for industry
WATER-RELATED DISASTERS	Drought factor	1. Drought damage		Economic damage caused by droughts
		2. Proportional area of drought	Xiao et al. (2007)	Drought area/Total area
		3. Drought occurrence frequency	Koontanakulvong et al. (2013)	Number of Drought occurrence per year

		4.Ratio of the area with water-saving irrigation to the total area of arable land	Xiao et al. (2007)	Area of Irrigation/ Area of arable
	Flood factor	1. Flood damage		Economic damage caused by floods
		2. Proportional area of flooding	Xiao et al. (2007)	Flooding area/Total area
		3. Flood occurrence frequency	Koontanakulvong et al. (2013)	Number of flood occurrences per year
		4. Percentage of population living in hazard prone areas	Mehr (2011)	Population living in hazard prone areas/Total population
		5. Disaster control capacity	Xiao et al. (2007)	Ratio of the water reserved in dams at the end of the year to the total water utilization
WATERSHED HEALTH	River health	1. Surface water quality factor		Dissolved Oxygen concentration/Permissible limit
		2. Ratio of the river length with water quality in Class IV to the total assessed river length	Xiao et al. (2007)	River length with water quality in Class IV/ Total river length (Class IV :Fairly clean fresh surface water resources used for : (1) consumption, but requires special water treatment process before using (2) industry)
		3. Average class water quality rivers	AWDO 2013	

		4. Biochemical oxygen demand(BOD) in water bodies	Mehr (2011)	
	Vegetation cover	Natural vegetation factor		Natural vegetation area/Basin area
WATER GOVERNANCE	Overall management of the water sector	Institution factor		Questionnaire
	Potential to adapt to future changes	Adaptability factor		Questionnaire

Dimension 4: Watershed health: This dimension captures the environmental angle of water security in the basin. Two indicators have been used to represent this dimension. The first is ***river health*** which throws light on the current condition of the major river bodies in the basin. Potential variables to measure this indicator are *surface water quality factor, average river class, and Biochemical Oxygen Demand of surface water*. The second indicator is ***vegetation cover*** that depicts the state of natural vegetation cover in this basin. The suggested way to measure this indicator is through an *assessment of the natural vegetation factor*.

Dimension 5: Water governance: This dimension captures the ability of the government to manage the water sector and plan for anticipated changes. Two indicators have been used to represent this dimension. The first of these is ***overall management of the water sector*** that depicts the picture of the overall management of the various elements of the water sector in the basin. The suggested way to measure this is through a questionnaire to evaluate the management practices of the major water related institutions in the basin (institutional factor). The second indicator is ***potential to adapt to future changes*** that evaluates how well equipped the basin is to cope up with emerging pressures on water security. The suggested way to measure this is also through a questionnaire to examine if the plans and policies for water sector development consider long-term drivers of water security (adaptability factor). The questionnaire for evaluating this dimension is presented in Table 5.

Table 5: Questionnaire for evaluating the governance dimension for basin-scale water security

Questions	Not yet considered	Under Consideration/development	In place but not yet implemented	Partially implemented	Mostly implemented
	1	**2**	**3**	**4**	**5**
Institutional factor					
1. Does the basin have an Integrated Water Resources Management (IWRM) plan?					
2 Does the basin have a River Basin organization (RBO)?					
3. Is there a provision to incentivize water conservation and/or water source protection?					
4. Is public opinion sought when developing water-related plans?					
5. Is there a mechanism to monitor pollution offences?					
Adaptability factor					
1. Is there a centralized database of water related information?					
2. Is there an Early warning system in place?					
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?					
4. Is there a mechanism for staff to upgrade knowledge?					
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?					

3.3 Application of city-scale water assessment framework

Bangkok

Table 6: Results of city-scale water security assessment for Bangkok

Dimension	Indicators	Variables	Estimation	2007	2009	2011	2013	2015
Water supply and sanitation	Water availability	Per capita water use (l/c/d)	Total domestic water consumption/City population	152.19	149.06	138.22	140.86	144.24
		Percentage of Imported water (%)	(Imported water production/ total water production) * 100	22.53	17.36	23.33	29.15	27.82
	Accessibility	Population access to piped water supply (%)	(Population of the city with access to piped water supply/City population) *100	84	86	82	87	91
	Quality of water supplied	Residual chlorine (%)	(Residual chlorine monitoring points satisfying the remnant requirement/Total monitoring points)X 100	79.2	33.3	66.7	87.5	95.7
	Hygiene and sanitation	Water borne disease factor (%)	(Hospitalized cases of water borne diseases/Total hospitalized cases)* 100	1.7	1.2	1.4	1.2	1.0
Water productivity	Economic value of water	Commercial water productivity (US$/m^3)	Non-agricultural GPP/ Non-agricultural water use in the city	240.03	254.06	341.91	377.65	330.05
Water-related disasters	Disaster mitigation interventions	Coping potential factor (%)	(Investment in disaster response mechanisms/ Total city budget) *100	0.4	1.4	0.5	0.1	3.0

	Resilience against disasters	Natural drainage factor (%)	(Total open space (green)/ Total city area)*100		24.5	24.0	24.0	24.2
Water environment	State of natural water sources	Natural water quality factor	Dissolved Oxygen (DO) concentration/Minimum required standard for DO	0.72	0.76	0.87	0.89	0.87
	State of pollution	Wastewater treatment factor (%)	(Amount of treated wastewater/Total wastewater generated)	62.9	58.8	66.9	60.4	58.2
Water governance	Overall management of the water sector	Institution factor	Questionnaire survey					4.70
	Potential to adapt to future changes	Adaptability factor	Questionnaire survey					4.30
	Citizen support for water security	Public support factor	Questionnaire survey for public support for WS enhancement					3.12

Table 6 presents the results of the city-scale water security assessment for Bangkok. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water supply and sanitation: There are four indicators under this dimension – water availability, accessibility, quality of water supplied, and hygiene and sanitation.

Water availability: Two variables have been used to measure the water availability indicator. The first is 'per capita water use'. In Bangkok, the per capita water use has been reducing steadily from 152.16 lpcd in 2009 to 144.24 in 2015. Because Bangkok has a large floating population, the calculations for this variable included the floating population estimates from various sources. The trend of reducing per capita water demand can be associated with improving water security because it indicates that water is being used judiciously for the various purposes, and water saving technology is being adopted. The second variable used to measure this indicator is 'percentage of imported water'. This is an important variable in Bangkok's context because the main source of water supply, the Chao Phraya River, is no longer sufficient for supplying the city's needs. In recent years, water from other basins (e.g. Mae Klong) has been procured to meet the needs. This trend of dependency on other basins is contrary to the ethos of water security. The percentage of imported water has generally been rising over the years, leading to reduced water security.

Accessibility: One variable has been used to measure this indicator – 'population access to piped water supply'. In Bangkok, this population access has been improving from 84% in 2007 to 91% in 2015, indicating improved water security in this regard.

Quality of water supply: The variable used to represent this indicator is 'residual chlorine'. The method of estimation was to evaluate what percentage of the monitoring points satisfied the remnant requirement g/L as stipulated by the Metropolitan Waterworks Authority. The results indicate that in 2009 only 33% of the monitoring points satisfied the requirement. However, this figure has been growing steadily and reached 95.7% in 2015, suggesting augmented water security in this aspect.

Hygiene and sanitation: The variable used to represent this indicator is 'water borne disease factor', which is a measure of the percentage of the hospitalized cases that are because of water borne diseases such as cholera, typhoid, dysentery, etc. For Bangkok, data from only the major government hospitals were collected for the analysis because these hospitals account for almost 60% of the hospitalized cases. The results suggest that water borne diseases are not too much of a concern in Bangkok with only 1% of the cases in 2015. Furthermore, this figure has been reducing from 2007 to 2015.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. The variable used to measure this indicator is 'commercial water productivity'. In Bangkok's case, the revenue data is divided into agricultural and non-agricultural. The non-agricultural revenue accounts for almost 97% of the total revenue because of which only the non-agricultural water productivity was considered for the analysis. The results reveal that this productivity has generally had a rising trend, suggesting increased water security in this regard.

Dimension-3: Water-related disasters: Two indicators have been used to assess this dimension of water security. These are ‘disaster mitigation interventions’ and ‘resilience against disasters’.

Disaster mitigation interventions: This indicator has been measured by the ‘coping potential factor’ variable, which essentially evaluates the level of financial investment made by the city to protect it against disasters. Hence, the estimation involves calculating the percentage of the city budget devoted for disaster mitigation interventions. The number of disasters have been increasing over the years which leads to the premise that investments in disaster mitigation interventions should also increase. However, this figure has shown no particular trend in Bangkok, suggesting that the investments are more of a political decision than need-based.

Resilience against disasters: The variable used to measure this indicator is ‘natural drainage factor’ that estimates the area of the city that is conducive to natural drainage whenever floods occur. In large cities like Bangkok, floods are a major concern, hence this variable looks at floods exclusively. The results suggest that the natural drainage factor has remained more or less constant at 24% throughout the period of analysis. In light of increasing flooding events, this figure needs to increase in order to improve water security.

Dimension-4: Water Environment: Two indicators represent this dimension of water security. These are ‘state of natural water resources’, and ‘state of pollution’.

State of natural water resources: The variable used to measure this indicator is ‘natural water quality factor’. This factor seeks to examine if the dissolved oxygen (DO) concentration in the city water bodies meets the minimum standard as prescribed by the Pollution Control Department of Thailand. The results show that in all cases, and in all years of the analysis, the DO levels are lower than the expected standards, suggesting a state of poor water security on this front.

State of pollution: The variable used to measure this indicator is ‘wastewater treatment factor” which is a measure of how much wastewater is treated before it is discharged into the receiving water bodies. In Bangkok, the wastewater treatment factor has actually been taking on a decreasing trend. The reasons for this is that the existing wastewater treatment plants have been operating at full capacity for some years now but the volume of wastewater has been increasing. This does not bode well for water security.

Dimension-5: Water governance: Three indicators have been used to represent this dimension- Overall management of the water sector, potential to adapt to future changes, and citizen support for water security.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are ‘institutional factor’ and ‘adaptability factor’ that are evaluated using a questionnaire survey with the water related organizations in the city. In Bangkok, the survey was conducted with senior officials of the Metropolitan Waterworks Authority, and the Bangkok Metropolitan Administration. The results of the survey for each of these organizations are presented in Tables 7 and 8.

Table 7: Results of the questionnaire survey carried out with Metropolitan Waterworks Authority (MWA)

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Is public opinion sought when developing water-related plans for Bangkok?					√	5
2. Is there a provision for general public to register their grievances?					√	5
3. Is there an official mechanism to monitor Non-Revenue Water (NRW)?					√	5
4. Is there a provision to incentivize water conservation?					√	5
5. Does MWA consult other water organizations (e.g. BMA, RID) during the development of annual or long-term plans?					√	5
Adaptability index						**5**
1. Does recycling and/or reuse of water take place in MWA?				√		4
2. Is there a centralized database for water related information?				√		4
3. Is there a system to forecast water availability and quality?					√	5
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term MWA master plans?					√	5
5. Is there a mechanism for MWA staff to upgrade water-related knowledge?					√	5
						4.6

Table 8: Results of the questionnaire survey carried out with Bangkok Metropolitan Authority (BMA)

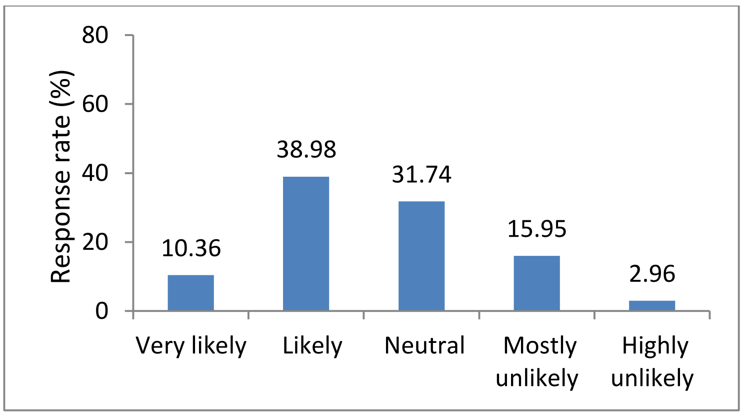
Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Is public opinion sought when developing water-related plans for Bangkok?					√	5

2. Is there a provision for general public to register their grievances?					√	5
3. Is there an official mechanism to monitor water pollution offences?					√	5
4. Is there a provision to incentivize water conservation and/or water source protection?		√				2
5. Does BMA consult other water organizations (e.g. MWA, RID) during the development of annual or long-term plans?					√	5
<u>Adaptability index</u>						**4.4**
1. Does recycling and/or reuse of water take place in Bangkok?					√	5
2. Is there a centralized database for water related information?	√					1
3. Is there an Early Warning System to prevent water-related disasters?					√	5
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term BMA master plans?				√		4
5. Is there a mechanism for BMA staff to upgrade water-related knowledge?					√	5
						4.00

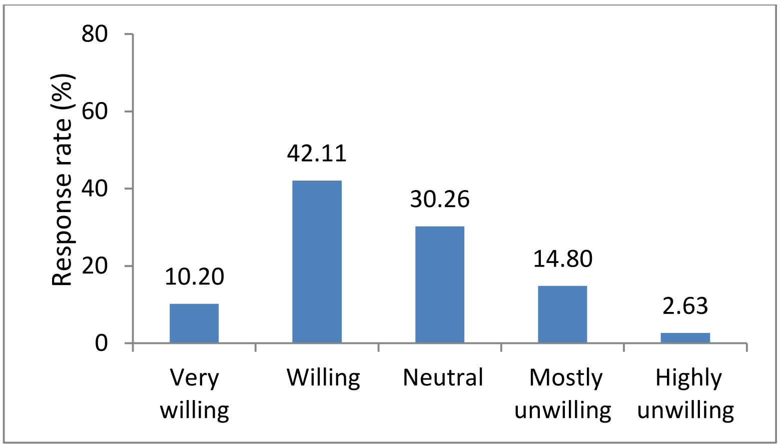
As seen in the results of the survey, the institutional factor and adaptability factor in Bangkok is overall very satisfactory.

Citizen support for water security: The variable used for this indicator is 'public support factor' that was evaluated using a questionnaire with 600 randomly selected respondents in various regions of Bangkok city, and the results are presented hereafter.

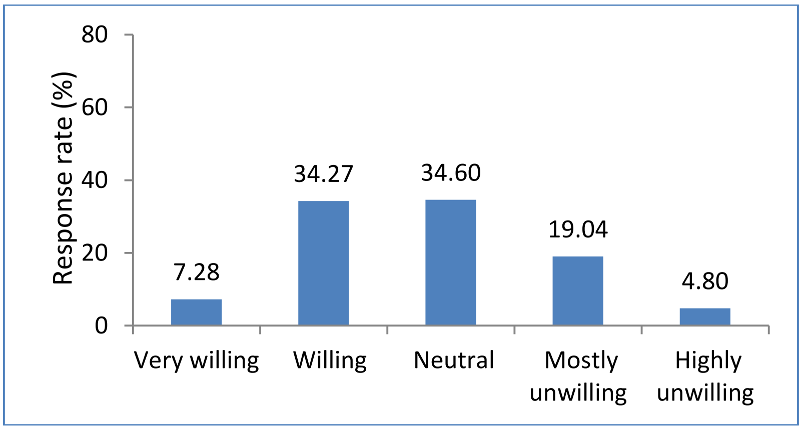
Question 1: If the government imposes a water conservation fee (20% of your water bill/month) to safeguard water resources, how likely are you to comply?



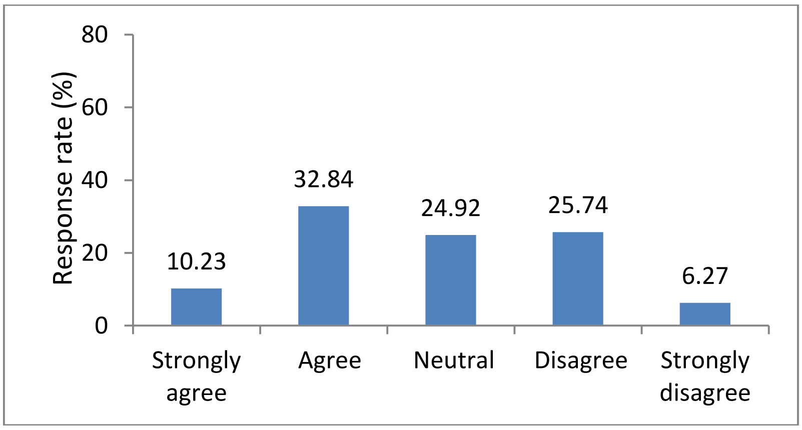
Question 2: How willing would you be to using recycled water in your house?



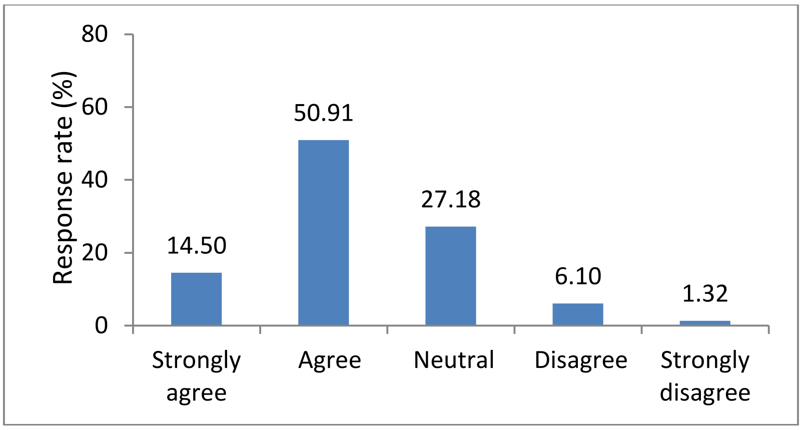
Question 3: How willing would you be to pay an additional tax (20% of your water bill/month) to reduce the impacts of disasters like floods?



Question 4: How well do you agree to 'income-based' payment of water fees? i.e. people with less income pay less fee and people with more income pay more fee.



Question 5: How well do you agree to the notion that water should be subsidized because it is a basic human need?



Question 6: How interested would you be to volunteer regularly (say, four times a year) in a water-watch programme, to observe and report problems that deteriorate the quality of water in rivers and local water sources?

As seen through the questionnaire responses, the citizen support for water security enhancement is not very strong. While citizens are aware of the problems related to water security, somehow this does not translate into expected action. In most cases, people are hesitant to pay extra to secure water security.

Jaipur

Table 9: Results of city-scale water security assessment for Jaipur

DIMENSION	INDICATOR	VARIABLES	ESTIMATION	2011	2013	2015
WATER SUPPLY AND SANITATION	Water availability	Per capita water use (lpcd)	Total domestic water consumption/City population	118.9	117.5	118.5
	Accessibility	Population access to piped water supply (%)	(Population of the city with access to piped water supply/City population)*100	94	93	94
	Quality of water supplied	Customer satisfaction with water quality	Number of customers/Number of employees in water utility			1721.3
	Hygiene and sanitation	Percentage of people using improved sanitation facilities (%)	(Number of people using improved sanitation facilities/City population)*100	73.2		80.0
WATER PRODUCTIVITY	Economic Value of Water	Water wealth (USD/m^3)	Total Income of people/Water used	32.7	31.5	
WATER RELATED DISASTER	Disaster mitigation interventions	GDP per capita (USD/capita)	Total Gross District Product / Total population	1369.5	1393.4	
	Resilience against Disasters	Drainage factor (%)	(Total open space (green)/ Total city area) * 100	8.9	13.0	15.2
WATER ENVIRONMENT	State of natural water sources	Natural water quality factor	Dissolved Oxygen (DO) concentration/Minimum required standard for DO	0.7		0.7
	State of pollution	Wastewater treatment factor (%)	(Amount of treated wastewater/Total wastewater generated) * 100			0.4
WATER GOVERNANCE	Overall management of the water sector	Institution factor	Questionnaire			3.75
	Potential to adapt to future changes	Adaptability factor	Questionnaire			3.90
	Citizen support for water security	Public support factor	Questionnaire			3.92

Table 9 presents the results of the city-scale water security assessment for Jaipur. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water supply and sanitation: There are four indicators under this dimension – water availability, accessibility, quality of water supplied, and hygiene and sanitation.

Water availability: The variable used to measure this indicator is 'per capita water use'. In Jaipur, the per capita water use has a more or less constant value over the period 2011-2015 at around 118 lpcd. The trend of constant per capita water demand is quite acceptable in this case, especially since the value is not too high. This goes on to show that the water demand in Jaipur has not increased over a good number of years.

Accessibility: One variable has been used to measure this indicator – 'population access to piped water supply'. In Jaipur, this population access has also been steady at around 94%, suggesting improved water security in this regard.

Quality of water supply: The variable used to represent this indicator is 'customer satisfaction with water quality'. Because of lack of data, the closest proxy that could be used in this case was to evaluate how many customers per employee existed in the water supply organization. The premise is that the water quality would be better if there were more number of employees per customer. The results suggest that there are 1721 customers per employee that suggests average water quality.

Hygiene and sanitation: The variable used to represent this indicator is 'percentage of people using improved sanitation services'. In Jaipur this trend has been on the rise from 73% in 2011 to 80% in 2015, indicating good water security in this regard.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. The variable used to measure this indicator is 'water wealth'. This is evaluated by dividing the total GDP of the city by the city water use. In Jaipur's case, the results reveal that this water wealth has generally a constant trend, with a magnitude of only USD 32/m^3 suggesting average water security in this regard.

Dimension-3: Water-related disasters: Two indicators have been used to assess this dimension of water security. These are 'disaster mitigation interventions' and 'resilience against disasters'.

Disaster mitigation interventions: This indicator has been measured by the 'per capita GDP' variable. The argument here is that if the per capita GDP is high, the city is better placed to invest in disaster mitigation interventions. In Jaipur, this figure has been more or less constant suggesting that the water security in this regard has not changed much over the years.

Resilience against disasters: The variable used to measure this indicator is 'natural drainage factor' that estimates the area of the city that is conducive to natural drainage whenever floods occur. The results suggest that the natural drainage factor has almost doubled from 8.9% in 2011 to 15.2% in 2015. This bodes well for water security in this aspect.

Dimension-4: Water Environment: Two indicators represent this dimension of water security. These are 'state of natural water resources', and 'state of pollution'.

State of natural water resources: The variable used to measure this indicator is 'natural water quality factor'. This factor seeks to examine if the dissolved oxygen (DO) concentration in the city water bodies meets the minimum standard as prescribed by the Pollution Control Department in Rajasthan. The results show that in all cases, and in all years of the analysis, the DO levels are lower than the expected standards, suggesting a state of poor water security on this front.

State of pollution: The variable used to measure this indicator is 'wastewater treatment factor" which is a measure of how much wastewater is treated before it is discharged into the receiving water bodies. In Jaipur, the wastewater treatment factor is only 40%. This does not bode well for water security.

Dimension-5: Water governance: Three indicators have been used to represent this dimension- Overall management of the water sector, potential to adapt to future changes, and citizen support for water security.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are 'institutional factor' and 'adaptability factor' that are evaluated using a questionnaire survey with the water related organizations in the city. In Jaipur, the survey was conducted with senior officials of the Public Health Engineering Department (PHED), Jaipur Development Authority (JDA), and Jaipur Municipal Corporation (JMC). The results of the survey for each of these organizations are presented in Tables 10, 11 and 12.

Table 10: Results of the questionnaire survey carried out with Public Health Engineering Department (PHED) of Jaipur city.

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
<u>Governance Index</u>						
1. Is public opinion sought when developing water-related plans for Jaipur?					√	5
2. Is there a provision for general public to register their grievances?					√	5
3. Is there an official mechanism to monitor water pollution offences?					√	5
4. Is there a provision to incentivize water conservation and/or water source protection?	√					1
5. Does PHED consult other water organizations (e.g. JDA, JMC) during the development of annual or long-term plans?			√			3

						3.8
Adaptability index						
1. Does recycling and/or reuse of water take place in Jaipur?				√		4
2. Is there a centralized database for water related information?					√	5
3. Is there an Early Warning System to prevent water-related disasters?				√		4
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term master plans?		√				2
5. Is there a mechanism for PHED staff to upgrade water-related knowledge?				√		4
						3.8

Table 11: Results of the questionnaire survey carried out with Jaipur Development Authority (JDA)

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Is public opinion sought when developing water-related plans for Jaipur?				√		4
2. Is there a provision for general public to register their grievances?					√	5
3. Is there an official mechanism to monitor water pollution offences?					√	5
4. Is there a provision to incentivize water conservation and/or water source protection?		√				2
5. Does JDA consult other water organizations (e.g. PHED, JMC) during the development of annual or long-term plans?			√			3
						3.8
Adaptability index						
1. Does recycling and/or reuse of water take place in Jaipur?					√	5
2. Is there a centralized database for water related information?					√	5
3. Is there an Early Warning System to prevent water-related disasters?				√		4

4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term master plans?		√				3
5. Is there a mechanism for JDA staff to upgrade water-related knowledge?					√	5
						4.4

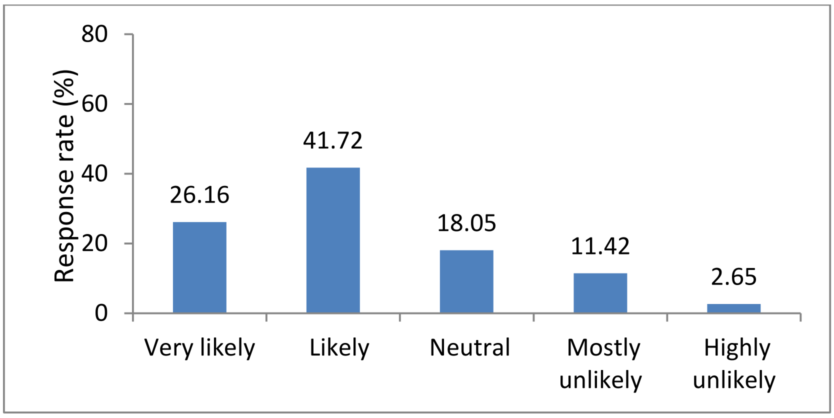
Table 12: Results of the questionnaire survey carried out with Jaipur Municipal Corporation (JMC)

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Is public opinion sought when developing water-related plans for Jaipur?			√			3
2. Is there a provision for general public to register their grievances?					√	5
3. Is there an official mechanism to monitor water pollution offences?					√	5
4. Is there a provision to incentivize water conservation and/or water source protection?		√				3
5. Does JMC consult other water organizations (e.g. PHED, JDA) during the development of annual or long-term plans?			√			2
						3.6
Adaptability index						
1. Does recycling and/or reuse of water take place in Jaipur?				√		4
2. Is there a centralized database for water related information?				√		4
3. Is there an Early Warning System to prevent water-related disasters?				√		4
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term master plans?		√				3
5. Is there a mechanism for JMC staff to upgrade water-related knowledge?				√		4
						3.8

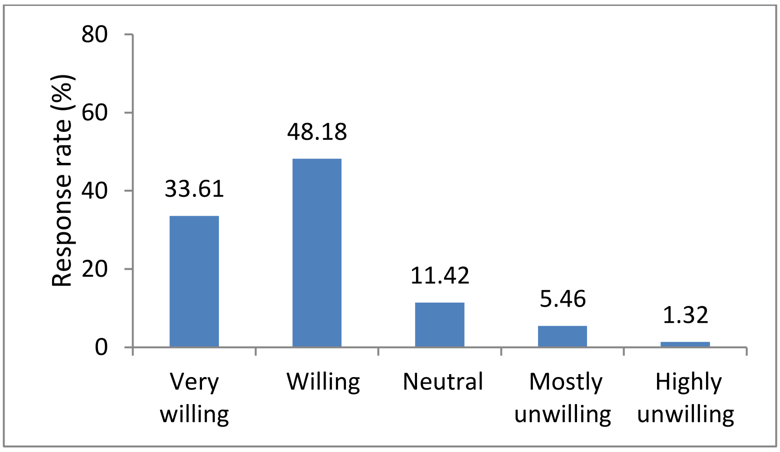
As seen in the results of the survey, the institutional factor and adaptability factor in Jaipur is better than average and reasonably satisfactory.

Citizen support for water security: The variable used for this indicator is 'public support factor' that was evaluated using a questionnaire with 600 randomly selected respondents in various regions of Jaipur city, and the results are presented hereafter.

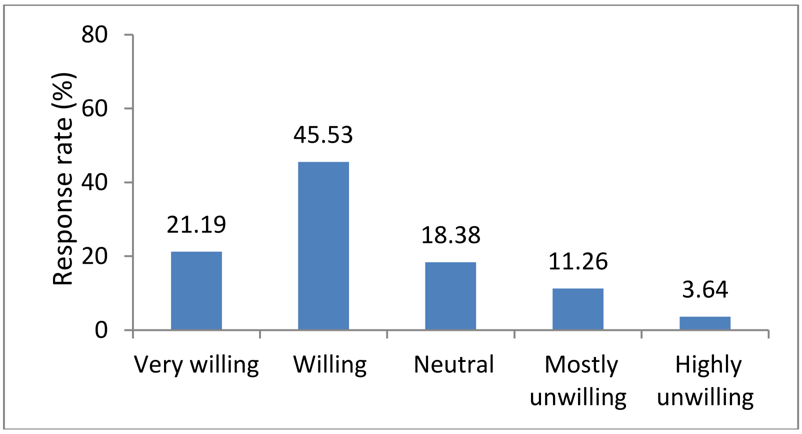
Question 1: If the government imposes a water conservation fee (20% of your water bill/month) to safeguard water resources, how likely are you to comply?



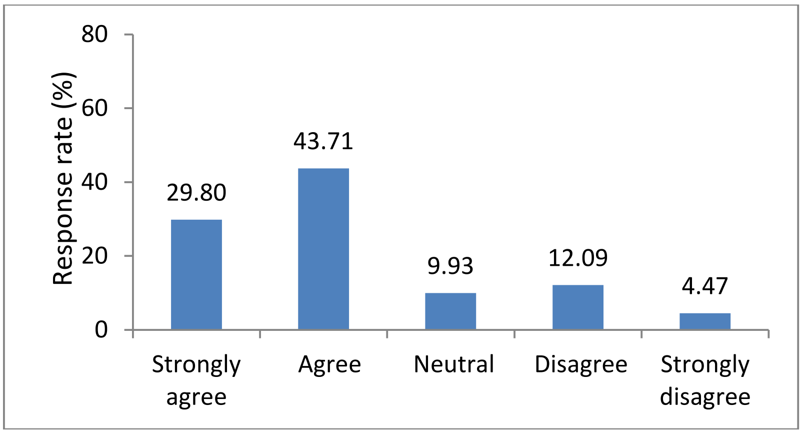
Question 2: How willing would you be to using recycled water in your house?



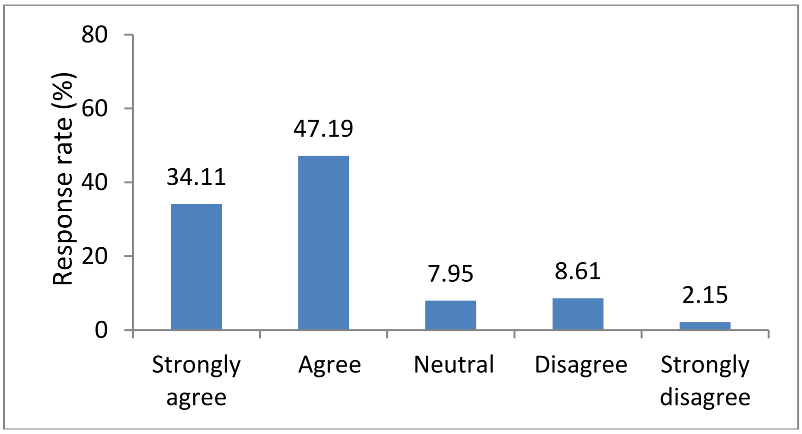
Question 3: How willing would you be to pay an additional tax (20% of your water bill/month) to reduce the impacts of disasters like floods?



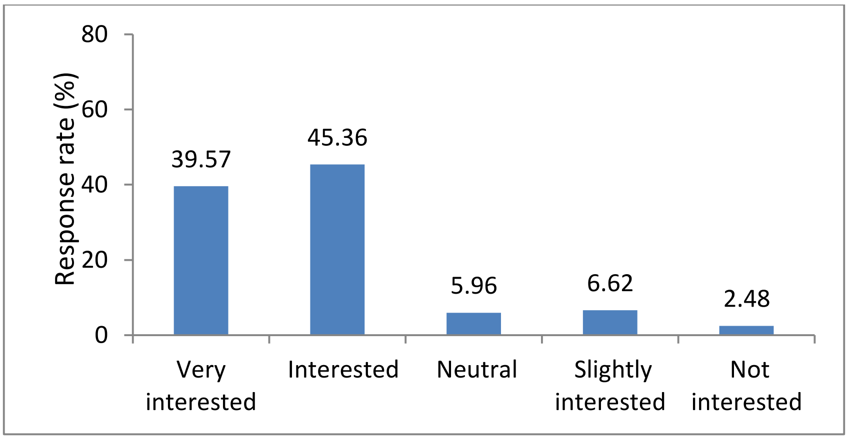
Question 4: How well do you agree to 'income-based' payment of water fees? i.e. people with less income pay less fee and people with more income pay more fee.



Question 5: How well do you agree to the notion that water should be subsidized because it is a basic human need?



Question 6: How interested would you be to volunteer regularly (say, four times a year) in a water-watch programme, to observe and report problems that deteriorate the quality of water in rivers and local water sources?



As seen through the questionnaire responses, the citizen support for water security enhancement is good, and better than Bangkok. Citizens are aware of the problems related to water security and are willing to pay extra to secure water security.

Hanoi

Table 13: Results of city-scale water security assessment for Hanoi

Dimension	Indicator	Variables	Estimation	2011	2013	2015
Water supply and sanitation	Water availability	*Per capita water use (lpcd)*	Per capita water demand	122.5	132.5	145
	Accessibility	*Population access to piped water supply (%)*	Serviced population/City population	36	38	41
	Quality of water supplied	*Customer satisfaction with water quality*	pH of supplied water	7.0	7.1	7.0
	Hygiene and sanitation	*Number of people using improved sanitation facilities (%)*	(Number of people using improved sanitation facilities / Total population) * 100	89.7	89.8	91.3
Water productivity	Economic value of water	*Agricultural water productivity* (US$/m^3)	Agricultural revenue/Agricultural water use	0.86	0.92	0.96
		Industrial water productivity (US$/m^3)	Industrial revenue/Industrial water use	66.33	68.05	68.87
Water-related disasters	Disaster mitigation interventions	*Coping potential factor (%)*	(Investment in WI disaster response mechanisms/ Total city budget) *100	3.9	1.3	1.8
	Resilience against disasters	*Drainage factor (%)*	(Total open space (green)/ Total city area) * 100	15.49	15.19	14.89
Water environment	State of natural water sources	*Natural water quality factor*	BOD5 values/Permissible limit	4.00	4.00	4.00
	State of pollution	*Wastewater treatment factor (%)*	(Amount of treated wastewater/Total wastewater generated) *100	38	50	59

Water governance	Overall management of the water sector	*Institutional factor*				
	Potential to adapt to future changes	*Adaptability factor*				
	Citizen support for water security	*Public support factor*				

Table 13 presents the results of the city-scale water security assessment for Hanoi. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water supply and sanitation: There are four indicators under this dimension – water availability, accessibility, quality of water supplied, and hygiene and sanitation.

Water availability: The variable used to measure this indicator is 'per capita water use'. In Hanoi, the per capita water use has increased from 122.5 lpcd in 2011 to 142 lpcd in 2015. This indicates that the demand for water is increasing which does not reflect well on the water security situation in the city.

Accessibility: One variable has been used to measure this indicator – 'population access to piped water supply'. In Jaipur, this population access is quite poor with 36% access in 2011 which increased to 41% in 2015. Although the trend is increasing it is still a matter of concern that more than 50% of the city still does not have access to piped water supply.

Quality of water supply: The variable used to represent this indicator is 'pH of supplied water'. The premise is that good water quality would have a neutral pH of around 7. The results suggest that the pH has remained constant at 7 over the period of analysis, suggesting good water quality.

Hygiene and sanitation: The variable used to represent this indicator is 'percentage of people using improved sanitation services'. In Hanoi, this trend has been on the rise from 89% in 2011 to 91% in 2015, indicating good water security in this regard.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. Two variables used to measure this indicator- agricultural water productivity, and industrial water productivity.

Agricultural water productivity: Hanoi has a significant peri-urban area where the major revenue source is agriculture. Hence, this variable was considered in the analysis. The results reveal that the agricultural water productivity has generally increased from $0.88/m^3 in 2011 to $0.96/m^3 in 2015. However, the productivity is still under $1/m^3 suggesting poor water security in this regard.

Industrial water productivity: The industrial water productivity in Hanoi has also been on a rising trend from $66/m^3 in 2011 to $69/m^3 in 2015. However, the increase is not very significant.

Dimension-3: Water-related disasters: Two indicators have been used to assess this dimension of water security. These are 'disaster mitigation interventions' and 'resilience against disasters'.

Disaster mitigation interventions: This indicator has been measured by the 'coping potential factor' variable that is a measure of the portion of the city budget that is allocated for disaster mitigation interventions. In Hanoi, this figure has been between 1-3 % over the period of analysis, suggesting that the water security in this regard has not changed much over the years.

Resilience against disasters: The variable used to measure this indicator is 'natural drainage factor' that estimates the area of the city that is conducive to natural drainage whenever floods occur. The results suggest that the natural drainage factor has remained constant at around 15% during the period of analysis suggesting the water security in this aspect has not changed over the years.

Dimension-4: Water Environment: Two indicators represent this dimension of water security. These are 'state of natural water resources', and 'state of pollution'.

State of natural water resources: The variable used to measure this indicator is 'natural water quality factor'. This factor seeks to examine if the Biochemical Oxygen Demand (BOD) concentration in the city water bodies meets the required standard as prescribed by the Pollution Control Department in Vietnam. The results show that in all cases, and in all years of the analysis, the BOD levels are four times higher than the permissible limits, indicating a state of poor water security on this front.

State of pollution: The variable used to measure this indicator is 'wastewater treatment factor" which is a measure of how much wastewater is treated before it is discharged into the receiving water bodies. In Hanoi, the wastewater treatment factor has increased from 38% in 2011 to 59% in 2015, which indicates that the water security in this regard is improving over the years.

Dimension-5: Water governance: Three indicators have been used to represent this dimension- Overall management of the water sector, potential to adapt to future changes, and citizen support for water security.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are 'institutional factor' and 'adaptability factor' that are evaluated using a questionnaire survey with the water related organizations in the city. In Jaipur, the survey was conducted with senior officials of the water supply company in Hanoi. The results of the survey are presented in Table 14.

Table 14: Results of the questionnaire survey carried out with the water supply company in Hanoi

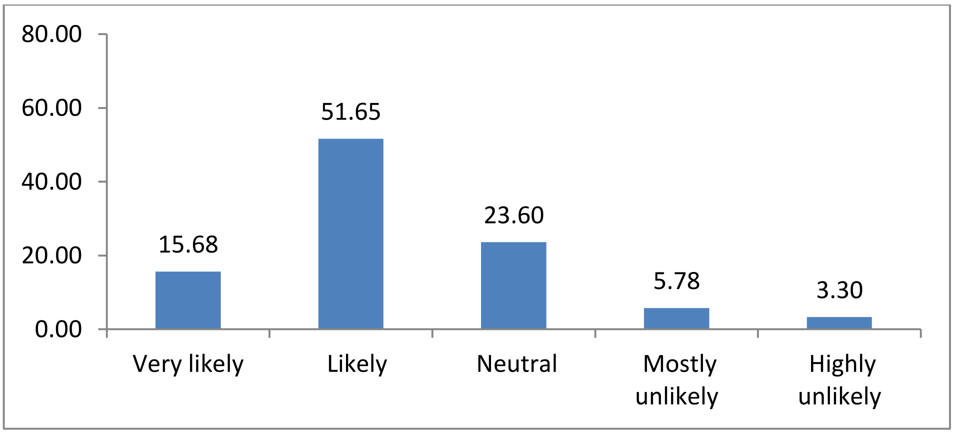
Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
<u>Governance Index</u>						
1. Is public opinion sought when developing water-related plans for Hanoi?				√		4
2. Is there a provision for general public to register their grievances?		√				2
3. Is there an official mechanism to monitor water pollution offences?		√				2

4. Is there a provision to incentivize water conservation and/or water source protection?				√		4
5. Does the organization consult other water organizations during the development of annual or long-term plans?		√				2
						3.2
<u>Adaptability index</u>						
1. Does recycling and/or reuse of water take place in Hanoi?		√				2
2. Is there a centralized database for water related information?		√				2
3. Is there an Early Warning System to prevent water-related disasters?			√			3
4. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term master plans?		√				2
5. Is there a mechanism for staff to upgrade water-related knowledge?			√			3
						2.4

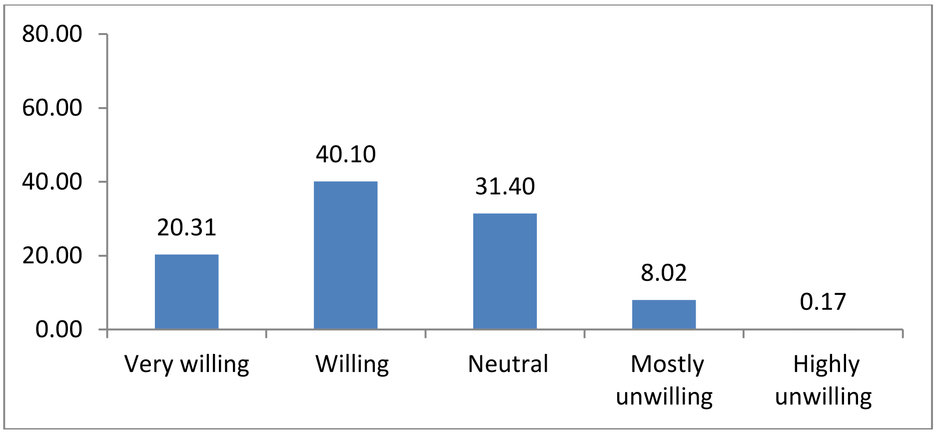
As seen in the results of the survey, the institutional factor and adaptability factor in Hanoi is not very satisfactory. The city especially lacks the ability to plan for future drivers of change that are likely to impact water security.

Citizen support for water security: The variable used for this indicator is ‘public support factor’ that was evaluated using a questionnaire with 600 randomly selected respondents in various regions of Hanoi city, whose results are presented hereafter.

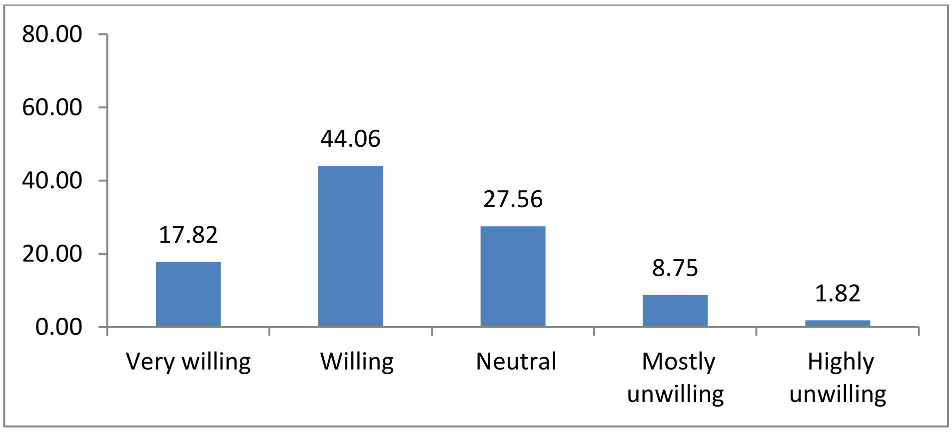
Question 1: If the government imposes a water conservation fee (20% of your water bill/month) to safeguard water resources, how likely are you to comply?



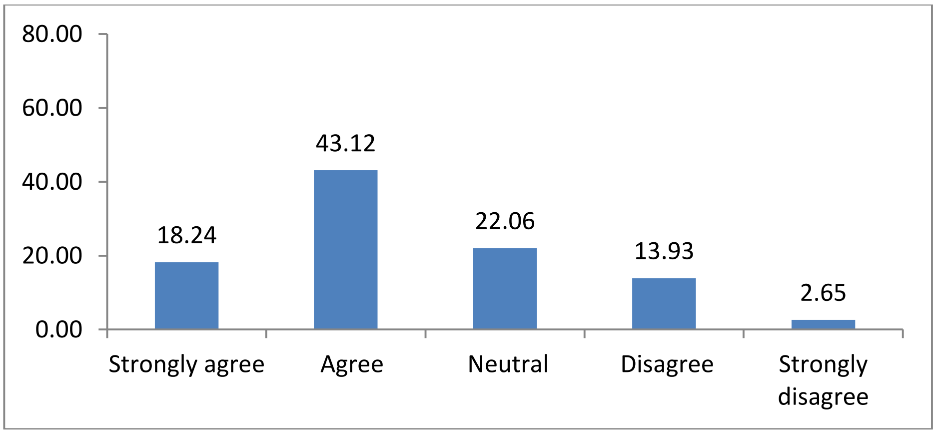
Question 2: How willing would you be to using recycled water in your house?



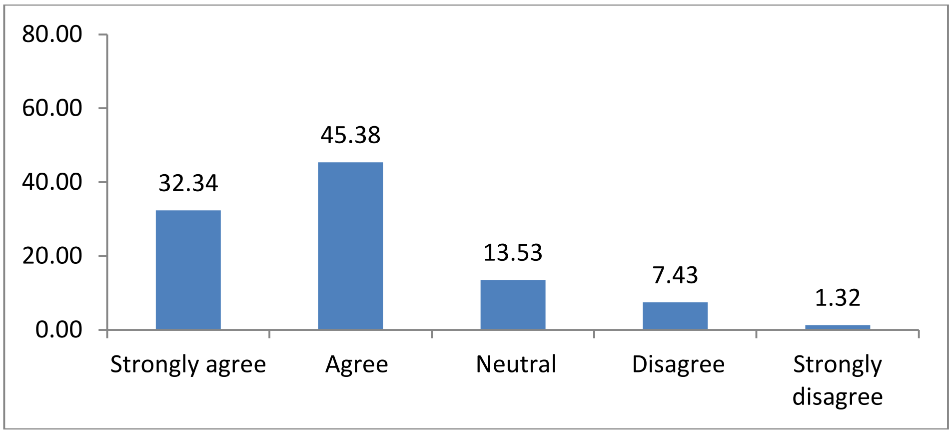
Question 3: How willing would you be to pay an additional tax (20% of your water bill/month) to reduce the impacts of disasters like floods?



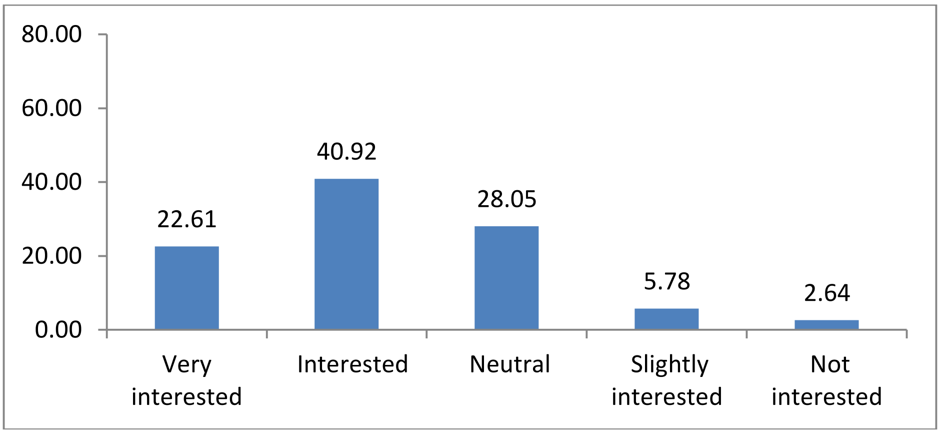
Question 4: How well do you agree to ‘income-based’ payment of water fees? i.e. people with less income pay less fee and people with more income pay more fee.



Question 5: How well do you agree to the notion that water should be subsidized because it is a basic human need?



Question 6: How interested would you be to volunteer regularly (say, four times a year) in a water-watch programme, to observe and report problems that deteriorate the quality of water in rivers and local water sources?



As seen through the questionnaire responses, the citizen support for water security enhancement is good, and better than Bangkok. Citizens are aware of the problems related to water security and are willing to pay extra to secure water security.

3.4 Application of the basin-scale water assessment framework

Chao Phraya River Basin, Thailand

Table 15: Results of city-scale water security assessment for Chao Phraya River Basin, Thailand

Dimension	Indicators	Variables	Estimation	2009	2011	2013	2015
Water availability	Sustainable basin exploitation	Per capita water availability (m^3/capita/year)	Surface runoff/Population	1,439.65	4,589.35	1,984.85	610.04
Water Productivity	Economic value of water	Commercial/industrial revenue per drop (US$/$m^3$)	Non-agricultural GPP/ Non-agricultural water use in the basin	109.89	133.33	143.12	137.48
		Agricultural, Aquaculture and Livestock revenue per drop (US$/$m^3$)	Agricultural, Aquaculture and Livestock GPP/ Agricultural, Aquaculture and Livestock water use in the basin	0.18	0.24	0.30	0.34
Water-related disasters	Drought factor	Drought damage (Million US$)	Economic damage caused by droughts	1.05	0.22	1.75	2.93
	Flood factor	Flood damage (Million US$)	Economic damage caused by floods	43.43	553.02	12.49	0.41
Watershed Health	Health of water bodies	Surface water quality factor	Dissolved Oxygen concentration/Permissible limit	0.89	0.86	0.91	0.88
	Vegetation cover	Natural vegetation factor (%)	(Natural vegetation area/Basin area) * 100	43	43	40	40
Water governance	Overall management of the water sector	Institution factor	Questionnaire				4.4
	Potential to adapt to future changes	Adaptability factor	Questionnaire				4.1

Table 15 presents the results of the basin-scale water security assessment for Chao Phraya River Basin, Thailand. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water availability: This dimension is assessed by the indicator 'sustainable basin exploitation'. The variable used to measure this indicator is 'per capita water availability', which is estimated by dividing the surface runoff in the basin by the population. In the Chao Phraya River Bain, per capita water availability has varied considerably over the period of analysis and was the highest in 2011 at 4589 m^3/person. However, in 2011 Thailand was hit by an unprecedented flooding event that could explain this high value. In 2015, the per capita water availability was a meagre 610 m^3/person which translates to severe water stress condition, contrary to the ethos of water security.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. Two variables used to measure this indicator- commercial and industrial revenue per drop, and agricultural, aquaculture and livestock revenue per drop.

Commercial and industrial revenue per drop: This variable shows significant increase over the period of analysis from \$110/m^3 in 2009 to \$137/m^3 in 2015. This indicates that the commercial and industrial revenue per drop is quite satisfactory, contributing to improved water security.

Agricultural water productivity: Agriculture plays an important role in the livelihoods of people in the Chao Phraya River Basin, and makes a significant contribution to the basin's work force. The value for this variable has shown an increasing trend from \$0.18/m^3 in 2009 to \$0.34/m^3 in 2015. However, the increase is not very significant.

Dimension-3: Water-related disasters: Two indicators have been used to assess this dimension of water security. These are 'drought factor' and 'flood factor'.

Drought factor: Droughts are an important phenomenon in the Chao Phraya River Basin given the level of agriculture in the basin. The drought factor in this context looks to throw light on the economic damage caused by droughts. The damage has generally been on an increasing trend from USD 1 Million in 2009 to almost USD 3 Million in 2015, suggesting that the basin is insecure with respect to security against droughts.

Flood factor: Floods are a recurring phenomenon in the Chao Phraya River Basin, with increasing frequency and intensity. The flood factor in this context looks to throw light on the economic damage caused by floods. The damage has generally been on a decreasing trend from USD 43 Million in 2009 to USD 0.4 Million in 2015. An exception was in the year 2011 when Thailand was hit by an unprecedented flooding event. Nonetheless, the decreasing trend of this variable suggests that adequate measures are being taken to mitigate flood damages, thereby improving water security in this regard.

Dimension-4: Watershed health: Two indicators represent this dimension of water security. These are 'health of water bodies, and 'vegetation cover'.

Health of water bodies: The variable used to measure this indicator is 'surface water quality factor. Chao Phraya Basin has a number of major rivers flowing through it. This variable focused on these major rivers. This variable seeks to examine if the Dissolved Oxygen (DO) concentration in the city water bodies meets the minimum standard prescribed by the Pollution Control Department in Thailand. The results show that in all cases, and in all years of the analysis, the DO levels are lower than the minimum standards, indicating a state of poor water security on this front.

Vegetation cover: The variable used to measure this indicator is 'natural vegetation factor' which is a measure of how much basin area is covered with natural vegetation. In the Chao Phraya Basin this value has ranged between 40-43% over the period of analysis, which indicates that the water security in this regard has remained more or less constant over the years.

Dimension-5: Water governance: Two indicators have been used to represent this dimension- Overall management of the water sector, and potential to adapt to future changes.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are 'institutional factor' and 'adaptability factor' that are evaluated using a questionnaire survey with the water related organizations in the basin. In Chao Phraya River Basin, the survey was conducted with senior officials from the Royal Irrigation Department (RID) and the Department of Water Resources (DWR). The results of the survey are presented in Tables 16 and 17.

Table 16: Results of the questionnaire survey carried out with the Royal Irrigation Department, Thailand

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Does the basin have an Integrated Water Resources Management (IWRM) plan?				√		4
2 Does the basin have a River Basin organization (RBO)?		√				2
3. Is there a provision to incentivize water conservation and/or water source protection?				√		4
4. Is public opinion sought when developing water-related plans?					√	5
5. Is there a mechanism to monitor pollution offences?					√	5
						4
Adaptability index						

1. Is there a centralized database of water related information?				√		4
2. Is there an Early warning system in place?					√	5
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?				√		4
`4. Is there a mechanism for staff to upgrade knowledge?					√	5
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?				√		4
						4.4

Table 17: Results of the questionnaire survey carried out with the Department of Water Resources, Thailand

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Does the basin have an Integrated Water Resources Management (IWRM) plan?				√		5
2 Does the basin have a River Basin organization (RBO)?		√				5
3. Is there a provision to incentivize water conservation and/or water source protection?				√		4
4. Is public opinion sought when developing water-related plans?					√	5
5. Is there a mechanism to monitor pollution offences?					√	5
						4.8
Adaptability index						
1. Is there a centralized database of water related information?		√				2
2. Is there an Early warning system in place?					√	5
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?			√			3

`4. Is there a mechanism for staff to upgrade knowledge?					√	5
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?					√	5
						3.75

As seen in the results of the survey, the institutional factor and adaptability factor in the Chao Phraya River Basin is quite satisfactory, with both DWR and RID displaying a high level of water governance. An area of improvement within the DWR would be on the adaptability factor, especially in terms of centralizing all water related information and data.

Banas River Basin, India

Table 18: Results of city-scale water security assessment for Banas River Basin, India

DIMENSION	INDICATOR	POTENTIAL VARIABLES	SUGGESTED WAYS TO MEASURE	2007	2009	2011	2013	2015
WATER AVAILABILITY	Sustainable Basin Exploitation	Per capita water availability (m^3/per person)	Annual per capita water resources availability	502.15	421.06	647.10	618.11	498.40
WATER PRODUCTIVITY	Economic value of water	Commercial/industrial revenue per drop ($\$/m^3$)	Non-agricultural GDP/ Non-agricultural water use in the basin	5.78	6.01	7.02		
		Agricultural revenue per drop ($\$/m^3$)	Agricultural GDP /Agricultural water use in the basin	0.18	0.14	0.27		
WATER-RELATED DISASTERS	Drought factor	Proportional area of drought (%)	(Drought affected agricultural area /Total agricultural area) * 100	0	69	0	68	
WATERSHED HEALTH	Health of water bodies	Surface water quality factor	Dissolved Oxygen concentration/Permissible limit	0.92	0.89	0.86	0.95	0.88
	Vegetation Cover	Natural Vegetation factor (%)	Natural Vegetation area (sq.km)/ Basin Area (sq. km)	11	10	10	10	10
WATER GOVERNANCE	Overall management of the water sector	Institution factor	Questionnaire					3.40
	Potential to adapt to future changes	Adaptability factor	Questionnaire					3.55

Table 18 presents the results of the basin-scale water security assessment for Banas River Basin, India. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water availability: This dimension is assessed by the indicator 'sustainable basin exploitation'. The variable used to measure this indicator is 'per capita water availability', which is estimated by dividing the surface runoff in the basin by the population. In the Banas River Bain, per capita water availability has varied between 421 and 647 m^3/person over the period of analysis. The whole range still translates to severe water stress condition, contrary to the ethos of water security.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. Two variables used to measure this indicator-commercial and industrial revenue per drop, and agricultural, aquaculture and livestock revenue per drop.

Commercial and industrial revenue per drop: This variable has remained more or less constant over the period of analysis at around USD 6/m^3. This value for productivity is significantly lower than that of Bangkok, and casts severe aspersions on the water security on this front in the basin.

Agricultural water productivity: Agriculture plays an important role in the livelihoods of people in the Banas River Basin, and makes a significant contribution to the basin's work force. However, the agricultural water productivity in the basin appears to be very low (reaching a maximum of $0.27/$m^3$ in 2011.

Dimension-3: Water-related disasters: One indicator has been used to assess this dimension of water security. This is the 'drought factor'. Droughts are a very important phenomenon in the Banas River Basin given the basin is located in a desert land. The drought factor in this context looks to throw light on the portion of the basin area affected by droughts. Droughts appear to be a biannual affair in the basin with around 60% of the basin area affected every two years. Because more than half the basin area is affected by drought regularly, the basin is insecure with respect to security against droughts.

Dimension-4: Watershed health: Two indicators represent this dimension of water security. These are 'health of water bodies, and 'vegetation cover'.

Health of water bodies: The variable used to measure this indicator is 'surface water quality factor. This variable focused on the major rivers in the Banas Basin. This variable seeks to examine if the Dissolved Oxygen (DO) concentration in the city water bodies meets the minimum standard prescribed by the Pollution Control Department in Rajasthan. The results show that in all cases, and in all years of the analysis, the DO levels are lower than the minimum standards, indicating a state of poor water security on this front.

Vegetation cover: The variable used to measure this indicator is 'natural vegetation factor' which is a measure of how much basin area is covered with natural vegetation. In the Banas Basin this value has remained constant at around 10% over the period of analysis, which indicates that the water security in this regard has remained more or less constant over the years.

Dimension-5: Water governance: Two indicators have been used to represent this dimension- Overall management of the water sector, and potential to adapt to future changes.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are 'institutional factor' and 'adaptability factor' that are evaluated using a questionnaire survey with the water related organizations in the basin. In Chao Phraya River Basin, the survey was conducted with senior officials from the Central Agricultural Department (CAD), Water Resources Department (WRD), and Groundwater Department (GWD). The results of the survey are presented in Tables 19, 20 and 21.

Table 19: Results of the questionnaire survey carried out with the Central Agriculture Department (CAD), Rajasthan, India.

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Does the basin have an Integrated Water Resources Management (IWRM) plan?				√		4
2 Does the basin have a River Basin organization (RBO)?		√				2
3. Is there a provision to incentivize water conservation and/or water source protection?			√			3
4. Is public opinion sought when developing water-related plans?		√				2
5. Is there a mechanism to monitor pollution offences?					√	5
						3.2
Adaptability index						
1. Is there a centralized database of water related information?				√		4
2. Is there an Early warning system in place?			√			3
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?		√				2
`4. Is there a mechanism for staff to upgrade knowledge?					√	5
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?				√		3
						3.4

Table 20: Results of the questionnaire survey carried out with the Water Resources Department, Rajasthan, India.

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						
1. Does the basin have an Integrated Water Resources Management (IWRM) plan?				√		4
2 Does the basin have a River Basin organization (RBO)?					√	5
3. Is there a provision to incentivize water conservation and/or water source protection?				√		4
4. Is public opinion sought when developing water-related plans?					√	5
5. Is there a mechanism to monitor pollution offences?					√	5
						4.6
Adaptability index						
1. Is there a centralized database of water related information?					√	5
2. Is there an Early warning system in place?					√	5
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?					√	5
`4. Is there a mechanism for staff to upgrade knowledge?				√		4
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?				√		4
						4.6

Table 21: Results of the questionnaire survey carried out with the Groundwater Department, Rajasthan, India.

Questions	Not yet considered **1**	Under Consideration/development **2**	In place but not yet implemented **3**	Partially implemented **4**	Mostly implemented **5**	Score for each question
Governance Index						

1. Does the basin have an Integrated Water Resources Management (IWRM) plan?		√				2
2 Does the basin have a River Basin organization (RBO)?			√			3
3. Is there a provision to incentivize water conservation and/or water source protection?		√				2
4. Is public opinion sought when developing water-related plans?		√				2
5. Is there a mechanism to monitor pollution offences?					√	5
						2.8
<u>Adaptability index</u>						
1. Is there a centralized database of water related information?		√				2
2. Is there an Early warning system in place?	√					1
3. Are future drivers of change (e.g. climate change) taken in consideration when developing long-term DWR master plans?					√	5
`4. Is there a mechanism for staff to upgrade knowledge?					√	5
5. Is there a flexibility to change water allocation quota for different users, whenever there is need to do so?	√					1
						2.8

As seen in the results of the survey, the institutional factor and adaptability factor in the Banas River Basin is overall satisfactory. Among the three agencies, the Water Resources Department appears to be most equipped to handle water governance.

Red River Basin, Vietnam

Table 22: Results of city-scale water security assessment for Red River Basin, Vietnam

Dimension	Indicator	Variables	Estimation	2011	2013	2015
Water availability	Sustainable basin exploitation	*Per capita water availability* (m^3/capital/year)	Surface runoff / Total population	2,501.8	3,558.3	2,725.7
Water Productivity	Economic value of water	*Industrial water productivity factor* (US$/$m^3$)	Industrial revenue/Industrial water demand	40	39	41
		Agricultural water productivity factor (US$/$m^3$)	Agricultural revenue/Agricultural water demand	0.94	0.97	1.02
Water-related disasters	Drought factor	*Ratio of the area with water-saving irrigation to the total area of arable land (%)*	Area of Irrigation/ Area of arable	82		
	Flood factor	*Flood damage* (Million US$)	Flood loss (Million US$)	8.11	85.13	175.57
Watershed Health	Health of water bodies	*Surface water quality factor*	BOD5 concentration/Permissible limit	4.80	2.80	2.53
	Vegetation cover	Natural Vegetation factor (%)	(Vegetation area / Basin area) * 100	61	64	52
Water governance	Overall management of the water sector	Institutional factor	Questionnaire			3.3
	Potential to adapt to future changes	Adaptability factor	Questionnaire			2.9

Table 22 presents the results of the basin-scale water security assessment for Red River Basin, Vietnam. Described hereafter is the assessment of each dimension of water security.

Dimension-1: Water availability: This dimension is assessed by the indicator 'sustainable basin exploitation'. The variable used to measure this indicator is 'per capita water availability', which is estimated by dividing the surface runoff in the basin by the population. In the Red River Bain, per capita water availability is quite high ranging from 2500 m^3/person in 2011 to 3559 m^3/person in 2013. The whole range translates to good water security in this aspect.

Dimension-2: Water productivity: Just one indicator has been used to assess this dimension of water security – economic value of water. Two variables used to measure this indicator-commercial, and industrial water productivity, and agricultural water productivity.

Industrial water productivity: This variable has remained more or less constant over the period of analysis at around USD 40/m^3. This value for productivity is significantly lower than that of Bangkok, but is higher than that of Jaipur suggesting a state of medium water security on this front.

Agricultural water productivity: Agriculture plays an important role in the livelihoods of people in the Red River Basin, and makes a significant contribution to the basin's work force. However, the agricultural water productivity in the basin appears to be low (an average of \$1/m^3 over the period of analysis.

Dimension-3: Water-related disasters: Two indicators have been used to assess this dimension of water security - 'drought factor', and 'flood factor'.

Drought factor: The variable used to measure this indicator is the 'ratio of the area with water-saving irrigation to the total area of arable land', which essentially estimates how much of the arable land is irrigated. Given the abundant water resources in the Red River Basin, this ratio is quite high at 82% in 2011, suggesting that the basin figures well with respect to security against droughts.

Flood factor: Floods are a recurring phenomenon in the Red River Basin, with increasing frequency and intensity. The flood factor in this context looks to throw light on the economic damage caused by floods. The damage has generally been on a steeply increasing trend from USD 8 Million in 2011 to USD 176 Million in 2015. This steep increasing trend indicates poor water security in the basin against flood damage.

Dimension-4: Watershed health: Two indicators represent this dimension of water security. These are 'health of water bodies, and 'vegetation cover'.

Health of water bodies: The variable used to measure this indicator is 'surface water quality factor. This variable focused on the major rivers in the Banas Basin. This variable seeks to examine if the Biochemical Oxygen Demand (BOD) concentration in the city water bodies meets the required standard prescribed by the Pollution Control Department in Vietnam. The results show that in all cases, and in all years of the analysis, the BOD levels are higher than the required standards, indicating a state of poor water security on this front.

Vegetation cover: The variable used to measure this indicator is 'natural vegetation factor' which is a measure of how much basin area is covered with natural vegetation. In the Red River Basin this value has been on a decreasing trend from 61% in 2011 to 52% in 2015. This indicates that the environment aspects have been side-lined to accommodate development in the basin leading to state of insecurity on this front.

Dimension-5: Water governance: Two indicators have been used to represent this dimension- Overall management of the water sector, and potential to adapt to future changes.

Overall management of the water sector and Potential to adapt to future changes: The variables for these indicators are 'institutional factor' and 'adaptability factor' that are evaluated using a questionnaire survey with the water related organizations in the basin. In Red River Basin, the survey was conducted with senior officials from a number of government agencies, given the large number of stakeholders involved in the water governance in the Basin. The results revealed that the overall management of water sector scores 3.3 which is just about satisfactory although there is plenty of room for improvement. However, with a score of 2.9, the potential to adapt to future changes in relatively low.

4. Conclusions

Water security is an emerging paradigm and receiving increasing attention in both academic and the policy sectors. The objective of this study was to develop a water security assessment framework at basin- and city-scales, that would act as a decision support tool to make informed decisions on operationalizing water security. At the city-scale the framework has 5 dimensions and 12 indicators, while at the basin-scale the framework comprises of 5 dimensions and 8 indicators. The frameworks developed in the study were then applied in diverse regions of Asia – Thailand (Chao Phraya River Basin, and Bangkok city), India (Banas River Basin, and Jaipur city), and Vietnam (Red River Basin, and Hanoi city).

Following are the main findings and conclusions of the study.

i) Quantification of water security is very much possible. However, choosing the right indicators are crucial to portraying a correct picture of the water security situation. This does not, however, preclude qualitative indicators from entering the fray. Qualitative analysis can still be considered so long as it is not subjective and can help in clear decision making.

ii) Consulting the appropriate stakeholders in the development of the framework is crucial for establishing a robust framework.

iii) The frameworks for each scale developed in the study have been designed to be generic in nature so that those can be applied in any context. The framework, at the same time, however, allows for site specific aspects to be accounted for in the analysis of water security. It does so by having three levels in the structure. The first two are ‘dimensions’ and ‘indicators’, which are common to all conditions. The third level is the ‘variables’ which are site-specific, meaning that the user is free to choose any variable that correctly reflects the local conditions.

iv) The comparison of the city-scale water security assessment of the three cities Bangkok, Jaipur and Hanoi is provided in the Table 23.

Table 23: Comparison of city-scale water security assessments of Bangkok, Jaipur and Hanoi

Dimension	Bangkok	Jaipur	Hanoi
Water supply and sanitation	Bangkok measures reasonably well against this dimension. The per capita water demand has a decreasing trend, while the population access to piped water supply shows an increasing trend. The quality of water supplied is also the best among the three cities. A major drawback is its reliance on inter-basin transfer to meet the water demand.	Jaipur measures well against this dimension. The per capita demand has remained constant for last five years, indicating that the demand for water has not increased. The population access to piped water supply is in excess of 90%, while the number of people using improved sanitation has been on the rise.	Hanoi measures poorly against this dimension. The per capita demand is rising, population access to piped water supply is a low 41%. However, the sanitation situation is well advanced with over 90% of the population having access to improved sanitation.
Water productivity	The water productivity in Bangkok is high and shows an increasing trend, which enhances the	Jaipur features satisfactory against this dimension. The	Hanoi is the only city among the three that has a strong agricultural sector. The

	overall water security. Currently the productivity stands at $330/m^3.	productivity is at an average $32/m^3.	productivity of this sector is, however, under $1/m^3. In terms of industrial productivity the value is a currently at $69/m^3.
Water-related disasters	Bangkok features poorly against this dimension. Not only does the city have little provision for natural drainage, the investment made in disaster mitigation interventions are far from sufficient.	Jaipur features quite well against this dimension. The green/open spaces have doubled over a five-year period contributing to the natural drainage capacity of the city. The budgets for disaster mitigation have also remained constant over the years.	Hanoi features just about alright against this dimension. Around 1-3% of the city budget has been devoted to disaster mitigation consistently over the last few years. The green spaces have also remained constant
Water environment	Bangkok features poorly against this dimension as well. The canals in the city are all polluted and none of them meet the required standard of Dissolved Oxygen (DO). Furthermore, the wastewater treatment plants have been operating at full capacity for some time now, leaving no room for handling additional wastewater that is being produced every year.	Jaipur features poorly against this dimension. All the water bodies in the city are polluted and none of them meet the required DO standards. Furthermore, almost 60% of the wastewater is diverted to receiving bodies without any treatment.	Hanoi features mixed results against this dimension. On one hand in all the water bodies the standard for the permissible BOD is breached. On the other hand, wastewater treatment has shown an increasing trend and stands at 59% currently.
Water governance	Bangkok features well against this dimension. It has the required laws, regulatory bodies, institutions, and technologies required for water security enhancement. Further, the plans and policies developed for Bangkok are forward looking. Citizen support for water security is reasonable.	Jaipur features reasonably well against this dimension. The laws and policies to enhance water security are in a developing phase. There is also considerable support from citizens for water security enhancement.	The city especially lacks the ability to plan for future drivers of change that are likely to impact water security. However, citizen support for water security is strong.

v) The comparison of the basin-scale water security assessment of the three basins Chao Phraya, Banas, and Red is provided in the Table 24.

Table 24: Comparison of city-scale water security assessments of Bangkok, Jaipur and Hanoi

Dimension	Chao Phraya, Thailand	Banas, India	Red, Vietnam
Water availability	In the Chao Phraya River Bain, per capita water availability has varied considerably over the period of analysis and currently stands at a meagre 610 m^3/person.	In the Banas River Bain, per capita water availability has varied between 421 and 647 m^3/person over the period of analysis, and stood at 498 m^3/person in 2015.	In the Red River Bain, per capita water availability is quite high ranging from 2500 m^3/person in 2011 to 3559 m^3/person in 2013.
Water productivity	Water productivity in the basin is quite high given that most of the industrial activities that are financially lucrative are based in this basin. The non-agricultural productivity is lower but still shows an increasing trend.	Water productivity in the basin is low. The industrial productivity has remained more or less constant over the period of analysis at around \$6/m^3, while the agricultural productivity was a low \$0.27/m^3.	Water productivity in the basin is medium. The industrial productivity has remained constant over the period of analysis at around USD 40/m^3, while agricultural productivity just about \$1/m^3
Water-related disasters	The basin shows mixed results against this dimension. The drought damage has generally been on an increase and stood at almost USD 3 Million in 2015. The flood damage, however, has generally been on a decreasing trend and stood at 0.4 Million in 2015.	Droughts appear to be a biannual affair in the basin with around 60% of the basin area affected every two years. Because more than half the basin area is affected by drought regularly, the basin is insecure with respect to security against droughts.	Given the abundant water resources, the basin is quite secure against droughts. However, the trend is opposite in case of floods. The flood damage has been on a steeply increasing trend from USD 8 Million in 2011 to USD 176 Million in 2015.
Watershed health	The basin shows poor results against this dimension. The DO levels in all the major rivers are lower than the minimum standards. The natural vegetation cover has remained more or less constant over the period of analysis.	The basin shows poor results against this dimension. The DO levels in all the major rivers are lower than the minimum standards. The natural vegetation cover has remained more or less constant over the period of analysis.	The basin measures poorly against this dimension. The BOD levels in all the major rivers are higher than the prescribed standards. The natural vegetation cover has also been reducing over the years.
Water governance	Both the Department of Water Resources and Royal Irrigation Department, the main bodies responsible for water management at the basin level, display a high level of water governance.	The water governance in the Banas River Basin is overall just about satisfactory. Among all water-related agencies, the Water Resources Department appears to be most equipped to handle water governance.	A number of government agencies are involved in the water governance in the Basin. The overall management of water sector is just about satisfactory although there is plenty of room for improvement in the potential to adapt to future changes.

5 Future Directions

The current research work sought to develop frameworks at both city and basin scales to assess water security. The research has looked at the various drivers of water security at the two scales, and incorporated those into a generic framework that can be applied in any context. The framework has been designed at three levels so that the framework can capture both generic and site-specific aspects.

The future directions of this research include the following:

1. Focused research on each dimension of the water security separately, and expanding the list of indicators to capture additional aspects. This exercise would be particularly useful when a particular dimension of water security is found to be weak, and there is a need for additional analysis to bolster it.
2. Another area of research would be to look at how policies and plans to improve water security at various levels can be evaluated against the framework.
3. Evaluate projects and initiatives that are being proposed to improve water security against the framework developed by the study to get a sense of the magnitude of increase of water security.
4. Conduct research on water security enhancement measures that are likely to cause the largest increase in water security, using the assessment framework developed by the study.

6 Bibliography

Ait-kadi, M. and Arriens, W.L. (2012). *Increasing Water Security-A Development Imperative*. Retrieved August 2014, from Global Water Partnership Website: http://www.gwp.org/ToolBox/PUBLICATIONS/Perspectives-Papers/.

Asian Development Bank. (2013). Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific, Manila, Philippines.

Bahri, A. (2012). *Integrated Urban Water Management, No. 16.* Retrieved May 2015, from Global Water Partnership Website: http://www.gwp.org/en/ToolBox/PUBLICATIONS/Background-papers/

Babel, M. S. and Wahid, M. S. (2008). Freshwater under threat: South Asia Vulnerability Assessment of Freshwater Resources to Environmental Change, Kenya, United Nations Environment Programme.

Babel, M. S., Pandey, V. P., Rivas, A. A., and Wahid, S. M. (2011). Indicator-Based Approach for Assessing the Vulnerability of Freshwater Resources in the Bagmati River Basin, Nepal. *Environmental Management*, 48(5), 1044-1059.

Beek, E.V. and Arriens, W.L. (2014). *Water Security: Putting the Concept Into Practice, No. 20.* Retrieved October 2014, from Global Water Partnership Website: http://www.gwp.org/en/gwp-in-action/News-and-Activities/New-GWP-Publications-at-World-Water-Week-2014/

Brown, A. and Matlock, M. D. (2011). *A Review of Water Scarcity Indices and Methodologies*. Retrieved October 2014, from The Sustainability Consortium Website: http://www.sustainabilityconsortium.org/wp content/themes/sustainability/assets/pdf/whitepapers/2011_Brown_Matlock_Water-Availability-Assessment-Indices-and-Methodologies-Lit-Review.pdf

Burkhard, B. and Muller, F. (2008). Driver–Pressure–State–Impact–Response. In: Jørgensen SE, Fath BD, editors. Ecological indicators. Vol.(2) of Encyclopedia of EcologyOxford: Elsevier, 967-70.

Carr, E. R., Wingard, P. M., Yorty, S. C., Thompson, M. C., Jensen, N. K., and Roberson, J. (2007). Applying DPSIR to sustainable development. *International Journal of Sustainable Development & World Ecology*, 14(6), 543-555.

Cook, C. and Bakker, K. (2012). Water security: Debating an emerging paradigm. *Global Environmental Change*, 22(1), 94-102.

Cooper, P. (2013). Socio-ecological accounting: DPSWR, a modified DPSIR framework, and its application to marine ecosystems. *Ecological Economics*, 94, 106-115.

Department of Drainage & Sewerage. (2014). Action Plan For Flood Protection and Solution in Bangkok Year 2014. Bangkok, Thailand. (In Thai)

Global Water Partnership. (2000). Towards Water Security: A Framework for Action. Stockholm, Sweden.

Global Water Partnership. (2014). Processings from the GWP workshop: Assessing water security with appropriate indicators, Stockholm, Sweden.

Grey, D. and Sadoff, C.W. (2007). Sink or Swim? Water security for growth and development. *Water Policy*, 9(6), 545-571.

Howard, G. and Bartram, J. (2003). Domestic Water Quantity, Service Level and Health, Geneva, Switzerland.

Jha, A. K., Bloch, R., and Lamond, J. (2012). Cities and Flooding A Guide to Integrated Urban Flood Risk Management for the 21st Century, Washington, DC, United States of America.

Jun, K. S., Chung, ES., Sung, JY., and Lee, K. S. (2011). Development of spatial water resources vulnerability index considering climate change impacts. *Science of the Total Environment*, 409(24), 5228-5242.

Koontanakulvong, S., Doungmanee, P., Hoisungwan, P. (2013). Water Security Index Concept Thailand's Water Security Situation in the context of world and ASEAN. Thailand: Chulalongkorn University and Research Center, National Institute of Development Administration. (In Thai)

Ma, H., Liu, L., and Chen, T. (2009). Water security assessment in Haihe River Basin using principal component analysis based on Kendall τ. *Environmental Monitoring and Assessment*, 163(1-4), 539-544.

Manandhar, S., Pandey, V. P., and Kazama, F. (2012). Application of Water Poverty Index (WPI) in Nepalese Context: A Case Study of Kali Gandaki River Basin (KGRB). *Water Resources Management*, 26(1), 89-107.

Mekong River Commission. (2005). Overview of the Hydrology of the Mekong Basin. Vientiane, Laos.

Mehr, S. (2011). Integrated framework for assessment of water security. (Master research study No. WM-10-1, Asian Institute of Technology, (2011). Thailand: Asian Institute of Technology.

National Statistical Office of Thailand. *Gross Domestic Product in Thailand.* Retrieved October 2014, from National Statistical Office of Thailand Website: http://service.nso.go.th/nso/web/statseries/statseries15.html. (In Thai)

Norman, E. S., Dunn, G., Bakker, K., Allen, D. M., and Albuquerque, R. C. (2012). Water Security Assessment: Integrating Governance and Freshwater Indicators. *Water Resources Management*, 27(2), 535-551.

Organization for Economic Co-operation and Development. (2003). *OECD Environmental Indicators Development, measurement and use*. Retrieved September 2014, from Organization for Economic Co-operation and Development Website: http://www.oecd.org/environment/indicators-modelling-outlooks/24993546.pdf

Pinto, R., de Jonge, V. N., Neto, J. M., Domingos, T., Marques, J.C., and Patricio, J. (2013). Towards a DPSIR driven integration of ecological value, water use and ecosystem services for estuarine systems. *Ocean & Coastal Management*, 72, 64-79.

Pollution Control Department. *Calculation of Water Quality Index.* Retrieved April 2015, from Pollution Control Department Website: http://iwis.pcd.go.th/document/WQI.pdf (In Thai)

Shahin, A. and Mahbod, M. A. (2007). Prioritization of key performance indicators: An integration of analytical hierarchy. *International Journal of Productivity and Performance Management*, 56(3), 226-224.

Sharma, S. (2018). *Performance Indicators of Water Losses in Distribution System.* Retrieved April 2015, from SWITCH Central Management Unit UNESCO-IHE Website: http://www.switchurbanwater.eu/outputs/pdfs/GEN_PRS_PI_of_Water_Losses_AC_Apr08.pdf

Sinyolo, S., Mudhara, M., and Wale, E. (2014). Water security and rural household food security: empirical evidence from the Mzinyathi district in South Africa. *Food Security*, 6(4), 483-499.

Stefano, L. D. (2010). International Initiatives for Water Policy Assessment: A Review. *Water Resources Management*, 24(11), 2449-2466.

Sullivan, C. A., Meigh, J. R., Giacomello, A. M., Fediw, T., Lawrence, P., Samad, M., et al. (2003). The Water Poverty Index: Development and application at the community scale. *Natural Resources Forum*, 27(3), 189-199.

Suriyachan, C., Nitivattananon, V., and Nurul Amin, A. T. M. (2012). Potential of decentralized wastewater management for urban development: Case of Bangkok. Habitat International, 36(1), 85-92.

United Nations Environment Programme. (2012). Status Report on The Application of Integrated Approaches to Water Resources Management 2012, Nairobi, Kenya.

UN-Water. (2013). *Water Security and the Global Water Agenda A UN-Water Analytical Brief.* Retrieved August 2014, from UN-Water Website: http://www.unwater.org/publications/publications-detail/en/c/197890/.

Van Leeuwen, C. J., Frijns, J., Van Wezel, A., and Van de Ven, F. H. M. (2012). City Blueprint: 24 Indicators to Assess the Sustainability. *Water Resource Management*, 26(8), 2177-2197.

Vorosmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., et al. (2010). Global threats to human water security and river biodiversity. *Nature*, 467(7315), 555-561.

Water Quality Management Office. (2013). Annual Report 2013 Water Quality Management Office. Bangkok, Thailand. (In Thai)

World Health Organization. (1997). Guidelines for Drinking-Water Quality, 2nd edition, Geneva, Switzerland.

World Bank. (2009). Climate change impact and adaptation study for Bangkok metropolitan region: final report, Washington, DC, United States of America.

Xiao, S., Li, J., Xiao, H., and Liu, F. (2007). Comprehensive assessment of water security for inland watersheds in the Hexi Corridor, Northwest China. *Environmental Geology*, 55(2), 369-376.

Xiao-jun, W., Jian-yun, Z., Shahid, S., Xing-hui, X., Rui-min, H., and Man-ting, S. (2012). Catastrophe theory to assess water security and adaptation strategy in the context of environmental change. *Mitigation and Adaptation Strategies for Global Change*, 19(4), 463-477.

Zonensein, J., Miguez1, M. G., de Magalhães1, L. P. C, Valentin, M. G., Mascarenhas, F. C. B. (2008). Flood Risk Index as an Urban Management Tool, *11th International Conference on Urban Drainage*. Edinburgh, Scotland and United Kingdom.

7. Appendix

Appendix A: Workshops and Conferences

A1: 1st round of stakeholder workshops: INDIA

Workshop title: Developing an operational water security index, and demonstrating its application in diverse regions of Asia
Date: 10 March 2015
Venue: Malaviya National Institute of Technology, Malaviya Nagar, India
Agenda:
Background and workshop objectives
The Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) has embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam.

In India, the project's spatial coverage will focus on the Banas River Basin, and Jaipur City. Based on an exhaustive literature review, an initial framework for water security evaluation at basin and city scale has been tentatively proposed. However, the project recognizes that any form of water security evaluation would be incomplete without accounting for the views and opinions of the vast array of relevant stakeholders, across diverse sectors and streams.

This workshop has been organized for precisely this purpose—to provide a platform for stakeholders from various disciplines in the Banas River Basin to discuss, and deliberate upon, the various issues related to water security in the basin. It is expected that the inter-disciplinary discussions during the workshop will provide food for thought in deciding upon a more holistic, and robust, approach to evaluate the water security at different spatial scales.

Workshop programme

0900-0930h	Registration
0930-1030h	Welcome address by project leader (5 min)…………………M.S. Babel Welcome address by CURAJ (5 min)……………………...….K.C. Sharma Welcome address by MNIT (5 min)……………………………...R. Goyal Introduction of participants (15 min) Workshop objective and agenda (5 min)……………………..M.S. Babel Keynote speech (20 minutes)………………..…………….J.R. Sharma Vote of thanks (5 minutes)…………………………….....…..D. Sharma
1030-1045h	Presentation 1: Water security (**WS**) in the study area………D. Sharma
1045-1115h	Open discussion on WS related issues in the study area….…A. Gupta
1115-1135h	Group photograph and networking break
1135-1155h	Presentation 2: Existing and proposed WS evaluation framework/s…………………………………………………..……V. Shinde
1155-1200h	Formation of groups for post-lunch group discussions, and briefing on the modality of the discussions…………………………….……..M.S. Babel
1200-1330	Focused group discussion 1: • How to define WS from your perspective? • What are the factors affecting WS at city and basin scale? • What are the relevant dimensions of WS at city and basin scale?
1330-1430h	Lunch and networking
1430-1530h	Focused group discussion 2: • What are the future drivers of WS in the basin? • How can WS be mainstreamed?
1530-1545h	Coffee break
1545-1615h	Reports from working groups
1615-1630h	Recommendations from the workshop……………………….M.S. Babel

List of participants

S. No.	Name	Organization	Email
1	Prof. M.S. Babel	Asian Institute of Technology, Thailand	msbabel@ait.asia
2	Dr. Victor Shinde	Asian Institute of Technology, Thailand	victorshinde@ait.asia
3	Dr. V. S. P. Sinha	Banasthali	sinha_vinay@yahoo.co.uk
4	Dr. Subimal Sinha Roy	Birla Institute of Scientific Research	ssinharoy@yahoo.com
5	Dr. M.S. Rathore	Centre for Environment and Development Studies Jaipur	msr@cedsj.org
6	Dr. Rakesh Kushwaha	CGWB	rakeshcgwb@rediffmail.com
7	Sh. Sudhir Sharma	Construction Sector	sudhirgulpadiya@yahoo.co.in
8	Prof. K.C. Sharma	CURAJ	kcsharma@curaj.ac.in
9	Dr. Garima Kaushik	CURAJ	garimakaushik@curaj.ac.in
10	Dr. Dharampal Singh	CURAJ	
11	Dr. Jagdish Jadhav	CURAJ	jagdishjadhav_sw@curaj.ac.in, jagdishjadhav20@gmail.com
12	Dr. Devesh Sharma	CURAJ	deveshsharma@curaj.ac.in
13	Mr. Rahul Rathi	ECLEI South Asia	rahul.rathi@iclei.org

14	Dr. P.C. Ranka	Health	pcranka@hotmail.com
15	Prof. K.N. Joshi	IDS (water Policy) Jaipur	knjoshi@idsj.org; joshi.knjoshi@gmail.com; Kamalnarainjoshi@yahoo.com
16	Sh. J.R. Sharma	ISRO, Department of Space	jrsharma50@gmail.com
17	Sh. Anandilal Meena	ITC	Giresh.Mohan@itc.in, Sarvashish.Roy@itc.in, anandi.meena@itc.in
18	Sh. Sarvashish Roy	ITC	-
19	Dr. R.K. Vyas	MNIT	rkvyas2@rediffmail.com
20	Prof. Rohit Goyal	MNIT	rgoyal.ce@mnit.ac.in
21	Prof. A.B. Gupta	MNIT	akhilendra_gupta@yahoo.com
22	Dr. A.S. Jethoo	MNIT	asjethoo.ce@mnit.ac.in
23	Prof. Harish solanki	National Institute of Rural Development, Jaipur	hksolanki@nird.gov.in, harry.om2000@gmail.com
24	Sh. Anand Mani Shukla	Morarka Foundation	-
25	Sh. Manu Sharma	NGO	manu.sharma91@yahoo.co.in
26	Sh. Paramhance Yadav	GVT	s.bhattacharyya@gvtindia.org, gvtjaipur@gmail.com
27	Dr. Alpna Kateja	Rajasthan University	alpanakateja@gmail.com
28	Sh. K.C. Sharma	State Groundwater Board	sharmakc1511@rediffmail.com
29	Sh. S. M. Kanwar	State Groundwater Board	kanwarsatendra@yahoo.com
30	Dr. Nguyen Mai Dang	Vietnam	-
31	Sh. H.R. Koli	Water Resources Department	ce.wr-rj@rajasthan.gov.in; sumneshmathur77@gmail.com
32	Sh. Hemant Joshi	Water Sanitation Support Organisation, Rajasthan & Ex Executive Director, Department of Drinking Water Supply	hkjoshio5o5@gmail.com
33	Dr. Yasmin Khan		dryrkhan@gmail.com
34	Dr. Sanjay Palnitkar	Rajasthan pollution control board	sanjaypalnithar@yahoo.com
35	Sh. K.L. Bairwa	Water Resource Rajasthan	sespecialscheme@gmail.com
36	Dr. Alok Kumar	Central University of Rajasthan	alokjnu2383@gmail.com
37	Sh. N.P. Singh	Centre for Environment & Development Studies	npcedsj@gmail.com
38	Jitendra Saini	JHALSHALA , CURAJ	jitendrasaini25@gmail.com
39	Satish Meena	JHALSHALA , CURAJ	satismeena14@gmail.com
40	Sh. Amar Singh	Water Resource Rajasthan	s.amar46@gmail.com
41	Sh. Abhishek Gupta	Central Water Commission	abhishek.822@yahoo.com
42	Swatantra kr. Dubey	CURAJ	swatantratech1@gmail.com
43	Nitika Mundetia	CURAJ	nitikacuraj@gmail.com
44	Amir Bhat	CURAJ	aamirbhatphdenv2012@curaj.ac.in
45	Suresh Chandra	CURAJ	sureshchandra1987@hotmail.com
46	Manish Chaudhary	CURAJ	manishchoudhary679@gmail.com

47	Abhilash Arya	CURAJ	studabhiarya@gmail.com
48	M. Venkatesh	CURAJ	mvenkatesh666@gmail.com
49	Kuldeep Tiwari	MNIT, Jaipur	2012RCE9506@mnit.ac.in
50	Priymitra Munoth	MNIT, Jaipur	2014RCE9536@mnit.ac.in
51	Kuldeep	MNIT, Jaipur	2013PCW5186@mnit.ac.in
52	Praveen Kumar	MNIT, Jaipur	2013PCW5364@mnit.ac.in
53	Pankaj Khandelwal	MNIT, Jaipur	2013PCD5372@mnit.ac.in
54	Adhra Sarcend	MNIT, Jaipur	

A2: 1st round of stakeholder workshops: VIETNAM

Workshop title: Developing an operational water security index, and demonstrating its application in diverse regions of Asia
Date: 27 May 2015
Venue: Thuyloi University, Vietnam
Agenda:

Background and workshop objectives

The Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) has embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam.

In Vietnam, the project's spatial coverage will focus on the Red River Basin, and Hanoi City. Based on an exhaustive literature review, an initial framework for water security evaluation at basin and city scale has been tentatively proposed. However, the project recognizes that any form of water security evaluation would be incomplete without accounting for the views and opinions of the vast array of relevant stakeholders, across diverse sectors and streams.

This workshop has been organized for precisely this purpose—to provide a platform for stakeholders from various disciplines in the Red River Basin to discuss, and deliberate upon, the various issues related to water security in the basin. It is expected that the inter-disciplinary discussions during the workshop will provide food for thought in deciding upon a more holistic, and robust, approach to evaluate the water security at different spatial scales.

Workshop programme

08.30-09.00	Registration
09.00-09.15	Welcome address by TLU……………………………………….Le Dinh Thanh Welcome address by project leader…………………………..….Mukand Babel Workshop objective and agenda………………………………. Nguyen Dang Introduction of participants
09.15-09.35	**Keynote speech**: Water security (WS) assessment at city, basin and national scales: challenges and the way forward……………………..Le Huu Ti
09.35-09.55	**Presentation 1:** Proposed WS framework for water security assessment at city and basin scales………………………………………………..Mukand Babel
09.55-10.15	Group photograph and networking break
10.15-10.35	**Presentation 2**: WS related issues in the study area…………..Dao Trong Tu
10.35-10.55	**Presentation 3:** WS index development and application in Hanoi…………………………………………………………….Nguyen Duc Hai
10.55-11.50	Open discussion on WS related issues in the study area………Mukand Babel
11.50-12.00	Formation of groups for post-lunch group discussions, and briefing on the modality of the discussions
12.00-13.00	Lunch and networking
13.00-13.15	**Presentation 4:** Outcomes of the stakeholder workshop in India……………………………………………………….…….Devesh Sharma
13.15-14.15	**Focused group discussion 1**: Based on presentation-1, are there any specific suggestions you have to enhance this proposed WS assessment framework?
14.15-14.30	Coffee break
14.30-15.30	**Focused group discussion 2**: • What are the future drivers of WS in the basin? • How can WS be mainstreamed?
15.30-16.00	Reports from working groups
16.00-16.30	Final reflections…………………………………………………..Mukand Babel

List of participants

No.	Full name	Office	Position
1	Prof. Nguyen Quang Kim	Thuyloi University (TLU)	Rector
2	Prof. Mukand. S. Babel	Asian Institute of Technology (AIT)	Team Leader of the project
3	Asso.Prof. Nguyen Mai Dang	Water Security Center - TLU	Partner of the project in Vietnam
4	Dr. Devesh Sharma	Central University of Rajasthan, India	Partner of the project in India
5	Dr. Le Huu Ti	Water Security Center - TLU	Expert on water security
6	Prof. Le Dinh Thanh	Thuyloi University	Expert on environment
7	Dr. Dao Trong Tu	Center for Water Resources Sustainable Development and Climate Change Adaptation	Expert on Institution and policy
8	Dr. Dang Dinh Phuc	Office of NTP for Rural Water Supply and Environmental Sanitation (NCERWASS)	Senior Expert on groundwater
9	Mr. Nguyen Manh Hung	Department of Hydraulic Works Management - WRD - MARD	Expert on hydraulic works
10	Dr. Le Quang Tuan	Department of Natural Disaster Prevention and Control (DNDPC) - WRD - MARD	Vice Head of Science and International Cooperation Division
11	Dr. Dinh Thanh Mung	Department of Science, Technology and International Cooperation - WRD - MARD	Senior Expert on water resources engineering
12	Mr. Nguyen Duy Du	Hanoi Department of Agriculture and Rural Development (DARD)	Vice head of Appraisal Division
13	Mrs. Tran Thi Tuyet Hanh	Investment and Development Company for Irrigation and Drainage in Nhue River	Deputy Director General
14	Mr. Tran Van Chung	VINACONEX Water Supply Company	Expert on water supply
15	Mr. Dang Ngoc Duan	Hanoi Drainage Company	Expert on drainage and inundation management
16	Mr. Hoang Van Thang	Water Supply Company of Hadong district	Expert on water supply
17	Mr. Do Duc Thu	Hanoi Department of Natural Resources and Environment (DONRE)	Vice head of Division of Meteorology, Hydrology and Climate change
18	Mrs. Le Thi Minh Thu	Hanoi Sub-Department of Environmental Protection	Expert on environment
19	Mr. Ha Huu Thu	Viet Environmental Engineering Company	Expert on environment
20	Mr. Nguyen Van Long	Viet Environmental Engineering Company	Expert on environment

21	Dr. Tran Mai Kien	Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN)	Vice head of Climate Change division
22	Mrs. Giang Thanh Binh	Department of Water Resources Management - MONRE (DWM)	Expert on water resources
23	Mrs. Nguyen Thi Phuong Hoa	Department of Water Resources Management - MONRE (DWM)	Expert on water resources
24	Dr. Vu Trung Kien	National Center for Rural Water Supply and Environmental Sanitation (NCERWASS)	Expert on water supply and sanitation
25	Mr. Dang Duy Hien	Bac Hung Hai Irrigation and Drainage Company	Director general
26	Mr. Trinh The Truong	Bac Hung Hai Irrigation and Drainage Company	Head of Technical Division
27	Mr. Nguyen Quoc Viet	Bac Hung Hai Irrigation and Drainage Company	Expert on irrigation
28	Mr. Nguyen Van Phuc	Irrigation and Drainage Company of Dong Trieu district	Head of Technical Division
29	Mr. Bui Du Duong	National Center for Water Resources Planning and Investigation	Deputy Director of Water Resources Monitoring Department
30	Mr. Nguyen Ngoc Ha	National Center for Water Resources Planning and Investigation	Director of Surface Water Investigation Department
31	Mr. Pham Ba Quyen	Northern Division for Water Resources Planning and Investigation	Head of Water Resources Planning Division
32	Mr. Do Van Trung	VHL Company for Drinking water filter and irrigation equipment	Director (private company)
33	Mr. Vu Minh Duc	Mekong River Commission of Vietnam	Expert
34	Dr. Can Thu Van	Ho Chi Minh University of Natural Resources and Environment	Lecturer
35	Mr. Nguyen Thien Dung	Water Resources Planning Institute	Expert and doctoral student at TLU
36	Ms. Nguyen Thi Mui	Hong Duc University	Lecturer and doctoral student at TLU
37	Mr. Le Ngoc Vien	Central College of Technology, Economics and Water Resources	Deputy Rector
38	Mr. Nguyen Van Dinh	Central College of Technology, Economics and Water Resources	Expert on water resources engineering
39	Dr. Dang Kim Khoi	Institute of Policy and Strategy for Agriculture and Rural Development	Vice Director of Agriculture Policy Center
40	Asso.Prof. Tran Chi Trung	Center for Participate Irrigation Management (PIM)	Director

41	Dr. Hoang Thanh Tung	Faculty of Hydrology and Water Resources - TLU	Expert on hydrology
42	Mr. Nguyen Van Sy	Faculty of Environment - TLU	Expert on environment
43	Asso.Prof. Doan Thu Ha	Department of Water Supply and Drainage - TLU	Expert on water supply
44	Asso.Prof. Nguyen Thi Lan Huong	Thuyloi University	Expert on environment
45	Dr. Nguyen Quang Hung	VNU University of Science	Lecturer and expert on water drainage
46	Mr. Pham Van Long	Vinh Phuc Province Department of Hydraulic works and irrigation	Director
47	Mr. Pham Tran Minh	Water Security Center - TLU	Expert on water security
48	Mr. Nguyen Duc Hai	Water Security Center - TLU	Expert on water security
49	Ms. Nguyen Thi Trang	Water Security Center - TLU	Master student in IWRM
50	Ms. Nguyen Thi Hang	Thuyloi University	Lecturer and secretary
51	Ms. Dong Thi Thuy Linh	Thuyloi University	Lecturer and secretary
52	Ms. Nguyen Dieu Ngoc	Thuyloi University	Lecturer and secretary
53	Mr. Le Ngoc Hieu	Thuyloi University	Student in Civil Engineering
54	Mr. Dang Ngoc Huy	Thuyloi University	Student in Civil Engineering
55	Mr. Nguyen Dong Thai	Thuyloi University	Student in Civil Engineering
56	Mr. Nguyen Trong Hiep	Thuyloi University	Student in Civil Engineering

A3: 1st round of stakeholder workshops: THAILAND

Workshop title: Developing an operational water security index, and demonstrating its application in diverse regions of Asia
Date: 03 September 2015
Venue: Hotel Windsor Suites and Convention, Bangkok, Thailand
Agenda:

Background and workshop objectives

The Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) has embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam.

In Thailand, the project's spatial coverage will focus on the Chao Phraya River Basin, and Bangkok City. Based on an exhaustive literature review, an initial framework for water security evaluation at basin and city scale has been tentatively proposed. However, the project recognizes that any form of water security evaluation would be incomplete without accounting for the views and opinions of the vast array of relevant stakeholders, across diverse sectors and streams.

This workshop has been organized for precisely this purpose—to provide a platform for stakeholders from various disciplines in the Chao Phraya River Basin to discuss, and deliberate upon, the various issues related to water security in the basin. It is expected that the inter-disciplinary discussions during the workshop will provide food for thought in deciding upon a more holistic, and robust, approach to evaluate the water security at different spatial scales.

Workshop programme

0830-0090h	**Registration**
0900-0925h	Welcome address; Overview of the project; and workshop objectives and expectations (10 min) Introduction of participants (15 min)
0925-0940h	**<u>Presentation 1</u>**: Proposed water security (**WS**) assessment framework at city-scale
0940-1045h	Break out discussions on proposed WS framework at city-scale: • Is there anything that can be added/modified to enhance the proposed WS framework at city-scale? • How can citizens be engaged in enhancing the city's water security? • Who are the main players at city-scale and how can the WS framework be mainstreamed?
1045-1115h	**Group photograph and coffee break**
1115-1130h	**<u>Presentation</u>** <u>2</u>: Proposed WS assessment framework at basin-scale
1130-1230h	Break out discussion on proposed WS framework at basin-scale: • How should basin-scale water security assessments differ from those made at city-scale? • Is there anything that can be added/modified to enhance the proposed WS framework at basin-scale? • Who are the main players at basin-scale and how can the WS framework be mainstreamed?

1230-1330h	Lunch

List of participants

No.	Name	Organization	Email address
1	Dr. Sunil Parashar	Asian Disaster Preparedness Centre	sunil@adpc.net
2	Mr. Susantha Jayasinghe	Asian Disaster Preparedness Centre	susantha@adpc.net
3	Dr. Dilip Kumar Gautam	Regional Integrated Multihazard Early Warning System	dilip.gautam@rimes.int
4	Mr. Christoph Mairesse	GIZ	christoph.mairesse@giz.de
5	Mr. Roland Treitler	GIZ	roland.treitler@giz.de
6	Mr. Falk J. Momber	GIZ	FalkJonas.Momber@giz.de
7	Mr. Usman Tariq	UNEP	tariq@un.org
8	Dr. Surachit Koontanakulvong	Chulalongkorn University	sucharit.k@gmail.com
9	Dr. Sangam Shrestha	AIT	sangam@ait.asia
10	Prof. Mukand Babel	AIT	msbabel@ait.asia
11	Dr. Devesh Sharma	CURAJ	devesh.water@gmail.com
12	Dr. Nguyen Dang	TLU	dang@wru.vn
13	Dr. Victor R. Shinde	AIT	victorshinde@ait.asia
14	Ms. Anyamanee Onsomkrit	AIT	anyamanee.on@gmail.com
15	Chirayu Jaroenongard	AIT	chirayu.jaroenongard@ait.ac.th
16	Dr. Damien Jourdain	CIRAD/AIT	djourdain@ait.asia
17	Mr. Pankaj Kumar Phukhan	AIT	pankajkumar_phukan@yahoo.co m

A4: 2nd round of stakeholder workshops: THAILAND

Workshop title: "Developing an operational water security index, and demonstrating its application in diverse regions of Asia"
**Date : **05 June 2017
Venue: Crowne Plaza Bangkok Lumpini Park, Bangkok, Thailand
Agenda:

Background and workshop objectives

In 2015, the Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam. The research project is now complete and its results are ready to be shared with stakeholders.

The project partners have developed a framework to measure the water security at two different scales using an indicator-based approach. This involves the quantification of a water security index that comprises of relevant dimensions of water security, which are in–turn evaluated using appropriate indicators.

In Thailand, the project's spatial coverage focused on the Chao Phraya River Basin, and Bangkok City.

The purpose of this workshop is to have proactive discussions with experts in Thailand about the framework developed by the project partners, and critically review its operationalization potential.

Workshop programme

08:30-09:00	**Registration**
09:00-09:20	Opening Session • Welcome address……………………………..……….Mukand Babel • Overview of the project……………………………...Victor R. Shinde • Statement of workshop objectives and expectations..Mukand Babel • Introduction of participants **(Group photograph)**
09:20-09:50	**Water security (WS) framework at <u>basin-scale</u>** 1) Presentation (10 min)…………………….…………Victor R. Shinde 2) Plenary discussion (20 min) • Technical robustness of the framework • Mainstreaming the framework
09:50-10:20	**Water security (WS) framework at <u>city-scale</u>** 1) Presentation (10 min)……………………………………Mukand Babel

	2) Plenary discussion (20 min) • Technical robustness of the framework • Mainstreaming the framework
10:00-10:20	**Coffee break on the table**
10:20-12:45	Breakout discussion to establish the reference standards for indicators for basin-scale and city-scale analysis (2 groups)
12:45-13:00	Wrap up and closing remarks……………………………..….Mukand Babel
13:00	**LUNCH**

List of participants

No	Name	Organization	Email
1	Mr. Itesh Dash	RIMES	anshul@rimes.int
2	Mr.Roland Treitler	GIZ	roland.treitler@giz.de
3	Dr.Alex Smajgl	MFRI	alex.smajgl@mekongfutures.com
4	Dr.Aida Karazhanova	Environment and Development Division, ESCAP	karazhanova@un.org
5	Dr.Thanapon Piman	Stockholm Environment Institute	thanapon.piman@sei-international.org
6	Ms.Katharin Cross	the International Water Association	katharine.cross@iwahq.org
7	Dr.Chaiwat Ekkawatpanit	Department of Civil Engineering, King Mongkut's University of Technology Thonburi	chaiwat.ekk@kmutt.ac.th
8	Dr.Puspa Raj Khanal	FAO	PuspaRaj.Khanal@fao.org
9	Dr.Eunhee Lee	UNESCO Bangkok	e.lee1@unesco.org
10	Dr.Peter King	Institute for Global Environmental Strategies	pnking1948@yahoo.com.au
11	Mr.Robert Dobias	AECOM, ADAPT-Asia	bobdobias@gmail.com
12	Oranuj Lorphensri	Department of Groundwater Resources	oranuj.l@dgr.mail.gp.th
13	Warangkana Lasbkich	Department of Groundwater Resources	dnuop_7@hotmail.com
14	Mrs.Kanokpaan Tirakumsri	Strategy and Evaluation Department, BMA	
15	Ms.Natthida Piiaicharoen	Strategy and Evaluation Department, BMA	jomyuthonhut@gmail.com
16	Dr.Chao Nokyoo	Pollution Contral Department	cnokyoo@hotmail.com
17	Dr.Pinida Leelapanang Kamphaengthong	Pollution Contral Department	p.leelapanang@gmail.com
18	Mr.Dunyarit Homnan	Department of Water Resources	dunyarit@hotmail.com
19	Kanapoj Wandee	Department of Water Resources	kanapojaa@yahoo.com
20	Maneekan Chumkong	Department of Public waorks and Town&Country Planning	chu66th@yahoo.com
21	Panisara Daorueang	Department of Public waorks and Town&Country Planning	
22	Varittha Thanasumbun	Provincial Waterworks Authority	varitthat@pwa.co.th
23	Phuwanop Khunaworapanya	Provincial Waterworks Authority	phuwanopk@pwa.co.th
24	Dr.Seree Suppratid	Provincial Waterworks Authority	55000@pwa.co.th

25	Ms.Jeeranee Janrungautai	Charoen Pokphand Group (CP Group)	Jeeranee.Jan@cp.co.th
26	Ms.Pimsiri Puthivorachai	Charoen Pokphand Group (CP Group)	
27	Dr.Nalinrut Masomboon	Charoen Pokphand Group (CP Group)	
28	Ms.Thidakwan Pannarawong	Charoen Pokphand Group (CP Group)	
29	Mrs.Piyanud Siri	Department of City Planning, BMA	piyanudsiri@yahoo.com
30	Mr.Boonchuay Noisantia	Department of Disaster Prevention and Mitigation	mbasuris@disaster.go.th
31	Mr.Rattipat Pangwatcharakorn	Department of Disaster Prevention and Mitigation	rattipatp@hotmail.com
32	Ms.Suda Ittisupornrat	Department of Environmental Quality Promotion	suwimolteam@yahoo.com
Project team of AIT, CURAJ, TLU			
33	Prof. Mukand Babel	AIT	msbabel@ait.asia
34	Dr. Victor R. Shinde	AIT	victorshinde@ait.asia
35	Dr.Devesh Sharma	CURAJ	devesh.water@gmail.com
36	Dr.Nguyen Mai Dang	TLU	dang@wru.vn
37	Ms. Anyamanee Onsomkrit	AIT	anyamanee.on@gmail.com
38	Chirayu Jaroenongard (MWA)	AIT	chirayu.jaroenongard@ait.ac.th

A5: 2nd round of stakeholder workshops: INDIA

Workshop title: “Developing an operational water security index, and demonstrating its application in diverse regions of Asia”
**Date : **12 October 2017
Venue: Hotel Ramada, Raja Park, Jaipur, India
Agenda:

Background and workshop objectives

In 2015, the Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam. The research project is now complete and its results are ready to be shared with stakeholders.

The project partners have developed a framework to measure the water security at two different scales using an indicator-based approach. This involves the quantification of a water security index that comprises of relevant dimensions of water security, which are in–turn evaluated using appropriate indicators.

In India, the project's spatial coverage focused on the Banas River Basin, and Jaipur City. The purpose of this workshop is to have proactive discussions with experts in India about the framework developed by the project partners, and critically review its operationalization potential.

Workshop programme

09:30-10:00	**Registration**
10:00-10:30	**Opening Session** Opening address……………………………………………Mukand Babel Opening remarks………………………………………………Ravi Solanki Introduction of participants
10:30-10:50	**P-1**: Project Background……………………………………Mukand Babel
10:50-11:00	**P-2**: Water Security Framework for Basin Scale……….Victor R. Shinde
11:00-11:30	**Group photograph and Refreshment break**
11:30-11:50	**P-3**: Water Security Assessment for Banas River Basin..Devesh Sharma
11:50-12:00	Briefing for Small group discussion….Victor R. Shinde
12:00-13:00	Small group discussions • Gaps in the framework • Discussion to establish the reference standards for indicators for city-scale analysis
13:00-13:30	Group reports for basin-scale discussion
13:30-14:30	**LUNCH**
14:30-14:40	**P- 4:** Water Security Frameworks for City Scale……….Victor R. Shinde
14:40-15:00	**P- 5:** Water Security Assessment for Jaipur…………....Devesh Sharma
15:00-16:00	Small group discussion:

	• Gaps in the framework • Discussion to establish the reference standards for indicators for city-scale analysis
16:00-16:30	**Refreshment break**
16:30-17:00	Group reports for both basin- and city-scale discussion
17:00-17:15	Wrap-up and closing remarks……………………………..Mukand Babel

List of participants

S. No	Resources Person	Affiliation	Organization	Email
1	Prof. M.S. Babel	Professor	Asian Institute of Technology, Thailand	msbabel@ait.asia
21	Mr. Swatantra Kumar Dubey	PhD Scholar	Central University of Rajasthan	swatantratech1@gmail.com
16	Mr. Varun Sharma	Programmeme Coordinator	Aravali, Jaipur	varun@aravali.org.in
2	Dr. Victor Shinde	Senior Researcher	Asian Institute of Technology, Thailand	victorshinde@ait.asia
22	Mr. Manish Kumar	PhD Scholar	Central University of Rajasthan	manishchoudhary679@gmail.com
24	Dr. Jagdish Jadhav	Associate Professor	Central University of Rajasthan	jagdishjadhav_sw@curaj.ac.in
26	Sh. M. M. Kant	Superintending Hydrogeologist, GWD, Jaipur	Ground Water Department, Jaipur	
13	Prof. A.P. Garg	Pro Vice-Chancellor	JNU, Jaipur	amarprakashgarg@yahoo.com
10	Prof. A. B. Gupta	Professor	MNIT, Jaipur	akhilendra_gupta@yahoo.com
12	Prof. Rohit Goyal (Ms. Hansa Rajput)	PhD Scholar	MNIT, Jaipur	rgoyal.ce@mnit.ac.in
17	Sh.Hukum Chand	Addl. Chief Engineer	PHED, Jaipur	
6	Sh. Sunil Kumar Parashar	AEN, NRW Cell	PHED, Jaipur	aenphed1nrwcell@gmail.com
3	Dr.Vũ Thanh Tú	Faculty	Thuyloi University, Vietnam	
4	Sh. Ravi Solanki	Additional Chief Engineer	Water Resources Department, Jaipur	sejpr.wr@rajasthan.gov.in
7	Sh. C M Tejawat	AD(IWMP)/ Mies&Eavl	Watershed Development & Soil Conservation, Jaipur	addl.wdsc@rajasthan.gov.in
19	Ms. Priyanka Sinsinwar	Programmeme Officer	CEE, Jaipur	ceejaipur@ceeindia.org
20	Dr. Devesh Sharma	Assistant Professor	Central University of Rajasthan	deveshsharma@curaj.ac.in
23	Mr. Adity Sharma	Research Assistant	Central University of Rajasthan	adityacuraj@gmail.com
15	Dr. M.S. Rathore	Director	Centre for Environment and Development Studies	msr@cedsj.org, msrorama@gmail.com

9	Sh. R.S. Khichar	Dy. Director Agriculture (Agro.)	Department of Agriculture, Jaipur	rajkhichar@rediffmail.com
27	Sh. R. K. Jain	Senior Geophysicist	Ground Water Department, Jaipur	rkj18965@gmail.com
25	Sh. Anil Singhal	Chief Engineer	Jaipur Municipal Corporation	ieccgwb@gmail.com
14	Prof. R.C. Purohit	Director Engg	JNU, Jaipur	purohitrc@yahoo.co.in
11	Dr. Mahender Choudhary	Associate Professor	MNIT, Jaipur	mahender.choudhary@gmail.com
18	Sh. Dinesh Goyal	S.E.Project Circle (City)	PHED, Jaipur	
19	Sh. Ambuj Tyagi	Executive Engineer	Water Resources Department, Jaipur	
20	Smt. Sushila Yadav	DD(GIS, PFC)	Watershed Development & Soil Conservation, Jaipur	dir.wdsc@rajasthan.gov.in

A6: 2nd round of stakeholder workshops: VIETNAM

Workshop title: "Developing an operational water security index, and demonstrating its application in diverse regions of Asia"
**Date : **12 December 2017
Venue: Thuyloi University, Vietnam
Agenda:

Background and workshop objectives

In 2015, the Asian Institute of Technology (AIT), in collaboration with the Thuyloi University (TLU) in Vietnam and Central University of Rajasthan (CURAJ), and with the support from the **Asia Pacific Network** for Global Change Research (**APN**) embarked on a research project to develop an operational framework for evaluating the water security at different spatial scales, and to implement this framework in three selected study areas in Thailand, India and Vietnam. The research project is now complete and its results are ready to be shared with stakeholders.

The project partners have developed a framework to measure the water security at two different scales using an indicator-based approach. This involves the quantification of a water security index that comprises of relevant dimensions of water security, which are in–turn evaluated using appropriate indicators.

In Vietnam, the project's spatial coverage focused on the Red River Basin, and Hanoi City.

The purpose of this workshop is to have proactive discussions with experts in Vietnam about the framework developed by the project partners, and critically review its operationalization potential.

Workshop programme

07.30-8.00	Registration	Đăng ký đại biểu/khách mời
08.00-08.20	Introduction of workshop objective and agenda Welcome address by TLU Leader Welcome address by Project leader (Prof. Babel) Introduction of participants	Tuyên bố lý do giới thiệu đại biểu. Phát biểu khai mạc của Lãnh đạo Trường Đại học Thủy lợi. Phát biểu khai mạc của chuyên gia quốc tế. Các Đại biểu/Khách mời tự giới thiệu.
08.20-08.30	Presentation 1: Water security assessment framework for city scale - Application for Hanoi City **(Dr. Dang)**	Bài trình bày 1: Khung đánh giá an ninh nguồn nước cho một thành phố - Ứng dụng cho Tp Hà Nội.
08.30-08.40	Presentation 2: Application for Bangkok City **(Prof. Babel/Dr. Victor)**	Bài trình bày 2: Ứng dụng cho Tp Bangkok
08.40-10.10 **(Facilitators: Prof. Babel, Dr. Devesh, Dr. Victor, Dr. Dang, Dr. Tu)**	Guideline for discussions and group formation Discussions on threshold of water security Report from working group	Định hướng thảo luận và chia nhóm Thảo luận nhóm về chia ngưỡng đánh giá Báo cáo từ làm việc nhóm
10.10-10.30	Group photograph and networking break	Chụp ảnh lưu niệm và nghỉ giải lao
10.30-10.40	Presentation 3: Water security assessment framework for basin scale - Application for Red River Basin **(Dr. Dang)**	Bài trình bày 3: Khung đánh giá an ninh nguồn nước cho một lưu vực

		sông - Ứng dụng cho lưu vực sông Hồng.
10.40-10.50	Presentation 4: Application for Chao Phraya River Basin, Thailand **(Prof. Babel/Dr. Victor)**	Bài trình bày 4: Ứng dụng cho lưu vực sông Chao Phraya, Thái Lan
10.50-12.20 **(facilitators: Prof. Babel, Dr. Devesh, Dr. Victor, Dr. Dang, Dr. Tu)**	Guideline for discussions and group formation Discussions on threshold of water security Report from working group	Định hướng thảo luận và chia nhóm Thảo luận nhóm về chia ngưỡng đánh giá Báo cáo từ làm việc nhóm
12.20-12.30	Conclusions and Recommendations **(Prof. Babel)** Closing **(Dr. Dang)**	Báo cáo tổng hợp kết quả hội thảo Phát biểu bế mạc hội thảo
12.30-13.30	Lunch	Ăn trưa

List of participants

No.	**Full name**	**Office**	**Email**
1	Prof. Nguyen Quang Kim	Thuyloi University (TLU)	kimnq@tlu.edu.vn
2	Prof. Nguyen Trung Viet	Thuyloi University (TLU)	nguyentrungviet@tlu.edu.vn
3	Prof. Mukand. S. Babel	Asian Institute of Technology (AIT)	msbabel@ait.ac.th
4	Asso.Prof. Nguyen Mai Dang	Thuyloi University (TLU)	dang@tlu.edu.vn
5	Dr. Devesh Sharma	Central University of Rajasthan, India	deveshsharma@curaj.ac.in
6	Dr. Victor Shine	Water Security Center - TLU	victorshinde@ait.asia
7	Dr. Vu Thanh Tu	Thuyloi University (TLU)	vutu@tlu.edu.vn
8	Mr. Pham Quoc Hung	Ministry of Agriculture and Rural Development) MARD	hungpq.tl@gmail.com
9	Asso.Prof. Pham Quy Nhan	Hanoi University of Natural Resources & Environment (HUNRE)	phamquynhan@yahoo.com
10	Prof. Le Dinh Thanh	Thuyloi University	ldthanh@tlu.edu.vn
11	Dr. Dao Trong Tu	Center for Water Resources Sustainable Development and Climate Change Adaptation	tu.daotrong2013@gmail.com
12	Dr. Dang Quang Tinh	Association of Water Resources	trandangdng@yahoo.com
13	Dr. Dang Dinh Phuc	Association of Water Resources	

14	Dr. Nguyen Lan Chau	Association of Hydrology	nglchau@yahoo.com
15	Mr. Bui Phuong Nam	Board of Son La hydropower project management - EVN	nambp1.slamb@gmail.com
16	Asso.Prof. Nguyen Kien Dung	Hanoi University of Natural Resources & Environment (HUNRE)	nguyenkiemdung@gmail.com
17	Hoang Thi Nguyet Minh	Hanoi University of Natural Resources & Environment (HUNRE)	htnminh@hunre.edu.vn
18	Mr. Nguyen Van Thanh	Ministry of Agriculture and Rural Development) MARD	thanhnv.vh@gmail.com
19	Mr. Nguyen Huu Thoa	Ministry of Agriculture and Rural Development) MARD	ThoaNH@wrd.gov.vn
20	Mr. Nguyen Huu Tai	Department of Water Resources Management - MONRE	huutai039@gmail.com
21	Mr. Do Tien Lanh	Center for Economics and Water Resources - Department of Water Resources Management - MONRE	dovanlanh@gmail.com
22	Mr. Ha Thanh Lan	Institute for Water Resources Planning - MARD	lanht.iwrp@gmail.com
23	Ms. Sái Hồng Anh	Institute for Water Resources Planning - MARD	saihonganh@gmail.com
24	Mr. Nguyen Ngoc Ha	National Center for Water Resources Planning and Investigation (NAWAPI)	ha_tnn@yahoo.com
25	Mr. Luyen Duc Thuan	National Center for Water Resources Planning and Investigation (NAWAPI)	ducthuan43v@gmail.com
26	Dr. Nguyen Dang Giap	Vietnam Academy for Water Resources	ndgiap74@gmail.com
27	Dr. Do Hoai Nam	Vietnam Academy for Water Resources	namdh_vkhtl@yahoo.com
28	Asso.Prof. Nguyen Cao Don	Thuyloi University	donnc@tlu.edu.vn
29	Asso.Prof. Bui Quoc Lap	Thuyloi University	buiquoclap@tlu.edu.vn
30	Dr. Nguyen Hoai Nam	Thuyloi University	namnh@tlu.edu.vn

31	Ms. Tran Thi Mai Hoa	Thuyloi University	hoattm@wru.vn
32	Asso.Prof. Pham Viet Hoa	Thuyloi University	fv_hoa@tlu.edu.vn
33	Asso.Prof. Doan Thu Ha	Department of Water Supply and Drainage - TLU	thuha_ctn@tlu.edu.vn
34	Dr. Nguyen Thi Thu Nga	Department of Hydrology and Water Resources	ngatvct@tlu.edu.vn
35	Dr. Pham Van Chien	Department of River Training and Disaster Management	chienyonsei@gmail.com
36	Ms. Nguyen Thi Mui	Hong Duc University	nguyenmui2006@gmail.com
37	Mr. Le Ngoc Vien	Central College of Technology, Economics and Water Resources	vienphd2016@gmail.com
38	Ms. Pham Thi Hong Nhung	English Department	nhungpth@tlu.edu.vn
39	Mrs. Nguyen Thanh Thuy	School of International Education	NguyenThanhThuy@tlu.edu.vn
40	Mr. Pham Van Manh	Thuyloi University	manhpv3nk@wru.vn
41	Mr. Nguyen Trong Hiep	Thuyloi University	hiepnt3nk@wru.vn
42	Mr. Pham Viet Hung	Thuyloi University	phamhung0306@gmail.com
43	Ms. Nguyen Hoai Thanh	Thuyloi University	thanhnh3nk@wru.vn

A7: International conference: THAILAND

Conference title: “Water security and climate change: Challenges and opportunities in Asia”
**Date : **29 November-01 December, 2016
Venue: Asian Institute of Technology, Thailand
Agenda:

Background and conference objectives

The Asian region has been facing many water security challenges since decades because of multiple drivers such as increasing population, socio economic development, urbanization, migration, among others. Key concerns include quality and quantity of available water supplies, overpopulation, wastewater disposal and sanitation, environmental degradation, and water-induced disaster risks, especially in the context of climate change, among others.

As of 2015, 260 million people in Asia still did not have access to improved water supply, while 1.46 billion did not have access to improved sanitation facilities (WHO and UNICEF, 2015). This situation is likely to be compounded by the increasing rate of urbanization in Asia. Asia is one of the most rapidly urbanizing regions in the world, with a 2.4% annual growth of the urban population. By 2015, it was estimated that 2.7 billion people would live in urban areas placing considerable stress on the water resource base of the region’s cities (UN Water Report, 2015).

Climate change is also creating an additional threat to water security in the region. Changing weather conditions are likely to increase the incidence and severity of extreme events. Some projections show an increase in the number of years with above normal monsoon rainfall or extremely low rainfall (IPCC, 2014). Melting glaciers will affect water supplies, creating risks of glacial lake outburst floods and downstream flooding for some regions. This will lead to an overall reduction in water supplies from snow cover and glacial runoff in the long run (World Bank, 2013). Droughts will also become an even more serious concern, particularly given the already strained water access issues (IPCC, 2013).

From a governance point of view, there have been significant efforts made by Governments in Asia to make their countries and societies more resilient. However, much more work is needed. In many countries, national policies are not well implemented, measures to protect the most vulnerable are often lacking, and institutional capacity to handle disasters are at times still weak. There is, thus, a need for robust water security enhancement strategies that are grounded in sound scientific evidence, and that will stand the test of time.

This conference (http://sea.exceed-swindon.org/water_security_conference/) is a platform for engaging leading experts in the region and beyond in discussions on water security issues in Asia in order to facilitate the path towards water-secure societies. The conference is organized by the Exceed centers CNRD (Cologne) and SWINDON (Braunschweig) together with the Asian Institute of Technology (supported by the **Asia Pacific Network for Global Change Research**).

List of participants

No	Name	University / Organisation	Email address
1	ABM Firoz	Technical University of Cologne, Germany	firoz_urp2000@yahoo.com
2	Alex Smajgl	Mekong Region Futures Institute, Thailand	alex.smajgl@merfi.org
3	Alex Smajgl	Mekong Region Futures Institute, Thailand	alex.smajgl@merfi.org
4	Alida Alves	UNESCO-IHE, Netherlands	a.alves@unesco-ihe.org
5	Alpian Pratama	Resilience Development Initiative, Indonesia	alpian.pratama@rdi.or.id
6	Amrita Gautam	Technical University of Cologne, Germany	amritagtm4@gmail.com
7	Anyamanee Onsomkrit	Asian Institute of Technology, Thailand	anyamanee@ait.asia
8	Atiqur Rahman Sunny	WorldFish Bangladesh and South Asia, Bangladesh	atiksunny@yahoo.com
9	Aysha Akter	Chittagong University of Engineering and Technology, Bangladesh	aysha_akter@yahoo.com
10	Bharat Sharma	International Water Management Institute, India	b.sharma@cgiar.org
11	Bhesh raj Thapa	University of Yamanshi, Japan	bthapa.ioe@gmail.com
12	BHJ Premathilake	Coast Conservation and Coastal Resource Management Department, Sri Lanka	bhjprem@yahoo.com
13	Bing Wu	Tongji University, China	bingwu@tongji.edu.cn
14	Brijesh Kumar Yadav	Indian Institute of Technology Roorkee, India	brijeshy@gmail.com
15	Chandra Sekhar Bahinipati	Gujarat Institute of Development Research, India	chandrasekharbahinipati@gmail.com
16	Christian Ploberger	Independent Researcher	plobchr@gmail.com
17	Cilcia Kusumastuti	Petra Christian University, Indonesia	cilcia9@gmail.com
18	Devaraja Pathirage Chanaka Laknath	Lanka Hydraulic Institute, Sri Lanka	chanaka.laknath@gmail.com
19	Dung Nguyen Thien	Thuyloi University, Vietnam	dzungngt@tlu.edu.vn
20	Farhad Zulfiqar	University of Agriculture Faisalabad, Pakistan	farhaduaf@gmail.com
21	Farhana Khan Pushpa	Arannayk Foundation, Bangladesh	farhana@arannayk.org
22	Günter Meon	Technical University of Braunschweig, Germany	g.meon@tu-bs.de
23	Ishita Singh	Jammu University India	ishita13.2014@rediffmail.com
24	Jagdish Jadhav	Central University of Rajasthan, Ajmer, India	jagdishjadhav_sw@curaj.ac.in
25	Jane Elisabeth Wuysang	Parahyangan Chatolic University Bandung Indonesia	janeewuysang@gmail.com
26	Jeeban Panthi	The Small Earth, Nepal	jeeban@smallearth.org.np
27	Jon Gaviola	The Oscar M. Lopez Center, Philippines	jhgaviola.omlopezcenter@gmail.com
28	Kamal Narain Joshi	Institute of Development Studies, India	joshi.knjoshi@gmail.com
29	Mafizur Rahman	Bangladesh University Of Engineering and Technology, Bangladesh	mafizur@gmail.com

30	Manish Shrestha	Asian Institute of Technology, Thailand	manis_shrestha@live.com
31	Manohar Rathore	Centre for Environment and Development Studies, India	msr@cedsj.org
32	marlia mohd hanafiah	Universiti Kebangsaan, Malaysia	mhmarlia@ukm.edu.my
33	Mehmet Emin Aydin	Konya Necmettin Erbakan University, Turkey	meaydin@konya.edu.tr
34	Mohammad Mahmudul Islam	Sylhet Agricultural University, Bangladesh	mahmud.cmf@sau.ac.bd
35	Mohammed Abdul Baten	Independent University Bangladesh	baten_123@yahoo.com
36	Mokbul Ahmad	Asian Institute of Technology, Thailand	morshed@ait.asia
37	Muhammad Mizanur Rahaman	University of Asia Pacific, Bangladesh	rahamanmm-ce@uap-bd.edu
38	Ngai Weng Chan	Universiti Sains, Malaysia	nwchan1@gmail.com
39	Ngoc Huan Tran	Hanoi University of Natural Resources and Environment, Vietnam	tnhuan.tnn@hunre.edu.vn
40	Nguyen-Khoi Dao	VNUHCM University of Science, Vietnam	dnkhoi86@gmail.com
41	Nitin Bassi	University of Delhi, India	bassi43@gmail.com
42	Nureen Anisha	BRAC University, Bangladesh	nureen@bracu.ac.bd
43	Om Katel	Royal University of Bhutan, Bhutan	ombhutan2016@gmail.com
44	Pabitra Gurung	DanChurchAid, Nepal	pabitra.gurung@gmail.com
45	Pallav Shrestha	Asian Institute of Technology, Thailand	pallav3.14@gmail.com
46	Pankajkumar Sampat	Centre for Environmental Planning and Technology, India	p.sampat7@gmail.com
47	Puspa Raj Khanal	FAO, Thailand	PuspaRaj.Khanal@fao.org
48	Ranju Chapagain	Asian Institute of Technology, Thailand	chapagainranju@gmail.com
49	Robertus Triweko	Universtitas Katolik Parahyangan, Indonesia	triweko@unpar.ac.id
50	Roland Treitler	GIZ German International Cooperation, Thailand	roland.treitler@yahoo.de
51	Sae Ishihara	Japan Water Forum, Japan	ishihara@waterforum.jp
52	Sajjad Ahmad	COMSATS Institute of Information Technology, Vehari Campus, Pakistan	sajjad.ahmad@ciitvehari.edu.pk
53	Sandeep Shrivastava	Malaviya National Institute of Technology, India	sshrivastava.ce@mnit.ac.in
54	Santosh G. Thampi	National Institute of Technology, Calicut, India	santoshthampi@yahoo.com
55	Shahadat Chowdhury	NSW Department of Primary Industries, Australia	shahadat.chowdhury@dpi.nsw.gov.au
56	Shahriar Wahid	ICIMOD, Nepal	swahid@gmail.com
57	Shailendra Mandal	National Institute of Technology Patna, India	shailendra@nitp.ac.in
58	Shivani Dhage	VP, Aqura Enviro Projects Private Limited, Mumbai, India	shivanid25@gmail.com
59	Showet Basnet	Thribhuvan University, Nepal	showetb@gmail.com
60	Chhem Sochittra	Institute of Technology, Cambodia	Sochittrac7@gmail.com
61	Stuti Rawat	National University of Singapore, Singapore	stuti.r@u.nus.edu

62	Suresh Kulkarni	Maharashtra Water Resources Regulatory Authority, Mumbai, India	kulsur@gmail.com
63	Suria Darma Tarigan	Bogor Agricultural University, Indonesia	suriatarigan2014@gmail.com
64	Syed Tasfiq Mahmood	International Centre for Climate Change and Development, Bangladesh	mahmood.tashfiq@gmail.com
65	Theara Seng	Asian Institute of Technology, Thailand	thearaseng.itc@gmail.com
66	Thi Van Thu Tran	Vietnam National University, Vietnam	ttvanthu@gmail.com
67	Thushara Wickramaarachchi	University of Ruhuna, Sri Lanka	thusharanw@yahoo.com
68	Trinh Tran	Vietnam Academy for Water Resources, vietnam	tranductrinh@gmail.com
69	Tsuyoshi Kinouchi	Tokyo Institute of Technology, Japan	kinouchi.t.ab@m.titech.ac.jp
70	Tuhin Ghosh	Jadavpur University, India	tuhin_ghosh@yahoo.com
71	Uday Bhonde	National Institute of Urban Affairs, New Delhi, India	ubhonde@niua.org
72	Umamahesh Nanduri	National Institute of Technology, Warangal, India	mahesh@nitw.ac.in
73	Upali Imbulana	Mahaeli Water Security Investment Programme, Sri Lanka	upali.imbulana@gmail.com
74	Vishal Narain	Management Development Institute, India	vishalnarain@mdi.ac.in
75	Yolanda Gomez	WaterLinks, Philippines	ygomez@waterlinks.org
76	Zoran Vojinovic	UNESCO-IHE, Netherlands	z.vojinovic@unesco-ihe.org
77	Jang Su-Hyung	K-water, South Korea	kwaterjang@kwater.or.kr
78	Jittrakorn Suwanlert	Department of Groundwater Resources, Thailand	jittrakorn_dgr@hotmail.com
79	Thị Quỳnh Sa Nguyễn	Vietnam National University, Vietnam	sanguyenquynh@gmail.com
80	Rajendra Chhetri	Institute of Engineering, Nepal	rbc@ioe.edu.np
81	Mustafa Kamal Abu Hena	Universiti Putra, Malaysia	hena71@yahoo.com
82	Amitava Bandyopadhyay	University of Calcutta, India	amitava.bandy@gmail.com
83	Panha Hok	Asian Institute of Technology, Thailand	hokpanha8@gmail.com
84	Yuan Hongchun	Shanghai Ocean University, China	hcyuan@shou.edu.cn
85	Photchanat Intaramanon	Chiang Rai College of Agriculture and Technology, Thailand	muaykae@gmail.com
86	Swatantra Kumar Dubey	Central University of Rajasthan, India	swatantratech1@gmail.com
87	Nicholas Souter	Conservation International, Lao PDR	nsouter@conservation.org
88	Bertrand Lesaca	University of the Philippines, Philippines	bjlesaca@upd.edu.ph
89	Salman Khan	Hohai University, Nanjing, China	salman@hhu.edu.cn
90	Adam Wiryawan	Brawijaya University, Indonesia	adammipa@ub.ac.id
91	Md Arman Habib	Military Institute of Science and Technology, Bangladesh	habib.armaan@gmail.com
92	M Tauhid Ur Rahman	Military Institute of Science and Technology, Bangladesh	tauhid_cee@yahoo.com

93	Ahmet Karagunduz	Gebze Technical University, Turkey	akaragunduz@gtu.edu.tr
94	Amjad Altarawneh	Mutah University, Jordan	amjtar@hotmail.com
95	Cheima Fersi Ep Bennani	INRAP/Biotechpole Sidi Thabet, France	cheimafersi@yahoo.fr
96	Dang Nguyen	Thuyloi University, Vietnam	dang@tlu.edu.vn
97	David Coates	Secretariat of the Convention on Biological Diversity/PEDRR, UK	coatesbusiness@yahoo.co.uk
98	Devesh Sharma	Central University of Rajasthan, India	deveshsharma@curaj.ac.in
99	HA Nguyen	Ho Chi Minh City University of Natural Resources and Environment, Vietnam	ntvha@hcmunre.edu.vn
100	Karen Hussey	The University of Queensland, Australia	k.hussey@uq.edu.au
101	Lina Abu-Ghunmi	The University of Jordan, Jordan	linagh22@yahoo.co.uk
102	Mohamed Elshemy	Tanta University, Egypt	m.elshemy@f-eng.tanta.edu.eg
103	Santiago Penedo	Technical University of Cologne, Germany	santiago.penedo@th-koeln.de
104	Anja Lenk	Techncial Univeristy of Braunchweig, Germany	a.lenk@tu-braunschweig.de
105	Andreas Haarstrick	Techncial Univeristy of Braunchweig, Germany	a.haarstrick@tu-braunschweig.de
106	Lars Ribbe	Technical University of Cologne, Germany	lars.ribbe@th-koeln.de
107	Alexendra Nauditt	Technical University of Cologne, Germany	janeewuysang@gmail.com
108	Robert Costanza	Australian National University, Australia	rcostanz@gmail.com
109	Mehmet Bulent Topkaya	Ekdeniz University, Turkey	btopkaya@hotmail.com
110	Matti Kummu	Aalto Universty, Finland	matti.kummu@aalto.fi
111	Tuan Le Anh		latuan@ctu.edu.vn
112	Norbert Ditchl	Techncial Univeristy of Braunchweig, Germany	n.dichtl@tu-bs.de
113	Janos Bogardi	University of Bonn, Germany	bogardi@uni-bonn.de
114	Gyewoon Choi	Incheon National University, South Korea	gyewoon@inu.ac.kr>
115	Andreas Ernst	University of Kassel, Germany	ernst@usf.uni-kassel.de
116	Chhuon Veasna	Ministery of Water Resoure and Meteorology, Cambodia	chhounveasnaa@gmail.com
117	Christopher Imana	University of Nairobi, Kenya	chrisimana@gmail.com
118	Euiho Hwang	K-water, South Korea	ehhwang@kwater.or.kr
119	Hieng Sek	Ministry of Water Resource and Meteorology, Cambodia	hiengsek@yahoo.com
120	klinbubpha panuwat	Metropolitan Waterworks Authority, Thailand	panuwat_klinbubpha@hotmail.com
121	Peter Mackay	Climate Change Consultant	mackapc101@gmail.com
122	Pornsiri Khanayai	Royal Irrigation Department, Thailand	rid_envi@yahoo.com
123	Santiago Penedo	Technical University of Cologne, Germany	santiago.penedo@th-koeln.de
124	Sarann Ly	Institut de Technologie du Camboge, Cambodia	ly.sarann@itc.edu.kh
125	Seng Tong	Ministry of Water Resources and Meteorology, Cambodia	tongsenghydro@gmail.com

126	Sokchhay Heng	Institute of Technology, Cambodia	heng_sokchhay@yahoo.com
127	Ta'hirih Hokafonu	University of th South Pacific/Department of Environment	tfifitahokafonu@gmail.com
128	Ty Soy	Institute of Technology of Cambodia	soy@itc.edu.kh
129	William Tuivaga	Office of the Prime Minister, Cook Islands	william.tuivaga@cookislands.gov.ck
130	Pham Quy Nhan		pqnhan@hunre.edu.vn
131	Raza Farrukh	Asian Development Bank, Philippines	rfarrukh@adb.org
132	Michael Sugiyanto	Department of Primary Industries, Australia	michael.sugiyanto@dpi.nsw.gov.au

exceed
CNRD - SWINDON - AIT
Conference

Funded by
DAAD
Federal Ministry for Economic Cooperation and Development

WATER SECURITY AND CLIMATE CHANGE:
CHALLENGES AND OPPORTUNITIES IN ASIA

Asian Institute of Technology, Bangkok, *29 November - 01 December, 2016*

BACKGROUND

Achieving water security is one of the major challenges being faced by society today. Asia has been facing many water security challenges since decades because of multiple drivers such as increasing population, socio economic development, urbanization, migration, among others. Furthermore, climate change is also creating an additional threat. While significant efforts have been made by Governments in Asia to make societies water-secure; much more work is needed. There is a need for robust water security enhancement strategies that are grounded in sound scientific evidence, and that will stand the test of time.

This conference http://sea.exceed-swindon.org/water-security-conference/ is a platform for engaging leading experts in the region and beyond in discussions on water security issues in Asia in order to facilitate the path towards water-secure societies. The conference is organized by the exceed centers CNRD (Cologne) and SWINDON (Braunschweig) together with the Asian Institute of Technology.

SPECIAL KEYNOTE SPEAKER

Rajendra Singh
Stockholm Water Prize Winner, 2015

CALL FOR ABSTRACTS

Abstracts, not exceeding 250 words, are invited under the following themes and sub-themes. Abstracts on other themes are also welcome so long as these fit well with the conference agenda. Submit abstracts online on the conference website.

Water and Human Well-Being
- Water supply (sources, distribution, and treatment)
- Sanitation
- Wastewater treatment

Water-Related Hazards
- Extreme events
- Protection of individuals and agricultural areas
- Protection of habitats and urban areas
- Climate change impacts on extreme events

Ecosystems
- Water quality
- Vulnerable ecosystems
- Intelligent use and replenishing natural water resources
- Displacement of nutrient-rich and contaminated sediments

Economic Water Security
- Water for agriculture
- Water for industries
- Process-integrated water management
- Water infrastructure development (water supply, wastewater)
- Water economics
- Hydropower

Crosscutting Themes
- Water governance / policy
- Management of river basins
- Transboundary water challenges and potential
- Water crimes
- Gender and water
- Citizen science
- Information and communication technology

CONFERENCE STRUCTURE

Platform presentations; Poster presentations;
Panel discussions; Keynote speeches

CONTACT

Prof. Andreas Haarstrick
Scientific Coordinator,
Exceed Excellence Center,
TU Braunschweig, GERMANY
+49 (0) 531-391-3935;
a.haarstrick@tu-bs.de

Prof. Mukand S. Babel
Water Engineering and Management
Asian Institute of Technology
+66-2-524-7905;
msbabel@ait.asia

IMPORTANT DATES

Registration open:	20 June 2016
Deadline for receiving abstracts:	30 July 2016
Notify authors of selection:	15 August 2016
Full paper submission deadline:	30 Sept 2016

REGISTRATION

Registration link:
http://sea.exceed-swindon.org/registration/

Fee*: USD 250

**Covers the entrance fee, coffee breaks, lunch, reception dinner on first day, and a copy of the proceedings.*

Note: Limited financial support available for participants from Asian universities

Technische Universität Braunschweig · International Network on Sustainable Water Management in Developing Countries · AIT Asian Institute of Technology · APN · CNRD · ITT · Technology Arts Sciences TH Köln

APPENDIX B: Co-funding and in-kind contribution

i) All personnel time input by the main proponent and lead collaborators has been in-kind contribution by their respective organizations.
ii) Secretarial support from AIT, CURAJ, and TLU has been provided as in-kind contribution.
iii) Dedicated offices for the project work have been provided as in-kind contribution by AIT, CURAJ and TLU.
iv) For the international symposium, co-funding was provided by DAAD (Germany), Technical University of Braunschweig and Techncial University of Cologne, UNDP(Bangkok), and AIT (Thailand).
v) Several water sector experts in all three countries – India, Thailand and Vietnam – provided their time as in-kind contribution to help firm up the water security assessment frameworks.